Rhode Island Ocean
Special Area Management Plan

oceanSAMP

VOLUME 1



Adopted by the Rhode Island Coastal Resources Management Council
October 19, 2010

The Honorable Donald L. Carcieri, former Governor, State of Rhode Island

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Rhode Island General Assembly
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Rhode Island Ocean Special Area Management Plan (Ocean SAMP)
Volume I

Adopted October 19, 2010

A management program of the Rhode Island Coastal Resources Management Council

Council Members

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David Abedon*
Donald Gomez*
W. Michael Sullivan, RIDEM
Raymond C. Coia
Bruce Dawson
Robert G. Driscoll

(* Denotes Subcommittee Member)

Grover J. Fugate, Executive Director and Ocean SAMP Program Manager

Brian Goldman
Legal Counsel
Goldman Law Offices
Smith Street
Providence, RI 02903

This document was prepared for the Rhode Island Coastal Resources Management Council by Jennifer McCann, University of Rhode Island Coastal Resources Center/Rhode Island Sea Grant College Program, and (See list at end of Acknowledgements for affiliation acronyms):

Michelle Armsby Carnevale, CRC/RISG
Dave Beutel, CRMC
John Brown, NIT
Barry Costa-Pierce, RISG
Teresa Crean, CRC/RISG
Alan Desbonnet, RISG
Rebecca Eith, CRC/RISG
Susan Farady, RWU School of Law and the RISG Legal Program
Brian Goldman, for CRMC
Rick Greenwood, RIHPHC
Kate Haber, RWU School of Law and URI
Gwen Hancock, RWU School of Law and the RISG Legal Program
Doug Harris, NIT
Leanna Heffner, URI GSO
Megan Higgins, RWU School of Law and the RISG Legal Program
John Jensen, URI Archeology Group
Sue Kennedy, CRC/RISG
Dawn Kotowicz, CRC/RISG
Rod Mather, URI Department of History
Amber Neville, CRC/RISG
Pam Rubinoff, CRC/RISG
Ella Sekatau, NIT
Ryan Smith, RWU School of Law and the RISG Legal Program
Sarah Smith, CRC/RISG
Tiffany Smythe, CRC/RISG
Charlotte Taylor, RIHPHC
Jim Tobey, CRC
Chip Young, URI Coastal Institute
GIS guidance and support provided by the staff of the Environmental Data Center, Department Of Natural Resources Science at URI:

Christopher Damon
Eivy Monroy
Kevin Ruddock
Charles LaBash
Peter August

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Ocean SAMP Management Team
Sam DeBow, URI GSO
Grover Fugate, CRMC
Jennifer McCann, CRC/RISG
Kathryn Moran, URI GSO
Dennis Nixon, URI GSO
Malcolm Spaulding, URI DOE

Ocean SAMP Science Advisory Committee
Carlton D. Hunt, Co-Chairman, Battelle Ocean Sciences
Scott Nixon, Co-Chairman, URI GSO
Bob Beardsley, WHOI
Jon Boothroyd, Rhode Island State Geologist, URI CELS
Robert Buchsbaum, Massachusetts Audubon Society
Jeremy Collie, URI GSO
Jonathan Garber, EPA/AED
Candace Oviatt, URI GSO
Osvaldo Sala, Brown University
Caroly A. Shumway, BU
James Yoder, WHOI
Roman Zajac, University of New Haven

Research Team
Sam DeBow, team lead, URI GSO
Taylor Asher, URI DOE
Christopher Baxter, URI DOE
Marty Bell, Metlogic
Erin Bohaboy, URI GSO
Jon Boothroyd, Rhode Island State Geologist, URI CELS
David Casagrande, URI DOE
Daniel Codiga, URI GSO
Jeremy Collie, URI GSO
Alexander Crosby, URI DOE
Deborah Crowley, Applied Science Associates, Inc.
Lauren Decker, ASA
Steve Decker, Rutgers University Department of Environmental Sciences
Vincent Elia, New Jersey Audubon Society
Lindsey Fields, URI GSO
Robert Fogg, NJAS
Tony Fox, University of Aarhus, Denmark
Deborah French McCay, ASA
Andrew Gill, Cranfield University, UK
Stephen Granger, URI GSO
Annette Grilli, URI DOE
Stephan Grilli, URI DOE
Jeffrey Harris, URI DOE
Brian Heikes, URI GSO
Jonas Hensel, URI DOE
Patti Hodgetts, NJAS
Sau-Lon James Hu, URI DOE
John Jensen, URI Archeology Group
John King, URI GSO
Robert Kenney, URI GSO

Tania Lado, URI DOE
Monique LaFrance, URI GSO
David La Puma, NJAS
Thomas Magarian, NJAS
Anna Malek, URI GSO
Rod Mather, URI Department of History
Scott McWilliams, URI CELS
Daniel Mendelsohn, ASA
Jeff Mercer, URI GSO
Lisa Miller, URI DOE
David Mizrahi, NJAS
John Merrill, URI GSO
James Miller, URI DOE
Lisa Miller, URI GSO
Scott Nixon, URI GSO
Jeffrey Nystuen, University of Washington Applied Physics Laboratory
Bryan Oakley, URI Department of Geosciences
Stephen Olsen, CRC/SG
Candace Oviatt, URI GSO
Peter Paton, URI CELS
Kim Peters, NJAS
Rob Pockalny, URI GSO
Sheldon Pratt, URI GSO
Gopu Potty, URI DOE
Chris Roman, URI GSO
Kevin Ruddock, TNC
Peter Scheifele, UCONN Bioacoustics Laboratory
Ravi Sharma, URI DOE
Emily Shumchenia, URI GSO
Malcolm Spaulding, URI DOE
David Stuebe, ASA
Jay Titlow, WeatherFlow, Inc.
Carol Trocki, URI CELS
Frank Thomsen, Centre for Environment, Fisheries & Aquaculture Science, UK
Dave Ullman, URI GSO
Kristopher Winiarski, URI CELS

Research Finance and Support Team
Debra Bourassa, URI CELS
Kate Manning Butler, CRC/RISG
Sharon Clements, URI GSO
Charlotte Ferris, RWU School of Law and the RISG Legal Program
Rhonda Kennedy, URI GSO
Charles Labash, URI CELS
Amber Neville, CRC/RISG
Gail Paolino, URI DOE
Heather Rhodes, RISG

Outreach Team
Jennifer McCann, team lead, CRC/RISG
Monica Allard-Cox, RISG
Michelle Armsby, CRC/RISG
Bob Bowen, CRC
Kate Manning Butler, CRC/RISG
Teresa Crean, CRC/RISG
Rebecca Eith, CRC/RISG
Meredith Haas, RISG
Kim Kaine, CRC

Sue Kennedy, CRC/RISG
Amber Neville, CRC/RISG
Sarah Smith, CRC/RISG
Tiffany Smythe, CRC/RISG
Chip Young, URI CI

CRMC Ocean SAMP Staff
Dave Beutel, Policy and Planning
Dan Goulet, Policy and Planning
Laura Ricketson-Dwyer, Public Educator and Information Coordinator
Jeff Willis, Deputy Director

Federal Agency Assistance and Coordination
Allison Castellan, NOAA/OCRM
Tom Chapman, FWS
Mel Coté, EPA/OEP
Robert DeSista, ACOE
Michael Elliott, ACOE
Peter Holmes, EPA/WPS
David Kaiser, NOAA/OCRM
Edward LeBlanc, USCG
Chris Tompsett, NUWC
Erin Trager, BOEMRE
Sue Tuxbury, NOAA/NMFS

Tribal Government Advisors
John Brown, NIT
Doug Harris, NIT

State Agency Assistance and Coordination
Ames Colt, RIBRWCT
Julian Dash, RIEDC
Kim Gaffett, Town of New Shoreham
Rick Greenwood, RIHPHC
Fred Hashway, RIEDC
Jared Rhodes, RISPP
Ted Sanderson, RIHPHC
Michael Sullivan, RIDEM
Charlotte Taylor, RIHPHC

Technical Advisory Committees (Individual Chapters)

Ecology of the SAMP Region Technical Advisory Committee
Stuart Findlay, Cary Institute of Ecosystem Studies
Tim Gleason, EPA/AED
Allen Gontz, University of Massachusetts, Boston
James O'Donnell, UCONN
Eric Schneider, RIDEM
Caroly Shumway, BU
Barbara Sullivan-Watts, Providence College
Roman Zajac, University of New Haven

Global Climate Change Technical Advisory Committee
Wenley Ferguson, STB
Tim Gleason, EPA/AED
Scott Mowery, NOAA National Oceanographic and Coastal Data Centers
Eric Schneider, RIDEM
Caroly Shumway, BU

Arthur Spivack, URI GSO
Robert Thompson, URI Department of Marine Affairs
Kathleen Wainwright, TNC

Cultural and Historical Resources Technical Advisory Committee
Jim Crothers, South County Museum
Pamela Gasner, Block Island Historical Society
Pam Lyons, Charlestown Historical Society
Marjory O'Toole, Little Compton Historical Society
Lori Urso, Pettaquamscutt Historical Society Museum & Library

Commercial and Recreational Fisheries Technical Advisory Committee
Rick Bellavance, RIPCBA
Chris Brown, RICFA
Jeremy Collie, URI GSO
Julie Crocker, NOAA NMFS Protected Resources Division
Lanny Dellinger, RILA
Richard Fuka, RIFA
Mark Gibson, RIDEM
Richard Hittinger, RISAA
Rob Hudson, STB
Tricia Jedele, CLF
Chris Littlefield, TNC
Mike Marchetti, ENESA
Greg Mataronas, SPFA
Candace Oviatt, URI GSO
Ted Platz, RIMA
John Pappalardo, NEFMC
David Preble, NEFMC
Bill Silkes, Ocean State Aquaculture Association
Laura Skrobe, RISG
Brad Spear, ASMFC
David Spencer, CFRF
John Torgan, STB
Nicole Travisono, RIDEM
Sue Tuxbury, NOAA/NMFS
Kathleen Wainwright, TNC
Wendy Waller, STB
Russ Wallis, OSFA

Recreation and Tourism Technical Advisory Committee
Mark Brodeur, RIEDC
George Cochran, RIMTA
Michael Keyworth, RIMTA
Shelia McCurdy, Cruising Club of America
John Rainone, RIPCBA
Evan Smith, NBCCVB
Melissa Stanziale, RIDEM
Robin Wallace, Rhode Island State Yachting Committee

Marine Transportation, Navigation, and Infrastructure Technical Advisory Committee
Paul Costabile, NMPA
Stephen Curtis, ProvPort
Howard McVay, NMPA
Evan Matthews, Quonset Development Corporation
Chris Myers, Interstate Navigation
Edward O'Donnell, ACOE
Michael Riccio, ACOE

Michael Scanlon, RIDEM
Dick West, (ret) U.S. Navy
Matt Wingate, NOAA

Renewable Energy Technical Advisory Committee
Christopher Baxter, URI DOE
Phil Colarusso, EPA
Ames Colt, RIBRWCT
Tim Gleason, EPA/AED
Annette Grilli, URI DOE
Evan Matthews, Quonset Development Corporation
Walt Musial, NREL
Ken Payne, Rhode Island Office of Energy Resources
Paul Roberti, Rhode Island Public Utilities Commission
Michael Ryan, National Grid
Steve Textoris, BOEMRE
Bob Thresher, NREL
Dick West, (ret) U.S. Navy

Other Future Uses Technical Advisory Committee
Tim Gleason, EPA
Eric Schneider, RIDEM
Dan Sheehy, Aquabio, Inc.
Caroly Shumway, BU
Charles Yarish, UCONN

Existing Policies, Statutes and Regulations Technical Advisory Committee
Ames Colt, RIBRWCT
Susan Farady, RWU Law School
Tricia Jedele, CLF
Dennis Nixon, URI GSO
Tim Timmerman, EPA
Wendy Waller, STB

Ocean SAMP Stakeholder Group

Ken Payne, volunteer moderator
Dan Beardsley, Rhode Island League of Cities and Towns
Jeff Broadhead, Washington County Regional Planning Council
Paige Bronk, City of Newport
John Brown, NIT
Chris Brown, RICFA
Alison Buckser, Rhode Island Chapter of the Sierra Club
Charlie Cannon, Rhode Island School of Design
Jeffry Ceasrine, Town of Narragansett
Paul Costabile, NMPA
Vicki deAngeli, Jamestown Chamber of Commerce
Lanny Dellinger, RILA
Julio DiGiando, Jamestown Town Council
Denny Dillon, RIPCBA
Tina Dolen, Aquidneck Island Planning Commission
Charlene Dunn, Charlestown Town Council
Bernard Fishman, Rhode Island Historical Society
Richard Fuka, RIFA
Gina Fuller, Westerly Town Council
Kim Gaffett, Town of New Shoreham
Myrna George, South County Tourism Council
Tricia Jedele, CLF

Doug Harris, NIT
Debbie Kelso, Narragansett Chamber of Commerce
Michael Keyworth, RIMTA
John F. Killoy III, Rhode Island AFL-CIO
Karina Lutz, People's Power & Light
Mike Marchetti, ENESA
Gregg Mataronas, SPFA
Steve Medeiros, RISAA
Robert Mushen, Town of Little Compton
Ray Nickerson, Town of South Kingstown
Eleftherios Pavlides, Wind Power RI Project, RWU
Margaret Petruny-Parker, CFRF
Ted Platz, RIMA
David Prescott, Rhode Island Chapter of the Surfrider Foundation
Michael Ryan, National Grid
Paul Sanroma, Rhode Island Wind Alliance
Bill Silkes, Ocean State Aquaculture Association
Evan Smith, NBCCVB
David Spencer, Atlantic Offshore Lobstermen's Association
Keith Stokes, Newport County Chamber of Commerce
Larry Taft, Audubon Society of Rhode Island
Darlene Towne Evans, South Kingstown Chamber of Commerce
Kathleen Wainwright, TNC
Russell Wallis, OSFA
Wendy Waller, STB
Laurie White, Greater Providence Chamber of Commerce
Jessica Dugan Willi, Block Island Tourism Council
Ronald Wolanski, Town of Middletown

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Acronyms:
ACOE: U.S. Army Corps of Engineers
ASA: Applied Science Associates, Inc.
ASMFC: Atlantic States Marine Fisheries Commission
BOEMRE: U.S. Bureau of Energy Management, Regulation & Enforcement
BU: Boston University
CLF: Conservation law Foundation
CFRF: Commercial Fisheries Research Foundation
CRC: URI Coastal Resources Center
CRC/RISG: University of Rhode Island Coastal Resources Center/Rhode Island Sea Grant College Program
CRMC: Rhode Island Coastal Resources Management Council
ENESA: Eastern New England Scallop Association
EPA/AED: U.S. Environmental Protection Agency/Atlantic Ecology Division
EPA/OEP: U.S. Environmental Protection Agency/Office of Ecosystem Protection
EPA/WPS: U.S. Environmental Protection Agency/Wetlands Protection Section
FWS: U.S. Fish & Wildlife Service
NBCCVB: Newport and Bristol Counties Convention and Visitor's Bureau
NEFMC: New England Fisheries Management Council
NIT: Narragansett Indian Tribe
NJAS: New Jersey Audubon Society
NMPA: Northeast Marine Pilots' Association
NOAA: National Oceanographic and Atmospheric Administration
NOAA/NMFS: National Oceanographic and Atmospheric Administration/National Marine Fisheries Service
NOAA/OCRM: National Oceanographic and Atmospheric Administration/Office of Ocean and Coastal Resource Management
NREL: National Renewable Energy Laboratory
NUWC: U.S. Naval Undersea Warfare Center
Ocean SAMP: Rhode Island Ocean Special Area Management Plan
OSFA: Ocean State Fishermen's Association
RIBRWCT: RICFA Rhode Island Commercial Fishermen's Association
RICFA: Rhode Island Commercial Fishermen's Association
RIDEM: Rhode Island Department of Environmental Management
RIEDC: Rhode Island Economic Development Corporation
RIFA: Rhode Island Fishermen's Alliance
RIHPHC: Rhode Island Historical Preservation and Heritage Commission
RILA: Rhode Island Lobstermen's Association
RIMA: Rhode Island Monkfishermen's Association
RIMTA: Rhode Island Marine Trades Association
RIPCBA: Rhode Island Party & Charter Boat Association
RISAA: Rhode Island Saltwater Anglers Association
RISG: Rhode Island Sea Grant College Program
RISPP: Rhode Island Statewide Planning Program
RWU: Roger Williams University
SPFA: Sakonnet Point Fishermen's Association
STB: Save The Bay
TNC: The Nature Conservancy
UCONN: University of Connecticut
URI: University of Rhode Island
URI CELS: College of the Environment and Life Sciences
URI CI: University of Rhode Island Coastal Institute
URI GSO: University of Rhode Island Graduate School of Oceanography
URI DOE: University of Rhode Island Department of Ocean Engineering
USCG: U.S. Coast Guard
WHOI: Woods Hole Oceanographic Institution

Executive Summary

1. Through the Ocean Special Area Management Plan (Ocean SAMP), the Rhode Island Coastal Resources Management Council (CRMC) commits itself to uphold both its obligations to preserve, protect, develop, and where possible, restore the coastal resources of the state for this and succeeding generations, and to ensure that the preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured, judged and regulated.

2. The waters off Rhode Island's coasts have long served as an important and highly valuable environmental, economic and cultural hub for the people living in this region. The natural beauty of these offshore waters, along with its rich historic and cultural heritage, provides aesthetic, artistic, educational, and spiritual value and is part of the appeal that draws people to live, work, and play in Rhode Island. Rhode Island's offshore waters are an ecologically unique region and host an interesting biodiversity of fish, marine mammals, birds, and sea turtles that travel throughout this region, thriving on its rich habitats, microscopic organisms, and other natural resources.

3. As a means to promote, protect, enhance, and honor these existing human uses and natural resources of Rhode Island, while encouraging appropriate marine-based economic development, and facilitating the coordination of state and federal decision making, the CRMC has produced the Ocean SAMP. Using the best available science and working with well-informed and committed resource users, researchers, environmental and civic organizations, and local, state and federal government agencies, the Ocean SAMP provides a comprehensive understanding of this complex and rich ecosystem as well as describes how the people living in this region have long used and depended upon these offshore resources. To fulfill the Council's regulatory responsibilities, the Ocean SAMP lays out enforceable policies and recommendations to guide CRMC in promoting a balanced and comprehensive ecosystem-based management approach for the development and protection of Rhode Island's ocean-based resources within the Ocean SAMP study area.

4. Since 1983 the CRMC has successfully applied marine spatial planning (MSP) to achieve ecosystem-based management along Rhode Island's coastline. CRMC's six existing SAMP's, as well as the state's water type designations, successfully apply MSP. Through the Ocean SAMP, CRMC builds on this success and applies this same MSP technique to effectively manage Rhode Island's offshore waters.

5. Ecologically, economically, and culturally, Rhode Island is unavoidably linked to the ocean and therefore faces a number of challenges from climate change that are specific to the coastal and marine landscape. The Ocean SAMP intends to contribute to the mitigation of, and adaptation to, global climate change. CRMC believes that with advanced planning and coordination, the harm and costs associated with these potential impacts can be reduced and may be avoided.

6. There is an increased demand for the potential placement of many structures and activities, including liquefied natural gas infrastructure, aquaculture, and artificial reefs, in Rhode Island's offshore waters. However, the major driver for the development of the Ocean SAMP was the determination by the Rhode Island Office of Energy Resources in 2007 that investment in offshore wind farms would be necessary to achieve Governor Donald Carcieri's mandate that offshore wind resources provide 15 percent of the state's electrical power by 2020. In response, the CRMC proposed the creation of a SAMP as a mechanism to develop a comprehensive management and regulatory tool that would proactively engage the public and provide policies and recommendations for appropriate siting of offshore renewable energy.

7. The process to both develop the Ocean SAMP as well as establish policies and regulations is guided by goals and principles that were developed in coordination with the Ocean SAMP researchers and stakeholder group. The Ocean SAMP Goals highlight the commitment by CRMC to: foster a properly functioning ecosystem that is both ecologically sound and economically beneficial; promote and enhance existing uses; encourage marine-based economic development that considers the aspirations of local communities and is consistent with and complementary to the state's overall economic development, social, and environmental needs and goals; and build a framework for coordinated decision-making between state and federal management agencies.

8. The Ocean SAMP Principles commit CRMC to: develop the Ocean SAMP in a transparent manner; involve all stakeholders; honor existing activities; base all decisions on the best available science; and establish monitoring and evaluation that supports adaptive management.

Chapter 1: Introduction

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Section 100. Introduction

1. Rhode Island's offshore waters are an ecologically unique region—the Rhode Island Sound and Block Island Sound ecosystems, which are shallow, near shore continental shelf waters, are located at the boundary of two bio-geographic provinces, the Acadian to the north (Cape Cod to the Gulf of Maine) and the Virginian to the south (Cape Cod to Cape Hatteras). The area is dynamically connected to Narragansett Bay, Buzzards Bay, Long Island Sound, and the Atlantic Ocean via the Inner Continental Shelf. While this unique positioning places this ecosystem at high risk of impacts from global climate change, this positioning also allows it to contain and host an interesting biodiversity of fish, marine mammals, birds, and sea turtles that travel throughout this region, thriving on its rich habitats, microscopic organisms, and other natural resources.

2. The natural beauty of these offshore waters, along with its rich historic and cultural heritage, provides aesthetic, artistic, educational, and spiritual value. This natural beauty is part of the appeal that draws people to live, work, and play in Rhode Island and adds to the quality of life within the area.

3. The waters off Rhode Island's coasts have long served as an important and highly valuable environmental, economic and cultural hub for the people of this region. Commercial and recreational fishing, one of the oldest and most widespread human uses of the area, has sustained Rhode Island coastal communities by providing jobs to fishermen and supporting businesses and industries, as well as food for local consumption or export throughout the United States and overseas. Recreational fisheries support businesses and families throughout Rhode Island and are a key element of the region's recreation and tourism economy. Other recreational and tourism activities such as boating, sailing, diving, wildlife viewing, or shore-based activities such as surfing or beach going, have not only provided enjoyment but also have generated significant economic benefits for the state of Rhode Island.

4. Rhode Island's offshore waters are part of the nation's Marine Transportation System, which is the network of all navigable waterways, vessels, operators, ports, and intermodal landside connections facilitating the marine transport of people and goods in the United States.

5. Human activities have been taking place for hundreds of years in Rhode Island's offshore waters and as a result have influenced area resources and conditions. This area will continue to change due to existing and future human uses, as well as longer-term trends such as global climate change. It is the R.I. Coastal Resources Management Program's responsibility to ensure that decisions made concerning this area are well thought out and based on the best available science.

Section 110. The Rhode Island Coastal Resources Management Council's Ocean Special Area Management Plan

1. The Rhode Island General Assembly mandates the Rhode Island Coastal Resources Management Council (CRMC) to preserve, protect, develop, and where possible, restore the coastal resources of the state for this and succeeding generations through comprehensive and coordinated long range planning and management designed to produce the maximum benefit for society from these coastal resources; and that the preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured, judged and regulated [R.I.G.L. § 46-23-1(a)(2)]. To more effectively carry out its mandate, the CRMC has established use categories for all of the state's waters out to three nautical miles from shore. The Rhode Island Coastal Resource Management Program (RICRMP) is approved as part of the national Coastal Zone Management Program under the federal Coastal Zone Management Act of 1972, 16 U.S.C. § 1451 *et. seq.*

2. The Ocean Special Area Management Plan (Ocean SAMP) is the regulatory, planning and adaptive management tool that CRMC is applying to uphold these regulatory responsibilities in the Ocean SAMP study area. Using the best available science and working with well-informed and committed resource users, researchers, environmental and civic organizations, and local, state and federal government agencies, the Ocean SAMP provides a comprehensive understanding of this complex and rich ecosystem. The Ocean SAMP also documents how the people of this region have used and depended upon these offshore resources for subsistence, work, and play, and how the natural wildlife such as fish, birds, marine mammals and sea turtles feed, spawn, reproduce, and migrate throughout this region, thriving on the rich habitats, microscopic organisms, and other natural resources. To fulfill the Council's mandate, the Ocean SAMP lays out enforceable policies and recommendations to guide CRMC in promoting a balanced and comprehensive ecosystem-based management approach to the development and protection of Rhode Island's ocean-based resources within the Ocean SAMP study area as defined in section 130. The Ocean SAMP successfully fulfills its original stated objectives as summarized below in Section 150.

3. Ocean SAMP policies and recommendations build upon and refine the CRMC's existing regulations presented in the RICRMP. The policies, standards, and definitions contained in the RICRMP for Type 4 waters within the Ocean SAMP boundary, specifically from the mouth of Narragansett Bay seaward, between 500 feet offshore and the 3-nautical mile state water boundary, are herby modified. In addition, RICRMP Sections 300.3 and 300.8 and the 1978 Energy Amendments are hereby superseded within the Ocean SAMP study area.

4. The Ocean SAMP policies for Type 4 waters require that CRMC accommodate and maintain a balance among the diverse activities, both traditional and future water dependent uses, while preserving and restoring the ecological systems. CRMC recognizes that large portions of Type 4 waters include important fishing grounds and fishery habitats, and shall protect such areas from alterations and activities that threaten the

vitality of Rhode Island fisheries. Aquaculture leases shall be considered if the Council is satisfied there will be no significant adverse impacts on the traditional fishery. In addition, CRMC shall work to promote the maintenance and improvement of good water quality within the Type 4 waters (RICRMP Section 200.4).

5. As with the six existing Rhode Island SAMPs and CRMC's water type designations, CRMC implements the marine spatial planning (MSP) process to achieve ecosystem-based management (EBM) for the entire Ocean SAMP region. For the purposes of the Ocean SAMP, the CRMC adopts the definition of EBM put forth in the "Scientific Consensus Statement on Marine Ecosystem-Based Management" (McLeod et al. 2005), which defines EBM as "an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition that provides the services humans want and need."[1] Ecosystems are places and marine spatial planning (MSP) is the process by which ecosystem-based management is organized to produce desired outcomes in marine environments. Since 1983 the CRMC has successfully applied MSP to achieve EBM along Rhode Island's coastline.

6. The Ocean SAMP is a tool for implementing adaptive management. Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. Adaptive management requires careful implementation, monitoring, evaluation of results, and adjustment of objectives and practices. Adaptive management usually allows more reliable interpretation of results, and leads to more rapid learning and better management. To this end, CRMC will establish several mechanisms to ensure that the Ocean SAMP is implemented using this management approach. See Chapter 11, The Policies of the Ocean SAMP, for more details.

7. Through the Ocean SAMP process, much research has been conducted in the Ocean SAMP area by University of Rhode Island scientists and partners, resulting in a great deal of new data and information. The results of these research projects are summarized and/or referenced, as appropriate, in the Ocean SAMP document, and are detailed in a series of technical reports included in the Ocean SAMP Appendices. Datasets associated with these studies are being compiled at the Pell Library at the University of Rhode Island Graduate School of Oceanography, and will be available for public use through the library.

[1] The Scientific Consensus Statement on Marine Ecosystem-Based Management is signed by more than 220 scientists and policy experts from academic institutions throughout the United States. For further information see McLeod et al. 2005.

Section 120. Protection and Preservation within the Ocean SAMP area

1. Since its establishment in 1971, the CRMC has had the authority to manage and plan for the preservation of the coastal resources of the state. For Type 4 (multipurpose) waters, the CRMC's policy is to achieve a balance among diverse activities while preserving and restoring ecological systems. Consistent with this goal, the Ocean SAMP designates Areas of Particular Concern and Areas Designated for Preservation.

2. The Council recognizes that there are many cultural, social, and environmental areas within the Ocean SAMP study area that merit protection. To this end, the Council designates portions of the Ocean SAMP study area as Areas of Particular Concern. These Areas of Particular Concern have been identified through the Ocean SAMP process and include: areas with unique or fragile physical features, or important natural habitats; areas of high natural productivity; areas with features of historical significance or cultural value; areas of substantial recreational value; areas important for navigation, transportation, military and other human uses; and areas of high fishing activity. For example, glacial moraines within the Ocean SAMP area have been designated as Areas of Particular Concern because they are important habitat areas for fish due to their relative structural permanence and structural complexity. For a more detailed description of these areas and policies, see Chapter 11, The Policies of the Ocean SAMP.

3. Other areas of the Ocean SAMP area have been found to merit greater protection from offshore development and are identified as Areas Designated for Preservation. The purpose of Areas Designated for Preservation is to preserve important habitats for their ecological value. Areas Designated for Preservation include certain sea duck foraging habitats because of the significant role these habitats play to avian species. Ocean SAMP policies prohibit various types of offshore development that have been found to be in conflict with the intent and purpose of an Area Designated for Preservation. For a more detailed description of these areas and policies, see Chapter 11, The Policies of the Ocean SAMP.

Section 130. Goals and Principles for the Ocean SAMP

1. Using the best available science and working with well-informed and committed resource users, researchers, environmental and civic organizations, and local, state and federal government agencies, the Ocean SAMP will serve as the regulatory, planning and adaptive management tool to uphold CRMC's regulatory responsibilities and promote a balanced and comprehensive ecosystem-based management approach to the development and protection of Rhode Island's ocean-based resources within the Ocean SAMP study area.

2. CRMC integrates climate concerns and adaptation and mitigation responses into relevant policies and plans. It is the intent of the Ocean SAMP to contribute to the mitigation of, and adaptation to, global climate change as well as to facilitate coordination mechanisms between state and federal agencies and the people of Rhode Island. CRMC believes that with advanced planning, the harm and costs associated with these potential impacts can be reduced and may be avoided.

3. The following goals require engaging a well-informed, well-represented and committed public constituency to work with the Ocean SAMP project team to better understand the Ocean SAMP issues and the ecosystem, and provide input on Ocean SAMP policies and recommendations. Throughout the entire development of the Ocean SAMP document, the CRMC has been committed to engaging all sectors of the public through an extensive public process. For more information on this process, see Payne (2010), included in the Ocean SAMP Appendices.

4. The goals for the Ocean SAMP are to:

    a. **Foster a properly functioning ecosystem that is both ecologically sound and economically beneficial.** Restore and maintain the ecological capacity, integrity, and resilience of the Ocean SAMP's biophysical and socio-economic systems. Conduct research to better understand the current status of the natural resources, ecosystem conditions, and the implications of various human activities. Set standards within the SAMP document to protect and where possible restore and enhance natural resources and ensure that impacts from future activities are avoided and, if they are unavoidable, are minimized and mitigated. Establish monitoring protocols to evaluate the consequences of decisions and adapt management to the monitoring results.

    b. **Promote and enhance existing uses.** Through both scientific and anecdotal research, better understand the existing activities taking place within the Ocean SAMP study area. Work with individuals and organizations representing those uses as well as individuals from around the globe working on similar issues to identify policies and actions that can both promote and enhance existing uses while ensuring that negative and mitigated impacts from future activities are avoided and, if they are unavoidable, are minimized.

c. **Encourage marine-based economic development that considers the aspirations of local communities and is consistent with and complementary to the state's overall economic development, social, and environmental needs and goals.** This development should draw upon and be inspired by the beauty and quality of the environs, including the protection and enhancement of maritime activities, marine culture and a sense of place. Through the development of coastal decision-making tools, with accompanying standards and performance measures, determine appropriate and compatible roles for future activities within the study area, including offshore renewable energy infrastructure.

d. **Build a framework for coordinated decision-making between state and federal management agencies.** Engage federal and state agencies in all phases of the Ocean SAMP process to ensure that all appropriate regulatory requirements are integrated into the process. Ensure that neighboring states of New York, Connecticut, and Massachusetts are informed of all major actions. This coordination will allow for the sharing of technical information across all sectors, enhance management of these coastal ecosystems, and streamline the permitting process where and if appropriate.

5. The principles guiding Ocean SAMP design and development are to:

a. **Develop the Ocean SAMP document in a transparent manner.** Transparency guides the development of all documents and procedures related to the Ocean SAMP project. Project activities and phases are designed to be easily understandable to the general public. Accurate information must be made available to the public in an appropriate and timely manner.

b. **Involve all stakeholders**. Targeted efforts ensure opportunity is available for all stakeholders to have access to the Ocean SAMP planning process as early as possible. Stakeholder participation ensures that a broad range of issues, concerns, and creative ideas, are heard and examined throughout the SAMP process.

c. **Honor existing activities.** The Ocean SAMP area is a highly used and biologically and economically valuable place, with major uses such as fishing, recreation and tourism, transportation, and military activities. These, along with the area's biology and habitat, must be understood, and highly regarded, and respected as decisions for the incorporation of future activities are determined.

d. **Base all decisions on the best available science.** All management and regulatory decisions will be based on the best available science and on ecosystem based management approaches. The Ocean SAMP will require that the necessary studies be performed before a future activity is approved to better understand the impact of this activity on the ecosystem. Such necessary studies might include

gathering information on baseline resource conditions,[2] potential environmental and economic impacts, and potential mitigation measures.

e. Establish **monitoring and evaluation that supports adaptive management.** Incorporating monitoring and evaluation in the Ocean SAMP will contribute towards implementing a systematic process for continually improving management policies and practices in an environment exposed to constant change. The SAMP process is flexible enough to react to such changes and allow plans to be revised in due course. A strong stakeholder process, coordination among federal and state regulatory agencies, and a transparent, monitoring and evaluation mechanism ensures this activity. See Section 1130 for further discussion of implementing the Ocean SAMP through adaptive management.

[2] Baseline data collected and summarized as part of the Ocean SAMP are not intended to represent an idealized state or targeted abundance levels or conditions. Rather, these data are intended to provide insight into current conditions in order to inform decision-making.

Section 140. Ocean SAMP Study Area

1. The Ocean SAMP study area boundary includes approximately 1,467 square miles (3,800 square kilometers) of portions of Block Island Sound, Rhode Island Sound and the Atlantic Ocean. The study area begins 500 feet from the coastline in state waters, from the mouth of Narragansett Bay seaward (out to three nautical miles), and all federal waters within the boundary. The study area, which is an irregularly shaped polygon, is encompassed by a box represented by the coordinates listed below. See Figure 1.1 for a more detailed map:

   North: 41.497420°
   South: 40.912180°
   West: -71.907426°
   East: -70.848987°

   The study area abuts the state waters of Massachusetts, Connecticut and New York.

2. This area was selected as the Ocean SAMP study area because the natural and human activities that take place in these offshore waters have a reasonable foreseeable effect on the people of Rhode Island, and conversely, human activities also impact the Ocean SAMP ecosystem. A similar boundary was selected by the U.S. Army Corps of Engineers in 2003 as it implemented an Environmental Impact Statement for the selection of dredge disposal sites (*Long-Term Dredged Material Disposal Site Evaluation Project Alternative Site Screening Report*) and by the state of Rhode Island to determine potential wind energy infrastructure sites (*RIWINDS Phase I: Wind Energy Siting Study* document produced for the Rhode Island Office of Energy Resources in April 2007). Therefore, some relevant information had already been collected for this study area prior to project initiation. In addition, the distance from the Rhode Island coastline to the furthest offshore boundary – 30 miles – is appropriate since AC cables, which transport electricity, are cost effective at up to 20 miles from shore.

3. Although Block Island is part of the Ocean SAMP study area, for the purpose of this document, Block Island land-based activities under the CRMC jurisdiction, Great Salt Pond, and activities 500 feet seaward of mean high water are regulated using CRMC's existing regulatory program described in the RICRMP.

4. Most Ocean SAMP-related research has been focused within this study area as shown in Figure 1.1. When appropriate, such as for marine mammals and sea turtles, marine transportation, and fisheries, the acquisition and review of data has encompassed a wider area, at times even to include the Outer Continental Shelf. This information will assist the CRMC in managing both the development and protection of these offshore resources applying an ecosystem-management approach.

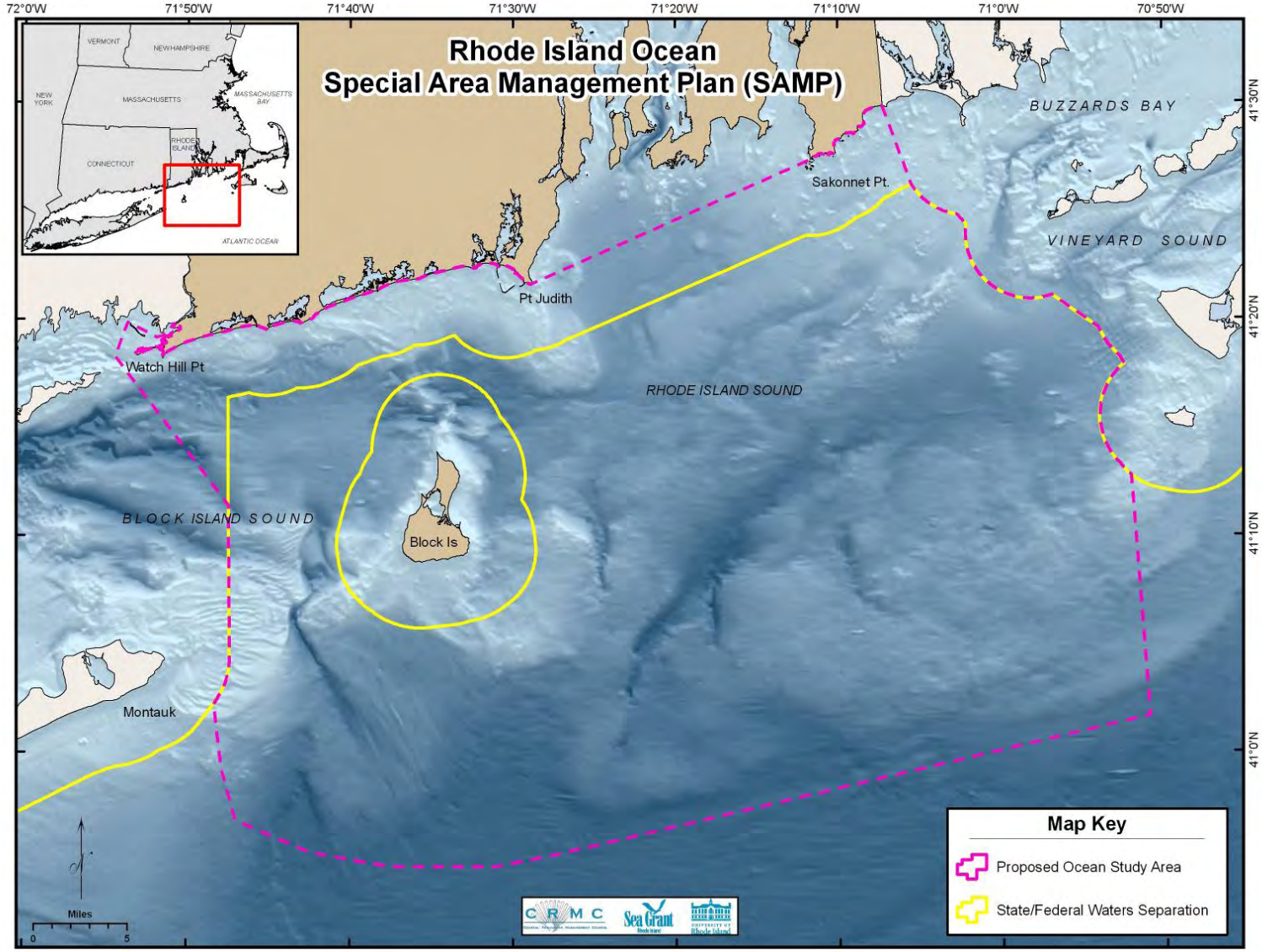


Figure 1.1. Ocean SAMP study area boundary.

Section 150.Origins of the Ocean SAMP

1. In 2005, the CRMC recognized that the uses of marine resources in Rhode Island were intensifying; that optimizing the potential of this intensification would require intentional action driven by design rather than accident; and that needed intentional actions are collaborative in nature. The Rhode Island General Assembly mandated the CRMC to develop a new plan, the Marine Resources Development Plan (MRDP), to meet these new demands while protecting the natural ecosystem. The plan is aimed at improving the health and functionality of Rhode Island's marine ecosystem, providing for appropriate marine-related economic development; and promoting the use and enjoyment of Rhode Island's marine resources. Central to the MRDP is the premise that better results are achieved when expectations are clear and when parties work together. The MRDP is structured around existing CRMC authority and builds on the CRMC's leadership in water-use zoning and special area management planning. SAMPs, which are guided by the MRDP, are ecosystem-based management strategies that are consistent with the Council's legislative mandate to preserve and restore ecological systems. The CRMC coordinates with local municipalities, as well as government agencies and community organizations, to prepare the SAMPs and implement the management strategies.

2. In 2006, through the Northeast Regional Ocean Council (NROC), the CRMC played a leadership role in the effort to engage the four southern states – New York, Connecticut, Rhode Island, and Massachusetts - in the initial phase of creating a multi-state SAMP. The Southern New England/New York Ocean Council working group was thus formed to prioritize issues (natural hazards, healthy ecosystems, marine transportation, and energy) requiring coordination among the four states and research mechanisms to enhance shared resources. Although a multi-state SAMP was never developed, this working group became officially recognized as the southern representation for the gubernatorial appointed NROC.

3. In 2004, the Rhode Island General Assembly passed the Renewable Energy Standard (R.I.G.L. 39-26-1 *et seq.*) which mandates that the state meet 16 percent of its electrical power needs with renewable energy by 2019. In 2007, Rhode Island's Office of Energy Resources (OER) determined that investment in offshore wind farms would be necessary for achieving Governor Donald Carcieri's additional mandate that offshore wind resources provide 15 percent of the state's electrical power by 2020. In response, the CRMC proposed the creation of a SAMP as a mechanism to develop a comprehensive management and regulatory tool that would proactively engage the public and provide policies and recommendations for appropriate siting of offshore renewable energy. In the CRMC's 2008 proposal to the Rhode Island Economic Development Corporation for the Ocean SAMP, the stated objectives of this project included: 1) Streamline cumbersome federal and state permitting processes and establish a more cost-effective permitting environment for investors; 2) Promote a balanced approach to considering the development and protection of ocean-based resources; 3) Complete the necessary studies to yield the most accurate and current ocean-based scientific data and technologies to build knowledge critical for supporting the permitting process; and 4) Foster a well-informed and committed public constituency.

4. Through the Ocean SAMP, the CRMC has met its stated objectives as outlined in the CRMC's 2008 proposal to the Rhode Island Economic Development Corporation. The Ocean SAMP has done so by: developing an offshore development regulatory framework; developing policies that both protect natural resources and manage existing and potential future uses; supporting new scientific research of the study area; and facilitating a rigorous stakeholder process.

Section 160. The CRMC's State and Federal Responsibilities

1. The CRMC is mandated to uphold all applicable sections of the federal Coastal Zone Management Act of 1972 (CZMA). The CZMA requires that the CRMC provide for the protection of natural resources within the coastal zone, including wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and fish and wildlife and their habitat, and must manage coastal development to improve, safeguard, and restore the quality of coastal waters, and protect existing uses of those waters. The CRMC must develop management plans that give full consideration to ecological, cultural, historic, and aesthetic values, as well as needs for compatible economic development. SAMP's are identified in the CZMA as effective tools to meet this mandate (16 U.S.C. § 1456b).

2. The Ocean SAMP assists CRMC in upholding its mandate to preserve the state's coastal resources on submerged lands in accordance with the public trust. As stated in Article 1, §17 of the Rhode Island Constitution, applicable statutes, and restated in the RICRMP, the state maintains title in fee to submerged lands below the high water mark, and holds these lands in trust for the use of the public, preserving public rights which include but are not limited to fishing, commerce, and navigation in these lands and waters. Rhode Island public trust resources are defined in RICRMP as the tangible physical, biological matter substance or systems, habitat or ecosystem contained on, in or beneath the tidal waters of the state, and also include intangible rights to use, access, or traverse tidal waters for traditional and evolving uses including but not limited to recreation, commerce, navigation, and fishing.

3. The CZMA finds that in order for the CRMC to uphold this mandate, it must actively participate in all federal programs affecting such resources and, wherever appropriate, develop state ocean resource plans as part of its federally approved coastal zone management program (16 U.S.C. § 1451).

4. The CRMC is the state authority for federal consistency under the CZMA (16 U.S.C. § 1456). Federal consistency requires federal agencies to alter projects to be consistent with state coastal management program policies. In addition, the statute requires non-federal applicants for federal authorizations and funding to be consistent with enforceable policies of state coastal management programs. A federal agency also has a statutory responsibility to provide neighboring or impacted states with the opportunity to review federal agency activities with coastal effects occurring wholly within the boundary of another state if that state has been approved for interstate consistency. For further information on federal consistency, see 15 CFR 930 *et seq.*

5. More recently, federal regulations per the CZMA have placed substantial energy-related planning responsibilities on states, such as requiring states to: 1) Identify energy facilities that are likely to locate in or which may affect the coastal region; 2) Develop a procedure for assessing the suitability of sites for such facilities; 3) Develop policies and techniques for managing energy facilities and their impacts; 4) Develop cooperative and coordinating arrangements between the CRMC and other agencies involved in energy facility planning and siting; and 5) Identify legal techniques to be used in managing energy facility siting and related impacts (16 U.S.C. § 1454 and15 CFR § 923.13).

160.1. The Existing Regulatory Framework for Offshore Development

1. The following is a summary of the existing regulatory framework for offshore development. For a more detailed description of applicable regulations, see Chapter 10: Existing Statutes, Regulations, and Policies.

2. The CRMC currently has jurisdiction for offshore projects within Rhode Island state waters which would fall under the applicable provisions of the RICRMP and Management Procedures. In addition to a Council permit, a successful applicant will also need to obtain a lease of the state's submerged lands. The leasing process is subsequent to the Council permit process, and to be eligible, an applicant will have to not only have the Council permit but will need the applicable federal, state and local permits as well as being identified as a preferred vendor by the R. I. Department of Administration.

3. For offshore wind infrastructure, the Federal jurisdiction is very complex but essentially falls onto two federal departments depending on location. In state waters, the primary permitting entity is the U.S. Army Corps of Engineers. In federal waters the primary permitting agency is the Bureau of Ocean Energy Management, Regulation, and Enforcement of the Department of Interior (BOEMRE), previously known as the U.S. Minerals Management Service (MMS). The recently released Bureau of Ocean Energy Management, Regulation, and Enforcement regulation recognizes the Ocean SAMP process with the following reference: "Two States—New Jersey and Rhode Island—are well along in planning efforts that will help to determine appropriate areas of the Outer Continental Shelf for development, and MMS has been an active partner with those States. Such efforts—supported by MMS environmental study and technical research initiatives, as well as the Coordinated OCS Mapping Initiative mandated by Energy Policy Act of 2005—will contribute significantly as MMS implements this final rule" (MMS 2009, 19643).

4. The Bureau of Ocean Energy Management, Regulation, and Enforcement also has the authority to issue leases for other forms of offshore renewable energy development such as hydrokinetic projects. Hydrokenetic projects, such as wave or tidal energy, require approval from the Federal Energy Regulatory Commission (FERC), which has exclusive jurisdiction to issue licenses for hydrokinetic projects under Part I of the Federal Power Act (16 USC § 791 *et seq.*) and issue exemptions from licensing under Section 405 and 408 of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. § 2601 *et seq.*) for the construction and operation of hydrokinetic projects on the Outer Continental Shelf. However, no FERC license or exemption for a hydrokinetic project on the OCS shall be issued before the Bureau of Ocean Energy Management, Regulation, and Enforcement issues a lease, easement, or right-of-way. For more information see Chapter 10, Existing Statutes, Regulations, and Policies and Chapter 8, Renewable Energy and Other Offshore Development.

5. Rhode Island was recognized a second time in the regulation with the following reference: "We received several comments recommending that we provide for accepting the results of competitive processes conducted by states and utilities to select developers of offshore wind generation projects. Notably, during the time that MMS has been

promulgating this rule, the states of Delaware, New Jersey, and Rhode Island have conducted competitive processes and have selected companies to develop wind resources on the OCS. We believe that the pre-existing state processes are relevant to the competitive processes that MMS is required to conduct following approval of this rule. We intend to do so by using a competitive process that considers, among other things, whether a prospective lessee has a power purchase agreement or is the certified winner of a competitive process conducted by an adjacent state. We also may consider a similar approach to recognize the winners of competitions held by states in the future. There is additional discussion of this issue in our explanation of multiple-factor bidding provided in the next section" (MMS 2009, 19663).

6. Each federal process (i.e. U.S. Army Corps of Engineers and Bureau of Ocean Energy Management, Regulation, and Enforcement), depending on the resources encountered by a project in Rhode Island's offshore waters, brings to bear a series of other federal regulations and processes.

160.2. Engaging Stakeholders

1. Ocean SAMP development and implementation depends on collaboration among and engagement by all stakeholders. Stakeholders are defined as government, citizens, civic and environmental organizations, resource users, and the private sector. The Ocean SAMP established a framework that engaged all major stakeholders. Major aspects of this stakeholder involvement include the following:

    a. **Ocean SAMP Stakeholder Group:** From the outset, the Ocean SAMP stakeholder group has been an integral part of both determining the scope and contents of the document as well as refining the described policies. New research and findings were shared and developed in coordination with the stakeholders as a mechanism to ground truth and enhance findings. The Ocean SAMP goals and principles upon which the Ocean SAMP was produced were refined and approved by the stakeholders. Through a web site, list serve, and monthly meetings, the Ocean SAMP stakeholder process provided the public with an opportunity to stay up to date on current research, learn about Rhode Island's offshore waters, ask questions and express concerns, as well as engage in the process of determining chapter scope and content (Payne 2010).

    b. **Technical Advisory Committees:** CRMC established a Technical Advisory Committee (TAC) for each Ocean SAMP chapter. The TAC was made up of scientists, government agency representatives, and resource users with expertise in the chapter topic. The purpose of the TAC was to provide expert advice on the contents and scope for each chapter. TAC members assisted CRMC in refining and enhancing the chapters.

    c. **Science Advisory Task Force:** The Ocean SAMP Science Advisory Task Force included scientists representing different areas of scientific expertise. The purpose of the Science Advisory Task Force was to provide expertise and input specific to the science and research-based aspects of the Ocean SAMP effort. The

Task Force met periodically to discuss the science and the research as well as provide advice.

d. **Federal and State Agency Coordination:** CRMC engaged federal and state agency representatives to help determine and respond to the scope of the Ocean SAMP document. This constant engagement ensured that the Ocean SAMP will help to fulfill many of the regulatory requirements for each of these agencies as well as identified appropriate coordination mechanisms among these agencies that assist in future decision making.

2. CRMC is committed to continuing the transparent decision making process established during the development of the Ocean SAMP process. See Chapter 11, The Policies of the Ocean SAMP, for more information.

Section 170. The Contents of the Ocean SAMP Document

1. The chapters that follow provide detailed findings of fact that describe the physical, biological and social aspects of the Ocean SAMP study area. This information comes from the best available science. When existing data did not exist - for example to better understand the physical oceanography, human uses of the study area by commercial mariners, recreational boaters and commercial and recreational fishermen - the CRMC, in coordination with the University of Rhode Island, implemented research to collect this necessary information.

2. Ocean SAMP policies and regulatory standards presented in this document represent actions the CRMC will take to uphold its regulatory responsibilities mandated to them by the Rhode Island General Assembly and the federal Coastal Zone Management Act to achieve the Ocean SAMP goals and principles described above. Policies presented for cultural and historic resources, fisheries, recreation and tourism, and marine transportation promote and enhance existing uses and honor existing activities (Goal b, Principle c). Ecology, global climate change, and other future uses information and policies provide a context for basing all decisions on the best available science, while fostering a properly functioning ecosystem that is both ecologically sound and economically beneficial (Goal a, Principle d). Renewable energy and offshore development policies and regulatory standards ensure there is a rigorous review for all ocean development so that the Council meets its public trust responsibilities.

3. The Ocean SAMP also provides thoughtful direction to encourage marine-based economic development that considers the aspirations of local communities and is consistent with and complementary to the state's overall economic development, social, and environmental needs and goals (Goal c). All chapters work towards establishing frameworks to coordinate decision-making between state and federal management agencies and the people who use the Ocean SAMP region (Goal d), developing the Ocean SAMP document in a transparent manner (Principle a), and promoting adaptive management (Principle e). All Ocean SAMP policies are important to ensure that the Ocean SAMP region is managed in a manner that both meets the needs of the people of Rhode Island, while protecting and restoring our natural environment for future generations.

Section 180. Literature Cited

ATM. 2007. RI Winds Summary Report, Applied Technology and Management for RI Office of Energy Resources, Providence, RI. Available online at: http://www.energy.ri.gov/documents/renewable/RIWINDS_RANKING.pdf. Last accessed March 15, 2010.

Battelle. 2003. Final Report, Task 10.4 Alternative Site Screening Report. June 2003.

McLeod, K. L., J. Lubchenco, S. R. Palumbi, and A. A. Rosenberg. 2005. Scientific Consensus Statement on Marine Ecosystem-Based Management. Signed by 221 academic scientists and policy experts with relevant expertise and published by the Communication Partnership for Science and the Sea at http://compassonline.org/?q=EBM.

MMS. 2009. "Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf; Final Rule." *Federal Register*, April 29, 2009, 74(81): 19638-19871.

Payne, K. 2010. Stakeholder Process. Report of the Ocean Special Area Management Plan. June 30, 2010.

Chapter 2: Ecology of the Ocean SAMP Region

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Section 200. Introduction

1. The term "ecology," translated from its Greek origins, literally means "the study of home." From this, ecology can be thought of as a description, based on information gleaned and gathered during various studies, of the place where something resides. Ecology incorporates study not just of living things—the biota—but also non-living elements—the abiotic resources—because they profoundly influence where and how the living organisms exist. Ecology attempts to understand and describe the interactions between various living organisms with each other, between living organisms and the non-living resources existing in the local environment, and between the various abiotic components of the ecosystem.

2. While ecological study can be performed at various scales in the environment, this chapter will generally attempt to provide description at an ecosystem scale, though that description may be based on a subset of smaller patches of environment with the ecosystem. An ecosystem is defined as the collection of the various ecological communities, which are comprised of the populations of different species living in the area, and the non-living resources upon which they depend. For the purposes of this chapter, the ecosystem being described is that of the Ocean Special Area Management Plan (SAMP) region, the boundaries of which are shown in Figure 2.1.

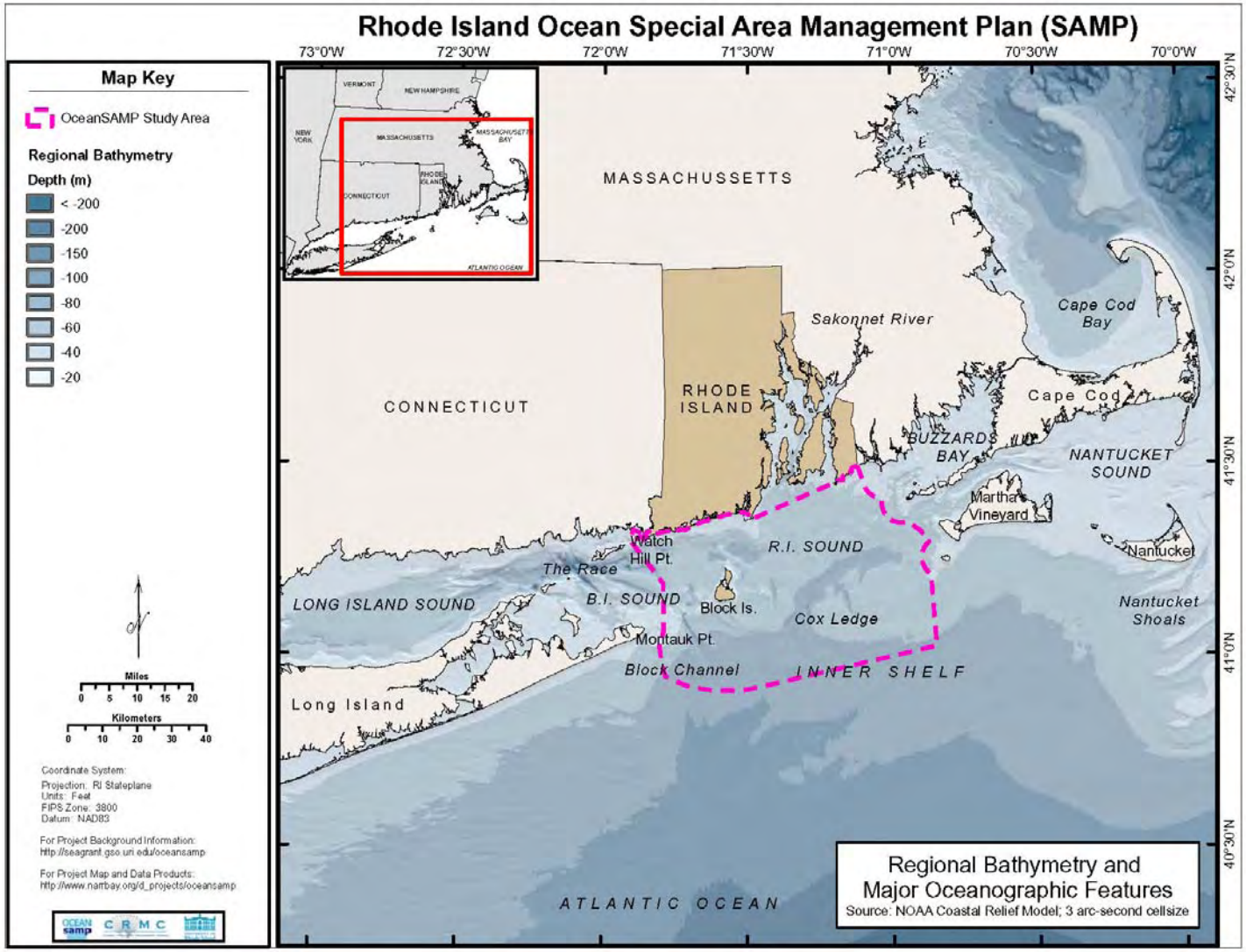


Figure 2.1. General geographic layout, basic bathymetry, and major features of the Ocean SAMP area as discussed in this chapter.

3. The Ocean SAMP region is a busy maritime entryway to Narragansett Bay, Long Island Sound, Buzzards Bay and the Cape Cod Canal. It could be anticipated that much would be known about the ecology, biology and ecological functioning of this important region. To date, mainly small-scale areas of the sea floor and water column have been intensively studied in Rhode Island Sound, Block Island Sound or the Offshore Ocean SAMP area (the region immediately south of Rhode Island Sound and Block Island Sound, roughly that area south of Block Island to the Continental Shelf Slope, is considered here to be the Offshore Ocean SAMP area, and will be referred to as such throughout this chapter). Therefore understanding of the overall ecology of this ecosystem is somewhat fragmented.

4. The Ocean SAMP area is an ecologically unique region—the Rhode Island Sound and Block Island Sound ecosystems are located at the boundary of two intermingling biogeographic provinces, the Acadian to the north (Cape Cod to the Gulf of Maine) and the Virginian to the south (Cape Cod to Cape Hatteras). Because of this, the Ocean SAMP area contains an interesting biodiversity that is a mix of northern, cold water species and more southern, warm water species.

5. Unfortunately, there is no baseline of information for the area that pre-dates human disturbances such as trawl fishing, so scientists have been and are investigating a changed ecosystem. New studies, however, are underway by a variety of researchers sponsored by various agencies and institutions. This chapter takes the patchwork of available information and attempts to stitch it together into a coherent fabric that describes the basic ecology of the overall Ocean SAMP area. The chapter should be updated from time to time to reflect the findings of new research.

6. The Ocean SAMP area includes Rhode Island Sound and the central and eastern portions of Block Island Sound, both of which are shallow, nearshore continental shelf waters lying between Martha's Vineyard/Elizabeth Islands, and Long Island. The area is dynamically connected to Narragansett Bay, Buzzards Bay, Long Island Sound, and the Atlantic Ocean via the Continental Shelf. Long Island Sound is a significant influence on the physical oceanography of the area due to the input of low salinity water from several major rivers (e.g., Connecticut River). A shallow sill extends from Montauk Point to Block Island at a depth of 15–25 meters, and partially isolates Block Island Sound from the Continental Shelf acting to some degree as a buffer to wave impacts. A canyon—Block Channel—extends several tens of kilometers from the deepest point of the sill, forming a deep connection between Block Island Sound and the Offshore Ocean SAMP area region of the Atlantic Ocean. The area of Rhode Island Sound and Block Island Sound overlapping the Ocean SAMP area is approximately 3,800 km^2.

7. Located in a temperate climate, the waters of the Ocean SAMP area are highly seasonal. Winter water temperatures, at both surface and bottom, range from 3–6°C and from 10–21°C during summer. During winter, bottom waters are often warmer, by several degrees, than surface waters, while in summer this trend is reversed with bottom water often 10°C colder than surface water. The disparity between surface and bottom water temperatures are important to the physical structure of the water column—summer conditions tend to promote stratification while winter conditions have a destabilizing effect that breaks

down stratification. Water column stratification, a naturally occurring event in Ocean SAMP area waters, reduces interaction between surface waters and the rest of the water column. Stratification often sets up physical conditions that concentrates food items and draws in marine life, becoming a "hot spot" of biological activity. In warm, shallow areas, stratification can sometimes lead to reduced oxygen concentrations in bottom waters, creating stressful conditions. Anoxia or hypoxia (no or little dissolved oxygen) are not reported for waters in the Ocean SAMP area.

8. With a direct, open connection to the Atlantic Ocean, salinity in the Ocean SAMP area has varying, small ranges, with lowest values in spring and summer as influenced by spring rains and melting snow pack. While these ranges are small, they can be important in driving circulation, assisting in the development and stability of stratification, and influencing the marine life inhabiting the region. The dynamic physical oceanography of the area sets up zones where sharp differences in temperature and/or salinity between inshore and shelf water create discontinuities, called fronts. These fronts, which occur mainly during summer along the Offshore Ocean SAMP area, and in a region just south of Block Island, provide unique biological and/or physical characteristics that cause them to be major fish attraction areas.

9. The Ocean SAMP area is a biologically productive area, comparable to though slightly less so than nearby waters, such as Long Island Sound and Nantucket Sound. The growth of phytoplankton is seasonal, with spring and fall generally being the most productive times of year. Species composition of phytoplankton in the Ocean SAMP area reflects its interactions with Narragansett Bay, Long Island Sound and the Continental Shelf regions. Like Narragansett Bay, the annual winter–spring bloom of phytoplankton in Rhode Island Sound appears to be becoming less consistent in its regularity. Zooplankton populations are also seasonal, generally following the trends of phytoplankton abundance. Species composition and seasonality of zooplankton abundances does not appear to have changed much over the past 50 or so years for dominant species. Shifts towards smaller species of copepods in Continental Shelf waters has been documented, but it is not clear if this trend is being mimicked in Ocean SAMP waters.

10. Juvenile fish and eggs (e.g., ichthyoplankton) in the Ocean SAMP area are rich and varied, and show strong seasonality for many species, which is most often linked to reproduction. The seasonality of some ichthyoplankton appears to be changing over time, but the data are too sparse to say this with any degree of surety. For adult fishes however, the pattern is clearer. The fish community of Ocean SAMP waters is dynamic and diverse, but has undergone major change over the recent past. Demersal, or bottom dwelling fishes such as winter flounder, once were the dominant fish types of the area. Since the mid-1970s there has been a shift towards pelagic fish species dominance, with a corresponding increase in bottom invertebrates such as crabs and lobster. Dominant fish species are now bluefish, butterfish, and sea robins, at the expense of winter flounder and hake, for example. Squid, a large pelagic invertebrate, has also increased in abundance as this shift from demersal fish species ensued. Similar change is being noted throughout the broader North Atlantic region, and appears to be correlated to warming water temperatures resulting from changing climate.

11. The organisms living in the sediments make up an important food source for demersal fishes, and play a critical role in the cycling of organic material. The benthic communities in the Ocean SAMP area are dominated by various species of amphipods, with tube dwelling species (e.g., ampeliscids) being the most dominant throughout the area. Bivalves, marine worms, and small shrimps make up the bulk of the remaining dominant benthic species. There appears to be correlation between the types of sediments making up the bottom and the species that occur in them, but there is not enough information at hand to map this in any meaningful way, or to make species–bottom type correlations with any degree of surety.

12. Marine mammals—whales, dolphins, porpoise and seals—utilize the Ocean SAMP area, but sparsely and generally on a seasonal basis. While whales will often venture into Ocean SAMP waters, they are not resident and generally are passing through; most whale sightings occur in deeper waters out over the Continental Shelf. Harbor seals do utilize Ocean SAMP waters during winter months, and a growing North Atlantic population of this species makes them a regular sight from late fall to early spring before the seals move north to breed. Gray seals are less common to the area, though increasing populations of this species is resulting in increased visitation as well. Sea turtles too are often sighted in Ocean SAMP waters, but most are traveling through the area and as such are considered occasional visitors.

13. Bird life throughout the Ocean SAMP area is varied, with waterbirds being the most abundant. Passerines utilize Ocean SAMP air space during migration periods, and Block Island is an important stop over and resting spot for many species. Use of Ocean SAMP waters by waterbirds is heaviest during winter months, with a peak from early March through mid-April. Water of less than 20 m in depth is important feeding habitat for diving ducks, and nearshore shallow waters are important feeding habitat for terns nesting onshore during summer months.

14. A major issue of concern for the overall ecology of the Ocean SAMP area is changing climate. Changes to fish communities are evident, and findings from adjacent waters suggest changes in phytoplankton and zooplankton communities as well; the benthos has not been studied robustly enough to determine if major shifts might be occurring, and is an area ripe for further study. Existing data however, suggest relative stability of the Ocean SAMP zooplankton community over the past several decades, which does not agree with trends reported for the larger North Atlantic area. Altered ecosystem conditions are allowing for various native species to increase in abundance, sometimes to nuisance proportions, and non-native (invasive) species are gaining a toe-hold as they expand their ranges, often out competing and excluding native species in the process. While less is known about marine microbial communities and disease organisms in Ocean SAMP waters, lobster shell disease is prevalent in the area and is being tied to changing climatic conditions. The northerly spread of shellfish diseases such as Dermo and MSX are also being documented, and again appear to be related to warming waters throughout the area.

15. In summary, the Ocean SAMP region is a dynamic, biologically productive, unique marine habitat area that is similar to nearby waters. It also is different in that it abuts two

major eco-regions, and is therefore an expression of both. The Ocean SAMP region, like nearby areas, appears to be undergoing change as a result of changing climatic conditions. Our knowledge-base for the Ocean SAMP area however, is patchy, and much of it outdated. This makes it an even further challenge to understand its complex ecology.

Section 210. Geological Oceanography

1. The basic geological characteristics of the Ocean SAMP area create the foundation for its ecology. Large scale features, such as glacial moraines and boulder fields, are largely stable over long spans of time. Smaller scale features however, influence the physical forces of waves, tides and currents that move and sort the sediments which form the basic benthic habitat types available for colonization by organisms. Some of these habitats are fairly stable (e.g., boulders) while others are quite transitory (e.g., sand waves). Each habitat type supports different communities of organisms that make up the mosaic of benthic life in the Ocean SAMP area.

2. The geology of a region determines the basic characteristics upon which physical, chemical and biological elements of the ecosystem build. The geology is generally a static or slowly changing element of the landscape, though cataclysmic alteration (e.g., an earthquake or volcanic eruption) can occur and bring rapid, dramatic change. Block Island Sound, Rhode Island Sound, and the Offshore Ocean SAMP area, derive their basic topography and geology from Pleistocene glaciation activity, in particular the Wisconsinan Laurentide ice sheet that reached its maximum extent about 24,000 years ago (Stone and Borns 1986; Boothroyd and Sirkin 2002). The maximum southern extent of the ice sheet falls within the Ocean SAMP area, and its retreat created a unique patchwork landscape of boulders, sand, gravel, and moraine features that make up the ecological foundation of Rhode Island Sound, Block Island Sound and the Offshore Ocean SAMP area region.

3. Marine waters are estimated to have entered Block Island Sound and Rhode Island Sound about 9,500 years ago when sea level was 35 m lower than at present. Prior to that time, ancient glacial lakes were in existence, and drainage from the lakes helped create some of the major submarine features (e.g., canyons) on the Continental Shelf (Figure 2.2). Sea level rose at an estimated rate of 2 m per century, filling the ancient lakes with seawater, then slowing to a rate of 30 cm per century (3 mm yr^{-1}) about 5,000 years ago (Boothroyd 2009). Current sea level rise rate at Montauk, New York is 2.78 mm yr^{-1} (± 0.32 mm yr^{-1}; NOAA Tides and Currents n.d.); the tidal station at Newport, Rhode Island, is experiencing a sea level rate of rise of 2.58 mm yr^{-1} (± 0.19 mm; NOAA Tides and Currents n.d.), the station in New London, Connecticut a rate of rise of 2.25 mm yr^{-1} (± 0.25 mm; NOAA Tides and Currents n.d.) and the station on Nantucket Island, Massachusetts a sea level rise rate of 2.95 mm yr^{-1} (± 0.46 mm yr^{-1}; NOAA Tides and Currents n.d.) . It is expected that the Ocean SAMP area would currently experience a rate of sea level rise somewhere within the bounds of the Montauk, New London, Newport, Nantucket tide stations (2.25–2.95 mm yr^{-1}). The overall impact of rising sea level on the ecology of the area, with its subsequent loss as well as creation of new habitat, is not known (see Chapter 3, Global Climate Change, for further discussion of sea level rise in the Ocean SAMP area).

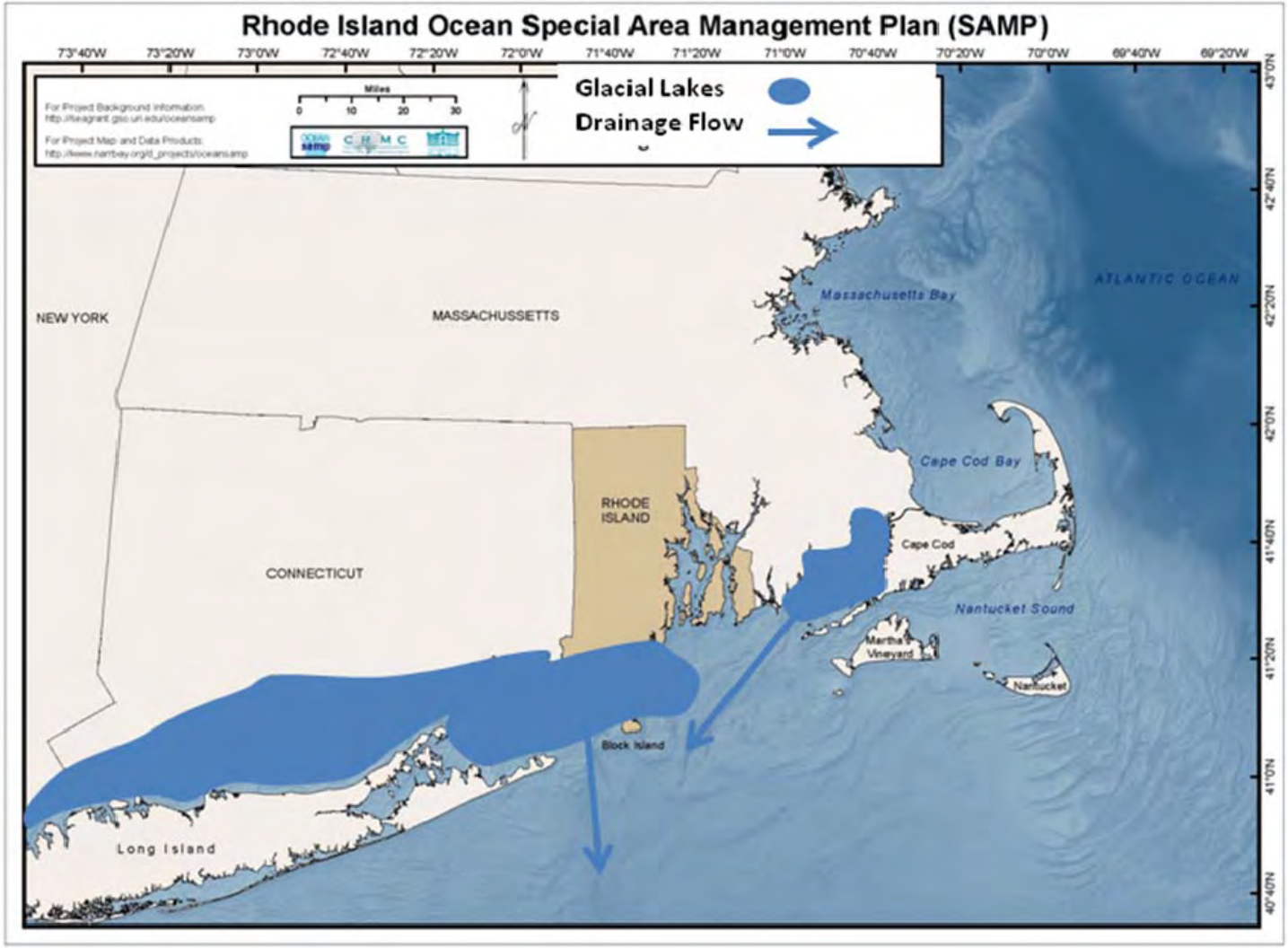


Figure 2.2. Schematic of approximate location of major glacial lakes and direction of drainage flows approximately 19,000 years ago, and which helped create current seabed topography. Adapted from Uchupi et al. (2001).

4. The geological features of Rhode Island and Block Island Sounds have strong influence on the physical oceanographic characteristics of those water bodies, which in turn has significant influence upon biological and ecological processes. Glacial moraines for instance, span the Ocean SAMP area, creating unique bottom topography which influences the patterns of currents, and creates a mosaic of habitats (e.g., sediment types) which diversifies the overall ecological fabric of the area (Figure 2.3). The moraine features, in general, are composed of coarse materials such as boulders and large rock. These materials provide vertical relief on the seafloor, which influences currents and provides greater surface area for colonization by attached organisms. In this way the moraines provide for habitat complexity. While other elements of the ecosystem may change dramatically and rapidly in response to changing climate, storms, and other perturbations, the basic geological foundation will remain as a solid influence in the face of all but the most catastrophic of events (e.g., volcanic activity). The basic resiliency of the benthic environment in the region has allowed the development of what appears to be a relatively stable benthic ecological community (see Section 250.2 for further details).

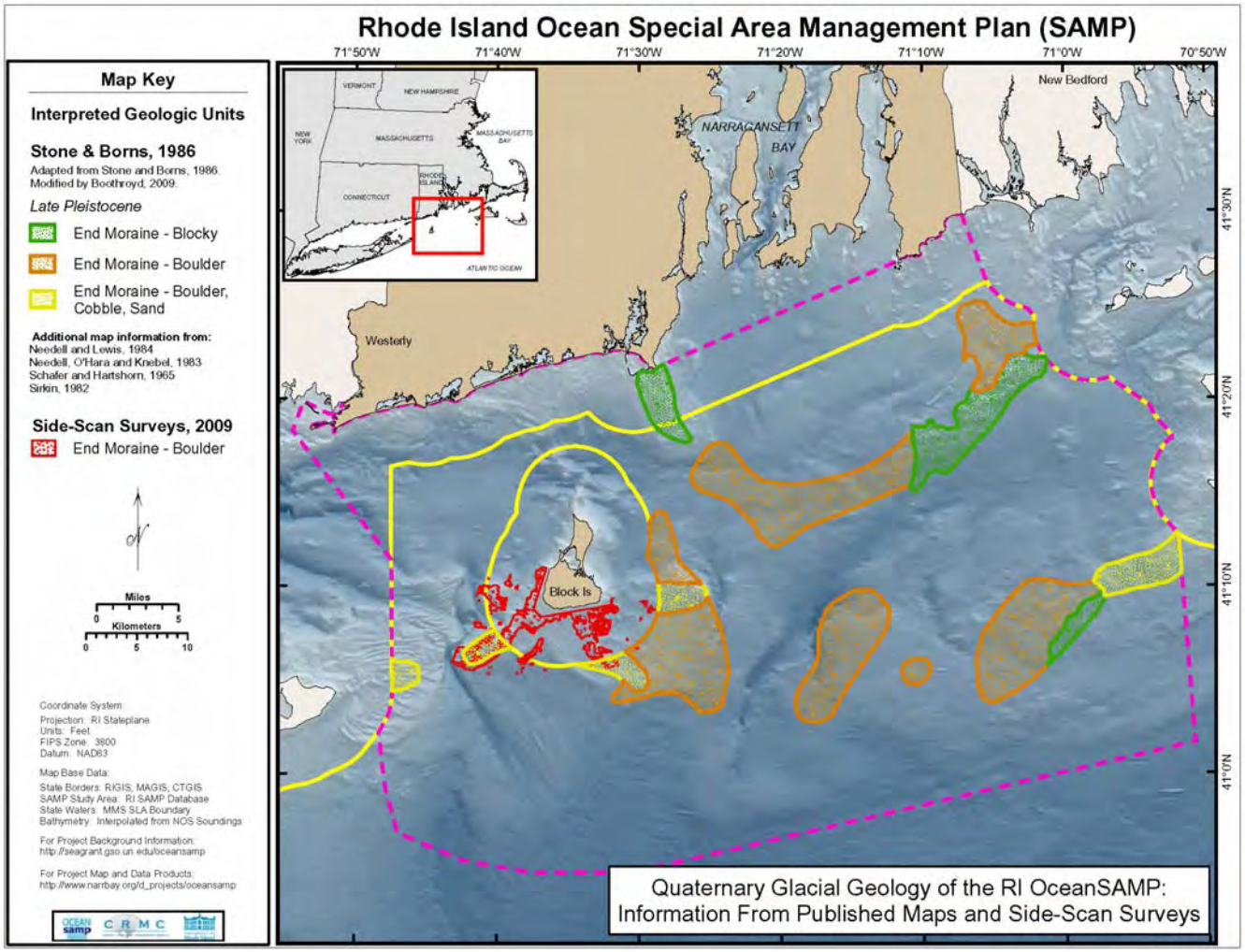


Figure 2.3. Location of glacial moraines in the Ocean SAMP area. The map is a composite of the moraines as defined by several researchers, shown according to compositional materials to emphasize the largest possible extent of the more substantial bottom materials such as boulders. These features help shape physical oceanographic forces such as currents, as well as benthic ecological habitats.

5. The glacially derived bottom topography and composition determines the benthic characteristics that will create the ecological habitats of Rhode Island and Block Island Sounds. Boothroyd (2009) finds that the seafloor bottom in the Ocean SAMP area is characterized by four (4) major depositional environments, presented below in order of increasing grain size:

    a. A shore-parallel feature, called a depositional platform sand sheet, comprised of medium sand containing small ripples. This feature serves an important function as a short-term sand storage area for supplying alongshore transport of sand to the east, or onshore transport to shoreline environments. These features provide habitats that regularly undergo significant change;

    b. Features that are slightly lower than the cobble–gravel surrounding them, called cross-shore swaths, are composed of medium to coarse sand with small dunes. These features serve as a conduit for sand transport during storm events (Griscom 1978; Hequette and Hill 1993), providing habitat that undergoes regular, but less frequent, alteration;

    c. Cobble gravel that is in equilibrium (e.g., no loss or accretion), but often rearranged after and during storm events, called depositional gravel pavement. These features provide habitat that is relatively stable, yet subject to occasional disturbance;

    d. Concentrations of boulders and gravel inherited from the moraine, referred to as glacial outcrops, and which are more or less fixed in place, providing long-term habitats.

    These features, containing sand, coarse sand, cobble–gravel, and boulders, describe the composition of the major benthic environments found in the Ocean SAMP area. These features are characteristic, though not definitive, of the seafloor composition which shows gradation from and between one to another of these features.

6. While the basic overall geology of the Ocean SAMP area can be considered to be static, the actual local, physical, benthic environment found on the bottom is not. Sediments and bottom features are continually subjected to physical forces that alter their characteristics, and their location on the seafloor. Upwelling and downwelling currents, the orbital motion of waves, and unidirectional lateral flows all act upon and alter bottom features. Likewise channels, bottom topographic high points, and other bathometric features will influence as well as create these flows and currents. The flows and currents promote the transport of sand-sized materials and the migration of large bedforms such as dunes, sand ripples and sand waves, across the bottom. The sorting, movement, and placement of seafloor sediments that occurs during these processes creates a patchwork of habitats ranging from fine silts to gravelly areas to boulder fields (Figure 2.4; and see Figures 2.25 and 2.26). The diversity of physical habitats is a powerful influence on benthic ecological make up, determining what species will reside in what habitats in the bottom community; most often, the greater the structural physical diversity of an environment, the greater the biotic diversity of that ecosystem (Eriksson et al. 2006). Since these ecological "shaping" processes are ongoing, the bottom

community of the Ocean SAMP area, particularly those comprised of mud, sand, and/or silt, are in a constant state of flux as habitat patches are altered or destroyed, moved or recreated along the bottom. These benthic communities within the Ocean SAMP area could therefore be expected to be composed of organisms that can withstand, and perhaps even thrive in an ever changing physical benthic environment.

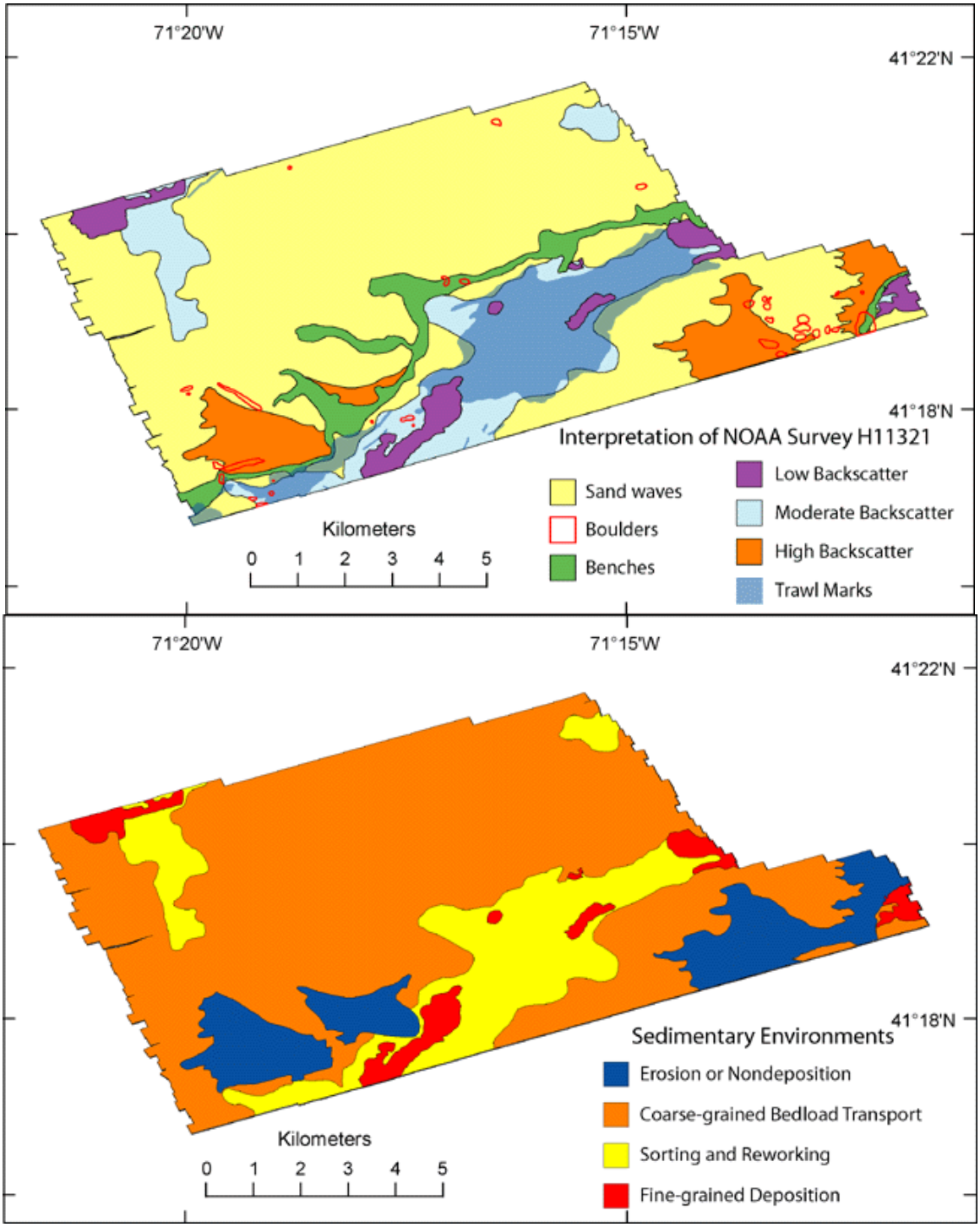


Figure 2.4. Bottom characteristics in a section of Rhode Island Sound as interpreted from sidescan sonar images (McMullen et al. 2008; their Figure 14 (upper) and Figure 10 (lower)). Note the large expanses of sandy area punctuated by scattered boulders in the upper panel. Yellow area in the lower panel shows more stable habitat areas, with orange (sand areas in the upper panel) areas being more transitory.

7. In recent side scan sonar surveys of portions of Rhode Island Sound (Figure 2.4), McMullen et al. (2008) found a mosaic of sedimentary environments that are the result of erosion and sediment transport, deposition and sorting, and reworking, with large areas comprised of transitory coarse-grained materials. Boulders were found scattered throughout the study area, though there were areas where concentrations of boulders existed, and which create areas of increased habitat complexity which would promote higher species diversity. Depositional areas where sediments were sorted and reworked tended to be found along channels and bathymetric high points. A preponderance of commercial fish trawl marks in depositional areas suggests an abundance of commercially important demersal fish species in these habitat/environment types. This in turn suggests a highly productive benthic community which is providing a rich food source. McMullen et al. (2008) found sand waves to be a predominant feature, and infer they are a result of coarse-grained bedload transport as was noted previously in this section. These features highlight the glacial origins of the area, and the stability of various features, for example glacial till, but also the transitory nature of other features, such as sand waves. Both bottom types—transitory and stable—are important characteristics in defining benthic habitat, and the types of organisms that will thrive there.

8. In an earlier survey conducted in Block Island Sound, Savard (1966) described the east–central portion as a smooth plain with an average depth of 34 m, with the rest of the section being dissected by holes, ledges and submerged valleys and ridges. In the area north of Block Island, the Savard (1966) found a northerly running ridge flanked by deep holes, and submerged hills and valleys. The deepest hole in Block Island Sound is an area 100 m deep located 6.4 km south of East Point on Fishers Island. This description notes similar features in Block Island Sound as are seen in Rhode Island Sound, and reinforces the existence of a mosaic of common bottom habitats through the Ocean SAMP area.

Section 220. Meteorology

1. Wind, waves, and storms are important forces shaping marine ecosystems. They influence water column mixing, current patterns and the transport of waterborne particles and planktonic organisms, as well as drive transport and sorting of bottom sediment. Water column mixing is enhanced by the turbulence created by winds and waves, thereby increasing oxygenation, and replenishing nutrients to the water column where they fuel plant production. Storms, although episodic, can create severe wind and wave stress, rapidly and completely breaking down stratification, altering seasonal productivity, and shaping both benthic and pelagic community composition. All these forces and their resulting influence on the area play a role in shaping the overall ecological makeup of the Ocean SAMP area.

2. A unique feature of Block Island Sound is that the impacts of large storm systems may be naturally mitigated, to some degree, by the submerged portion of the glacial moraine that extends from the eastern tip of Long Island to Block Island, and then continues northward toward Point Judith (see Figure 2.3). The moraine acts as a submerged jetty at the mouth of Block Island Sound, dissipating storm wave energy (Driscoll 1996). The degree of storm buffering provided, and its effect on Ocean SAMP area ecological and physical oceanographic functions, is not well understood. Though not cited as a cause-and-effect relationship, Spaulding (2007) reports that wave heights within Block Island Sound are 40–60% smaller than those propagated offshore.

220.1. Wind

1. While winds are a highly variable phenomenon, there are seasonal, and daily, patterns that occur and that influence various physical attributes of the water column and sea surface. By exerting this influence, wind no doubt plays a role in shaping the ecology of the Ocean SAMP area, though specific study of this is lacking.

2. Winds in the Ocean SAMP region contain a seasonal, diurnal (e.g., late morning through late afternoon/early evening), summer sea breeze component blowing from the southwest, with winter winds generally blowing from the northwest, and stronger than during summer (Loder et al. 1998). Winter northwesterlies often generate rough seas in Block Island Sound (Williams 1967), with east and southeast winds producing the biggest waves, up to 7 m reported. Wind velocities during winter months tend to be, on average, twice the speed of summer winds (Figure 2.5; O'Donnell and Houk 2009). Maximum wind speeds also show seasonality, but with a distinct decrease during May and June followed by a sharp increase during July and the early part of August (Figure 2.5). Increased maximal wind speeds during late summer assists in the breakdown of water column stratification. For instance, Shonting and Cook (1970) found wind stress to be an important element in the breakdown of the seasonal thermocline (e.g., stratification due to differences in temperature between surface and bottom water) in Rhode Island Sound.

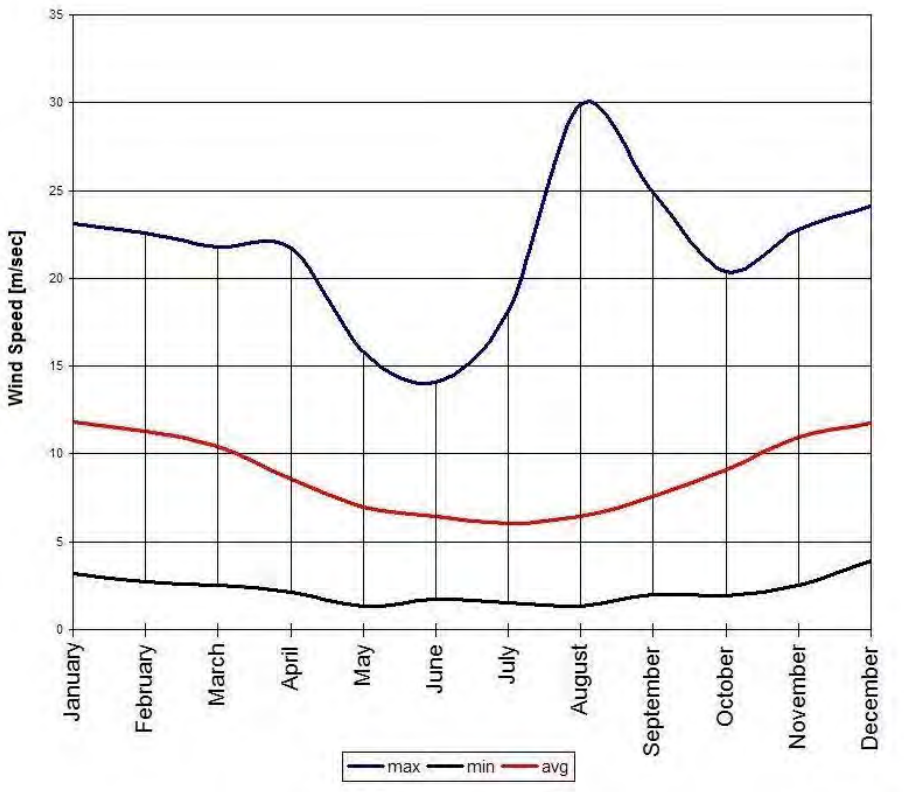


Figure 2.5. Average annual, average maximum, and average minimum wind speeds over the Ocean SAMP area. (Spaulding 2007).

3. Winds have not been shown to play a major role in driving the long-term circulation patterns observed in Rhode Island Sound or Block Island Sound, though on a seasonal and shorter time frame basis wind can be a significant factor. Summer south westerly winds (e.g., sea breeze), while only half as strong as winter winds, drives upwelling along the coast which appears to help drive the flow of Long Island Sound water towards the shelf and offshore (O'Donnell and Houk 2009). Codiga and Ullman (2010) and Ullman and Codiga (2010) have found that during winter months a weak, non-wind driven upwelling pattern is observed in Rhode Island Sound and in the offshore Ocean SAMP area. Westerly summer winds also tend to increase the exchange of water between Block Island Sound and Rhode Island Sound, while winter winds, predominantly from the northwest, promote increased water column mixing rather than increased horizontal exchange (Gay et al. 2004). This mixing may help bring nutrients into the water column for uptake by phytoplankton, perhaps contributing to spring blooms when they occur. Codiga and Aurin (2007) further support the above through direct observations, finding that the volume of water exchanged between Long Island Sound and Block Island Sound was weakest during winter months.

4. Pilson (2008) reports long-term changes occurring in the winds experienced over Narragansett Bay; a nearly 4.0 km per hour (1.11 m sec^{-1}) decrease in annual average wind speed has occurred since 1950, with westerly winds (e.g., blowing to the east) showing this trend more markedly than winds in other directions. Whether these patterns are applicable to the broader Ocean SAMP area is not known, but trends towards decreasing wind speeds,

suggested to be related to climatic warming, may have the potential to impact water column stratification events, upwelling of nutrients, and perhaps the overall ecology of the area as well.

220.2. Storms

1. The Ocean SAMP area is not an area regularly frequented by hurricanes—there has not been a single hurricane strike (to Rhode Island) since 1996, despite the period 2000–2010 being labeled one of the most active hurricane periods on record (NOAA Coastal Services Center n.d.). Figure 2.6 shows the historical record of hurricane activity in the Ocean SAMP area (e.g., those hurricanes where the eye crossed into Rhode Island). The historical record shows 17 hurricanes making landfall in Rhode Island; 7–Category 1, 8–Category 2 and 2–Category 3 rated storms. The most recent Category 3 hurricane was Esther during 1961, and the most recent named hurricane was Bob, a Category 2 hurricane, during 1991. Hurricanes and intense storms systems however, can have significant impact on marine ecosystems. For instance, Smayda (1957) found a 16 to 27-fold increase in phytoplankton standing crop at the mouth of Narragansett Bay following the passage of major hurricanes. Storms, particularly hurricanes because of their intense winds, have the ability to significantly impact marine aquatic ecosystems since the depth to which wave generated orbital motion will be deep, and can impact the bottom (e.g., First 1972), particularly transitory bottom types as described in Section 210. How such a disturbance event might influence the ecology of the Ocean SAMP area is not known, but it could be presumed that benthic habitat would be disturbed, and that some impact, positive or negative, would be imparted.

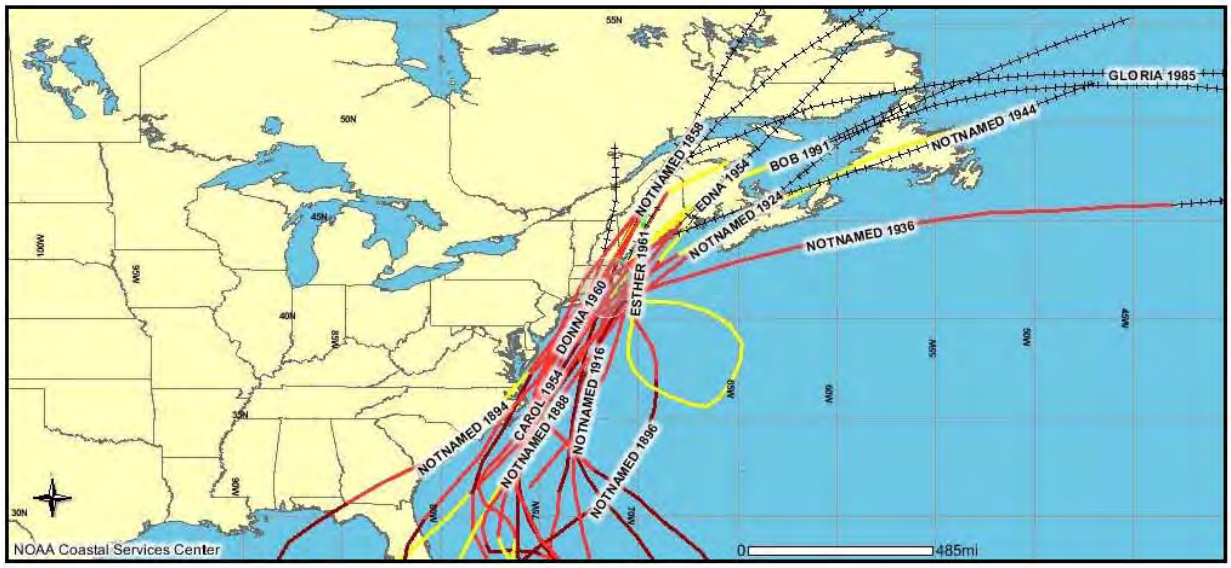


Figure 2.6. Hurricane tracks where the eye moved over Rhode Island, intersecting the Ocean SAMP area (NOAA Coastal Services Center n.d.).

2. While hurricane frequency in the Ocean SAMP area has generally been low, there is strong evidence that the power dissipation index (PDI, a measure of destructive potential) has markedly increased since 1980 (e.g., Emanuel 2005; Webster et al. 2005). This increase

correlates well with variations in tropical Atlantic sea surface temperature (Mann and Emanuel 2006; Holland and Webster 2007), which have been shown by numerous studies and reports to be on the increase, and has been linked to increased warming due to climate change (IPCC 2007). While currently not considered a major ecological driver, the potential impacts of more frequent intense hurricanes on Rhode Island Sound and Block Island Sound ecology, circulation dynamics, and sediment transport, has not been well considered, but could be significant, and would be dependent both on the frequency and intensity of the disturbance events.

3. Southern New England coastal waters experience frequent intensive wintertime storms referred to as Nor'easters that generate strong alongshore currents and cross-shelf pressure gradients that can be felt from Cape Cod to Cape Hatteras (Beardsley et al. 1976). These storms are largely responsible for the episodic events that drive destructive waves and currents, and ultimately sediment transport along the coastlines resulting in beach erosion and sediment re-suspension offshore. While impacts of Nor'easters are well known for Rhode Island shorelines, their impact, if any, on the ecology of the Ocean SAMP area is not. Nearshore benthic habitats would certainly be impacted as sand was moved across depositional environments (see Section 210). Boicourt and Hacker (1976) however, note that winds associated with Nor'Easters can move waterborne particles, similar in size to common zooplankton and larval fishes, 40 to 80 km over the course of the several days that these storms hold together and create strong winds over an area. Such movement could have considerable short-term impacts upon planktonic organisms, particularly settlement patterns and juvenile survival rates for a variety of vertebrate and invertebrate species. While such events, because they occur infrequently, would tend to have short term impact upon the ecology (e.g., poor juvenile survival in a given year class), increasing frequency of such events due to climate change increases the probability that ecological impact could occur.

4. All storms facilitate a "storm surge," which is a wave of water created by strong winds blowing in a given direction for extended periods of time. The size of the storm surge is dependent largely upon the wind speed, though bottom bathymetry, water depth, and duration of high wind speed are all important contributors. For the Ocean SAMP area, probable storm surge over given time frames are: 10 year–2.52 m; 50 year–3.51 m; 100 year–3.58 m; SPH (Simulated Particle Hydrodynamics)–4.85 m (Spaulding 2007). Asher et al. (2009) modeled slightly higher storm surges: 50 year–4.376 m; 100 year–4.446 m. The impact of storm surge on the ecology and/or physical oceanography of the Ocean SAMP area is not well known, though coastline areas would be suspected to receive the greatest impact from such events.

5. It has been noted that major storm tracks have been moving northward as a result of changing climate (Yin 2005). Major storms have the capacity to drive ocean circulation via wind stress, and can have significant impacts on vertical mixing of the water column (Hays et al. 2005), and hence upon water column stratification. If increased frequency and/or increased strength of storms alter circulation patterns in the Ocean SAMP area, plankton and larval fish distribution, and regeneration of nutrients into the water column, could be altered. Such change could alter the ecology of the Rhode Island Sound and Block Island Sound ecosystems, though in what ways and by what mechanisms is not known.

Section 230. Physical Oceanography

1. Rhode Island Sound, located in the eastern section of the Ocean SAMP area (Figure 2.1), encompasses approximately 1,530 km^2 (Shonting and Cook 1970), is bounded to the west by the eastern side of Block Island, to the north by the Rhode Island coast, and to the east by Martha's Vineyard and Nantucket Shoals. Rhode Island Sound is open to the Atlantic Ocean to the south, and has an average depth of 31 m and reaches depths of about 60 m, with a calculated volume of 4.74 x 10^{10} m^3 (surface area x average depth; McMullen et al. 2007; Shonting and Cook 1970). Rhode Island Sound exchanges water with Narragansett Bay through the East and West Passages, with the Sakonnet River, Buzzards Bay, Vineyard Sound and Block Island Sound, and with the Offshore Ocean SAMP area region of the Atlantic Ocean.

2. Block Island Sound, located in the western section of the Ocean SAMP area (Figure 2.1), encompasses approximately 1,350 km^2 (Staker and Bruno 1977), is bounded to the east by the western shore of Block Island, to the north by the Rhode Island coast, and to the west by Long Island, Fishers Island, and Long Island Sound. Block Island Sound is open to the Atlantic Ocean to its south, has an average depth of 40 m, reaching depths of 100 m, and has a calculated volume of 5.4 x 10^{10} m^3 (surface area x average depth; Staker and Bruno 1977). Block Island Sound exchanges water with Long Island Sound through The Race and via a smaller opening between the east end of Fishers Island and Napatree Point, and the Offshore Ocean SAMP area to the south. A shallow sill (part of the moraine; see Figure 2.3) extends from Montauk Point to Block Island at a depth of 15–25 m, and partially isolates Block Island Sound from the Continental Shelf (Edwards et al. 2004). A canyon—Block Channel—extends several tens of kilometers from the deepest point of the sill, forming a deep connection between Block Island Sound and the Offshore Ocean SAMP area region of the Atlantic Ocean (Edwards et al. 2004).

3. The region immediately south of Rhode Island Sound and Block Island Sound, roughly that area south of Block Island to the Continental Shelf Slope (Figure 2.1), is considered here to be the Inner Continental Shelf, and will be referred to as the Offshore Ocean SAMP area throughout this chapter. The Offshore Ocean SAMP area region shows a strong overall current flow to the west (Cowles et al. 2008). Winds over the Offshore Ocean SAMP area are highly variable and seasonal, tending to be light in summer with infrequent strong wind events in both fall and spring; intermediate to strong wind events occur more frequently during winter (Cowles et al. 2008). Waters of the Offshore Ocean SAMP area become strongly stratified on an annual cycle, being generally well mixed throughout the winter and strongly stratified in summer due to a combination of heating, freshwater influence and reduced wind strength (Cowles et al. 2008). The breakdown of stratification on the Offshore Ocean SAMP area results mainly from the impact of wind from the west. Cowles et al. (2008) report a front that separates fresher, nearshore shelf water from salty continental slope water, to be a prominent hydrographic feature located between 70 and 100 m isobaths (see Section 230.4.1 for further details). Cowles et al. (2008) also report that warm core rings, calved from the Gulf Stream, occasionally enter the area and may have significant but short-term impact on circulation over the Offshore Ocean SAMP area region. Another perturbation

in the form of low salinity water from the Long Island Sound system is seen during years of very high river flow (Cowles et al. 2008).

4. The physical oceanographic components of marine systems, such as tides, water temperature and circulation, have broad, and often strong influence over chemical and biological processes. Freshwater input for instance, mainly from Long Island Sound in this case, sets up and strongly influences water circulation in Block Island Sound. Rhode Island Sound is influenced by the circulation patterns of Block Island Sound, and by water moving in across the Offshore Ocean SAMP area and from the east across Nantucket Shoals. The mixing and mingling of these different masses of water, particularly with regard to vertical mixing which is a critical parameter for nutrient recycling and the breakdown of water column stratification, creates a dynamic environment over both space and time.

5. Beardsley et al. (1985) referred to the general area encompassed by the Ocean SAMP as a "mixing basin" because of the diversity of water types and species that were observed. At the scale of the North Atlantic Ocean, the Gulf Stream moves warm water northward, with a return flow of cold water moving southward from the Gulf of Maine. Warm water from the Gulf Stream interacts with the water on the Offshore Ocean SAMP area (Beardsley et al. 1985), and provides opportunities for southern species to access the Ocean SAMP area. Figure 2.7 depicts the large scale general flow of water in the Ocean SAMP region. A large, meandering lobe of warm water can be seen extending northward towards the Ocean SAMP area. Sometimes these lobes break free and are referred to as "warm core rings," that bring distinctive pockets of tropical water, including the biota entrained in it, onto the Continental Shelf where interaction with the Ocean SAMP area is possible. There are also distinct current flows that move from north to south, originating in the Gulf of Maine, moving around Cape Cod and then into and influencing the Offshore Ocean SAMP area region (Figure 2.7; Loder et al. 1998). In this fashion the Ocean SAMP area has contact with the larger Northeast US Large Marine Ecosystem, the cold northern water and the species that travel with it, as well as warm southern waters and the biota it carries. It should be noted however, that in the Ocean SAMP area there is a general flow to the southwest, exiting the Ocean SAMP area, and a commensurate inflow into the area from the northeast. Because of this, the Ocean SAMP area has a higher probability of coldwater species from the north entering the area. This also accentuates this importance of unusual events, such as storms from the south or Gulf Stream warm core rings, fostering the entry of more southerly species.

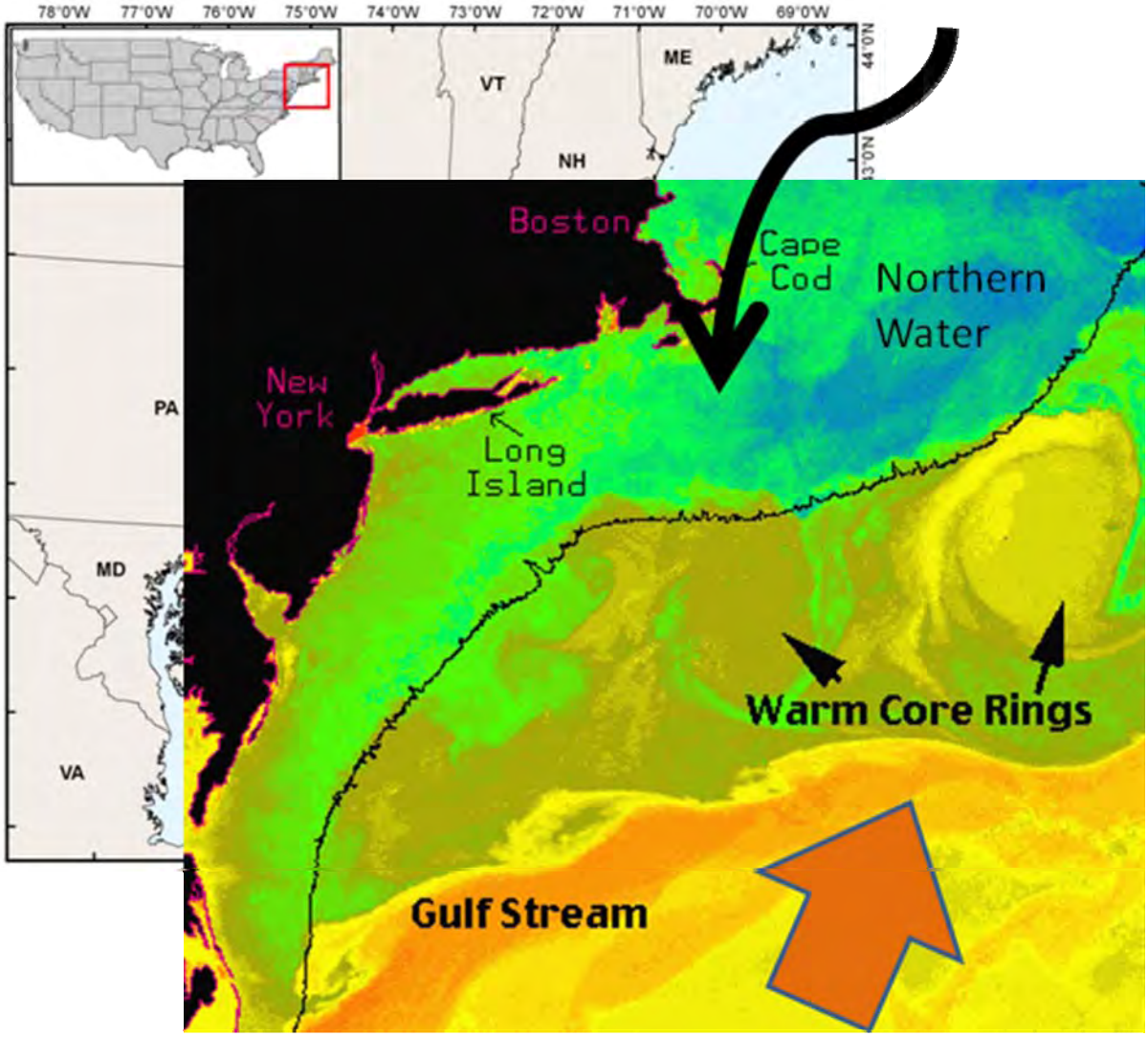


Figure 2.7. Schematic representation of northern cold water currents, southern warm water currents, and Gulf Stream warm core rings entering the Ocean SAMP area, making it a very dynamic ecosystem. Warm core rings graphic from: Coastal Carolina University n.d.

6. While there have been studies of the physical oceanographic characteristics of the Ocean SAMP area, many of them are geographically limited in their scope and do not portray a picture of how the area functions as a connected, dynamic system. A practical way to proceed at a systems-level scale is through modeling. The physical oceanography of the Ocean SAMP area however is complicated due to complex topography, which makes modeling attempts more challenging. Furthermore, a major challenge will be linking biological/ecological functions to physio-chemical processes to gain an ecosystem-based view of the region as a functional whole. Dr. Changshen Chen and collaborators have developed the U.S. Northeast Coastal Ocean Forecast System (NECOFS), which contains detailed geometry for Rhode Island Sound and Block Island Sound. Future application of this model to the Ocean SAMP area would assist in better understanding circulation dynamics,

and the ecology because biological components can be incorporated into the model to develop an ecosystem-level understanding. Many detailed aspects of physical oceanography in the Ocean SAMP area based on Finite Volume Coastal Ocean Model (FVCOM) hydrodynamic simulations, which underlie NECOFS, have been described by Codiga and Ullman (2010).

230.1. Waves

1. Wave analysis performed by Spaulding (2007) found that nearly 53% of the waves in the Ocean SAMP area come from three dominant directions: 22% from the south, 19% from the south southwest, and 12% from the south southeast, with average annual wave heights for each direction: 1.09 m (SSE), 1.15 m (S) and 1.29 m (SSW). Asher et al. (2009) are in agreement that the greatest frequency of waves, regardless of size, come from a southerly direction, with a mean wave height of 1.2 m and an extreme height of 8.4 m. Spaulding (2007) estimated probable wave height extremes for 10 year: 6.5–7.0 m; 25 year: 7.5–7.75 m; 50 year: 8.2–8.35 m; 100 year: 8.8–9.0 m frequencies. Asher et al. (2009) also estimated 9.0 m extreme wave height at a 100 year frequency, but noted that the probability of such a wave was not applicable to all Ocean SAMP areas. They found that geography influenced wave height, with waves from the south and the southeast having the greatest potential for larger size, with 10+ m extreme waves possible. Ullman and Codiga (2010) found average wave heights to range from 0.5 m to 2.5 m, with waves of less than 0.5 m occurring for less than a day during winter and up to several days during summer. Asher et al. (2009) found that the moraine stretching between Block Island and Montauk provided a wave damping action, with a net result that extreme wave heights would be 2–3 m less to the west of Block Island (versus to the south or southeast). This may be important ecologically as it tends to create an environment less influenced by disturbance events.

2. Average wave heights in the Ocean SAMP area tend to be 1–3 m, and overall, would be expected to have little impact on bottom waters, though surface waters would tend to stay well mixed. Larger waves, generated by winds associated with storms, will have a greater potential to impact the water column, particularly water column stratification. Ullman and Codiga (2010) found waves larger than 2.5 m in height to be associated with strong wind events, generally lasting 3 to 8 days, and being slightly more common during winter. First (1972) found that statistically modeled wave induced bottom velocity should be strong enough, given 97 km hr^{-1} (60 mph) winds, to impact bottom sediments at a depth of about 60 m (e.g., Cox Ledge). From their modeling efforts, First (1972) further determined that wave induced bottom impact in water depths of 60 m should occur 1.5–4.9% of the time between September and November. This suggests that high intensity winds have the potential to mobilize sediment at the surface of the seafloor throughout much of the Ocean SAMP area, reworking sediments and sorting them as described previously (see Section 210). The impact of wave disturbance on the benthic environment of the Ocean SAMP area is not well known.

230.2. Tides and Tidal Processes

1. Tides are a constant physical attribute of marine ecosystems in the New England area. Their impact along the shoreline in shaping intertidal ecology is apparent, though in deeper, offshore waters the influence of the tides may be less obvious. Tides are of major importance

in that they set up currents that alternate in direction every flood and ebb tide, moving water and waterborne constituents from place to place. Due to its geomorphology, tides in the Ocean SAMP area are major forces that shape circulation in the region, and tidal interaction with Long Island Sound is a defining feature of tidal circulation dynamics.

2. The Ocean SAMP area experiences a dominantly semi-diurnal tide (e.g., nearly twice daily) with a mean tidal range of about 1.0 m (Shonting and Cook 1970). The most extreme tide measured at the Newport gauge station was 2.96 m high on 19 August 1991 with the passage of Hurricane Bob, though this was due to storm surge plus the high tide, not just tidal influence (NOAA Tides and Currents n.d.). The diurnal tides move water from the Offshore Ocean SAMP area towards the sounds and then in an opposite direction on the following change of tide. The intensity of tidal interchange is much stronger in Block Island Sound than in Rhode Island Sound due to stronger tidal velocities, though how this influences ecological differences between the two sounds, if any, is not known. The tides also interact with connected bodies of water such as Nantucket Shoals, Buzzards Bay, Narragansett Bay and Long Island Sound, moving water throughout the various ecosystems.

3. Long Island Sound, because of the large volume of freshwater it receives, and the narrowness of the connection to Block Island Sound (e.g., The Race), is a significant influence upon the physical oceanographic and chemical characteristics of Block Island Sound. Current velocities in The Race, which are tidally driven, are strong (e.g., > 5 knots; Figure 2.8), and water moving out of Long Island Sound moves a considerable distance into Block Island Sound, and even into Rhode Island Sound. Freshwater, nutrients, pollutants and biota are mixed, mingled and exchanged between these water masses during each tidal cycle, particularly in the Block Island Sound ecosystem. The intense current flow at The Race, and at Montauk Point, create ideal feeding conditions for predatory fishes and these spots are noted regionally as prime fish concentration areas.

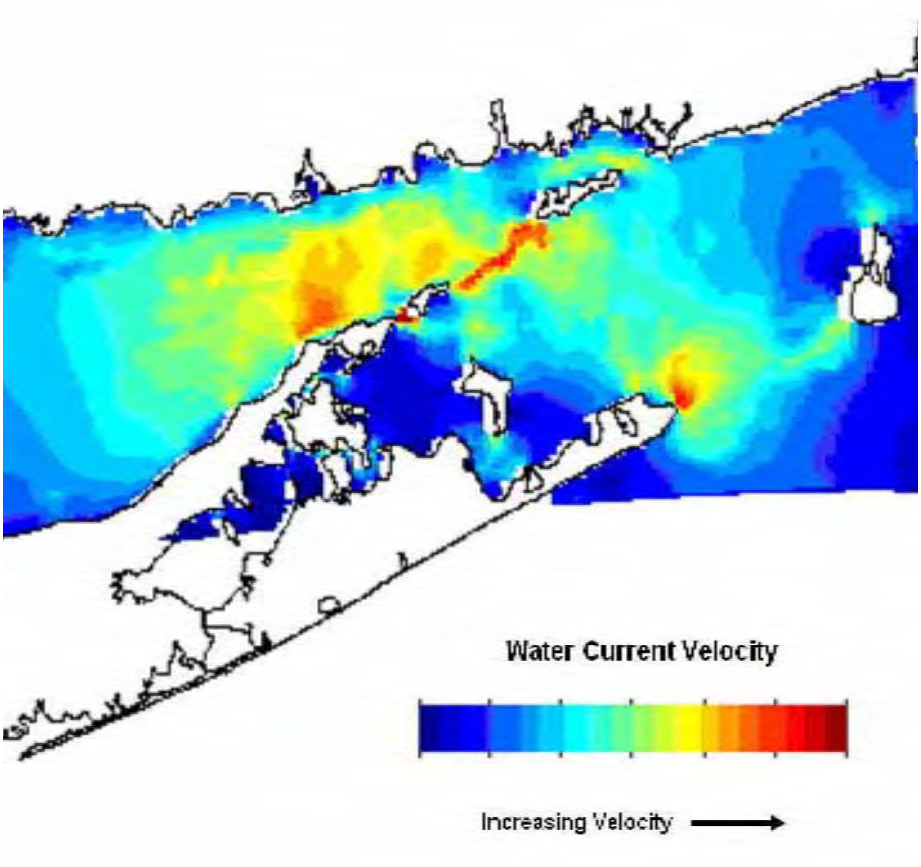


Figure 2.8. Water current velocities in Block Island Sound, particularly at The Race, showing the intense current speed in that area..

4. Riley (1952) described the tides in Block Island Sound as a progressive wave, with low water occurring 1½ hours earlier at Block Island than at The Race (the entrance to Long Island Sound). Riley found the topography of Block Island Sound to be a major force on tidal flows due to the variety of slopes and troughs found as bottom features. Such features create drag and turbulence, as well as upwelling and perhaps even downwelling currents, all of which influence sediment transport and sorting, and the overall ecological character of the benthos and water column.

5. Shonting and Cook (1970) found that tidal currents in Rhode Island Sound tended to have a northwest to southeast flow, but that this was quite variable due to the influence of wind stress and turbulent flow around shoals and islands (e.g., complex bottom topography). The major tidal flow in the Ocean SAMP area is via bottom water moving through Block Island Sound from offshore and into Long Island Sound via The Race (Edwards et al. 2004), and out again on the opposing tide.

6. Tidal flow from Long Island Sound interacts considerably less with Rhode Island Sound than it does with Block Island Sound. On the ebb flow from Long Island Sound, water runs east to the north of Block Island and interacts with the western edge of Rhode Island Sound. The majority of the ebb flow however moves out and around Montauk Point, creating high current velocities (Figure 2.8), and then to the southwest parallel to the coast of Long Island

and into the Mid-Atlantic Bight region (Edwards et al. 2004). Various studies (Koppelman et al. 1976; Kenefik 1985; Codiga and Rear 2004) suggest that more than 50% of the tidal transport entering Block Island Sound from Long Island Sound exits to the south between Montauk Point and Block Island. In all cases, the flow from Long Island Sound tends to be lower salinity water than that originating in the sounds, which has implications for mixing, stratification, circulation, and the ecology.

230.3. Hydrography

230.3.1. Temperature

1. Water temperature is a key criterion in determining the distribution of organisms, most all of which are limited to some degree geographically by physiological thermal tolerance that sets northern and southern (and often depth) limits to their range. Temperature is also an important factor that defines the density of water, which sets up circulation patterns at both vertical and horizontal scales, and plays an important role in water column stratification. In the Ocean SAMP area, temperature is highly seasonal, and therefore ecological change is highly seasonal as well. As a major element in defining the "comfort zone" of many marine organisms, temperature is a critical ecological variable.

2. Codiga and Ullman (2010) found during summer months that the warmest waters (11–21°C), at both surface and bottom of the Ocean SAMP area tended to reside in central Rhode Island Sound, and that Block Island Sound and the eastern portions of Rhode Island Sound were typically 1–2°C cooler. This is largely because stronger vertical mixing in Block Island Sound tends, as a result of its interaction with Long Island Sound, to keep the water column better mixed and temperatures therefore slightly cooler. It is unclear if this difference in summer temperatures plays any ecological role.

3. During winter, warmest waters occur offshore in the area around Cox Ledge, with lowest temperatures found along the periphery of the sounds abutting the landmass of the coast (Codiga and Ullman 2010). During summer, the warmest waters are seen in northern and central Rhode Island Sound, while Block Island Sound, the area around Block Island and the eastern portion of Rhode Island Sound are cooler, because of the influence of Long Island Sound (Codiga and Ullman 2010). A distinct thermal front (where two water masses that differ in their physical and/or chemical attributes collide) is noted south of Block Island at the periphery of cooler waters, and this front is coincident with a salinity front derived from the input of lower salinity water from Long Island Sound (see Section 230.4.1). During autumn, central Rhode Island Sound remains slightly warmer than adjacent waters.

4. Temperature data (Taylor et al. 2009) have been collected by the Northeast Fisheries Center as part of its Marine Resources Monitoring, Assessment and Prediction Program (MARMAP) conducted within the Northeast Continental Shelf ecosystem, with data collected at a suite of stations located within Ocean SAMP boundaries. Figure 2.9 shows the seasonality of water temperature, at both surface and bottom, showing a clear

difference in temperature (6–7°C) between surface and bottom from early spring through late fall, confirming that this is the time most probable for the water column to stratify.

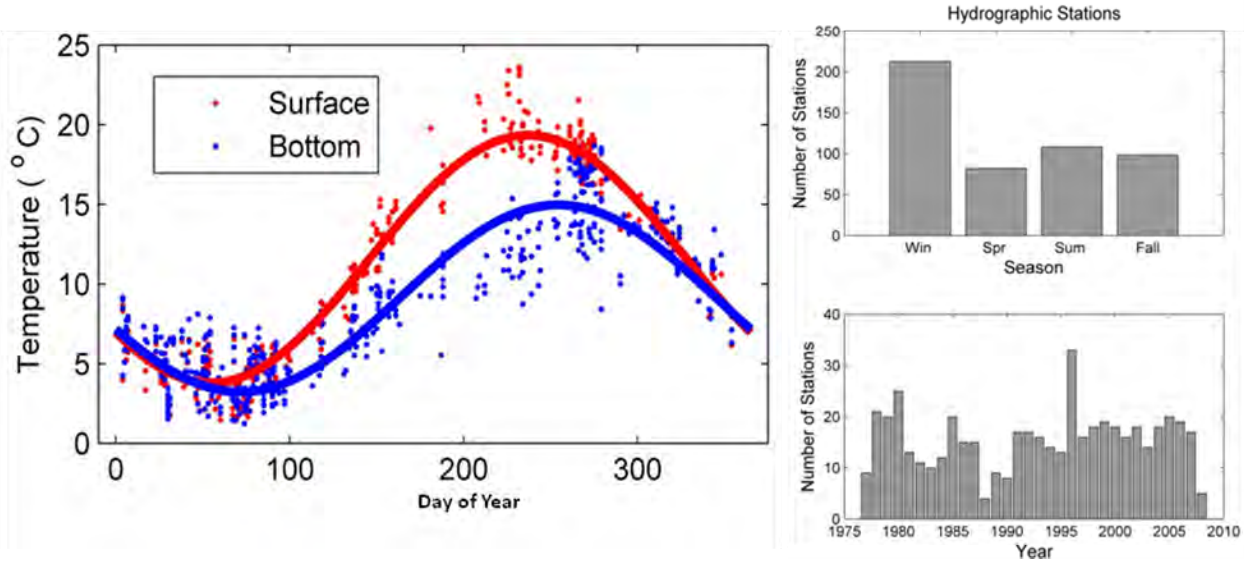


Figure 2.9. MARMAP water temperature data for all stations located within the Ocean SAMP area, and for all years of sampling (Taylor et al. 2009). Seasonality of collected data, as well as level of sampling effort over time, is shown in the stacked graphs to the right.

5. Figure 2.10 shows water temperatures within the Ocean SAMP area on a seasonal basis, and at various depths. It is important to note that during winter, bottom waters are considerably warmer than at surface or at mid-depth. Fish will often spend winter months near bottom where this thermal refuge exists (Sanders 1952; see Section 250.3). During summer months, bottom waters are cooler than at surface or at mid-depth, and fish will congregate near bottom as a refuge from warm surface waters that may be near the upper limit of their thermal tolerance. Strong storms that mix the water column could influence the occurrence of thermal refuges, though this has not been documented.

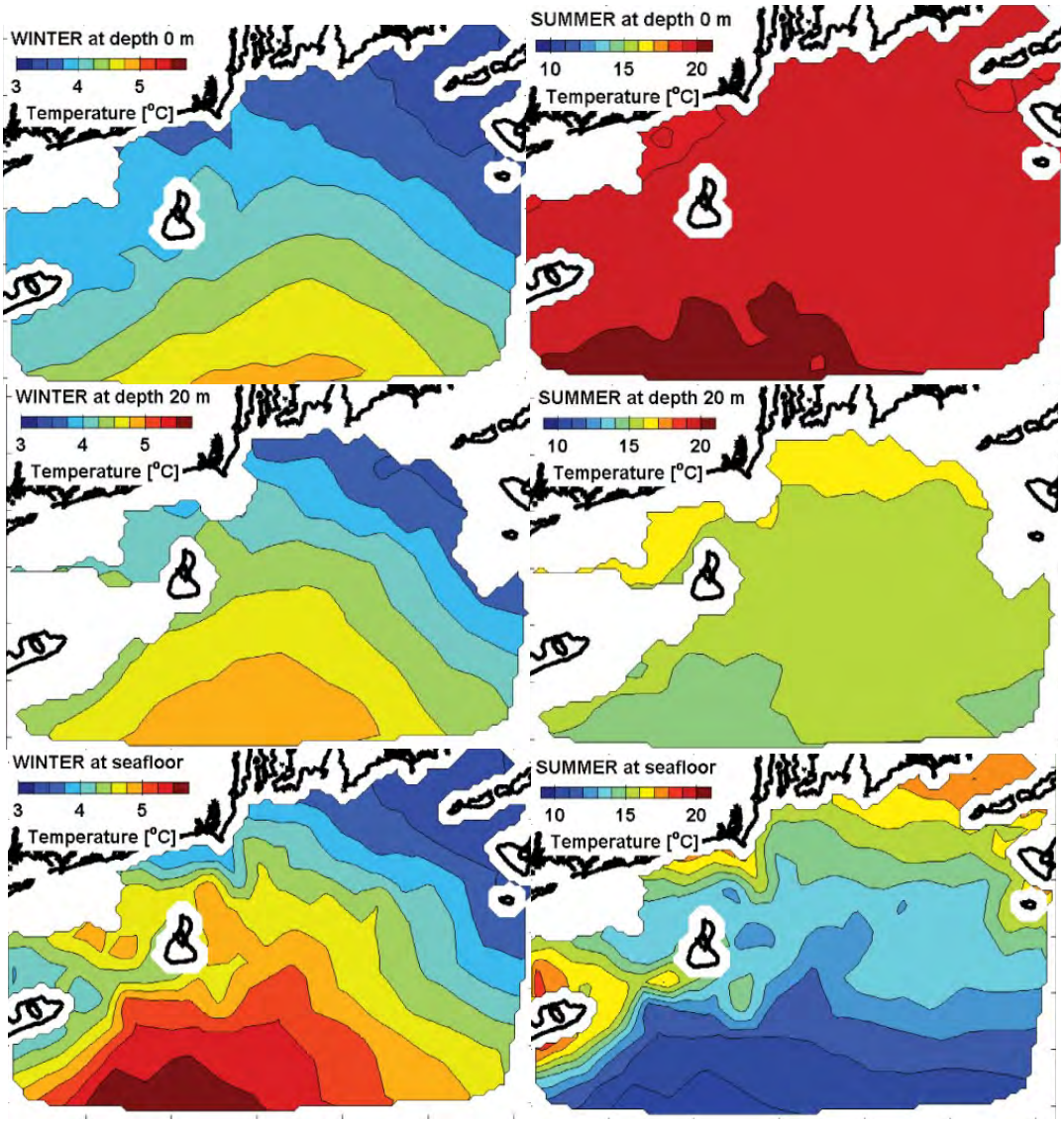


Figure 2.10. Seasonal water temperatures at sea surface, 20 m depth, and seafloor in the Ocean SAMP area, based on archived CTD data collected between 1980 and 2007 (from Codiga and Ullman 2010).

6. O'Donnell and Houk (2009) and Kaputa and Olsen (2000) note a strong seasonal signal in temperature at both surface and bottom at a station located northwest of Block Island, and about ¾ of the distance to The Race. Figure 2.11 shows the seasonal peak in water temperature consistently occurs in later summer/early fall (Aug/Sep), with the seasonal low occurring in late winter/early spring (Feb/Mar). During those years where surface and bottom temperatures are nearly identical (e.g., 1996), the water column is most likely well mixed. Conversely, in those years where surface and bottom temperatures are considerably divergent (e.g., 1998), the water column appears not to be well mixed and water column stratification is likely.

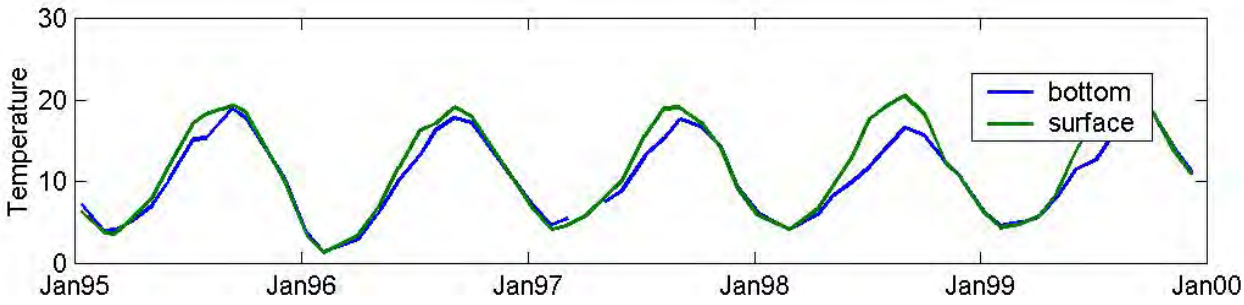


Figure 2.11. Average annual surface and bottom temperatures at a station in Block Island Sound (CTDEP No. N3; between NW of BI, ¾ of the way to The Race; from O'Donnell and Houk 2009).

230.3.2. Salinity

1. The seasonal input of freshwater is important to the ecology of the Ocean SAMP area—it brings an influx of terrestrial-based nutrients to fuel plant growth. The freshwater influx also promotes exchange with offshore bottom waters by fostering a return flow that offsets surface water outflow to offshore areas. It also brings the potential to promote water column stratification, particularly later in the season when overall wind speeds over the area decrease, and water temperatures increase. All of these factors shape the ecological composition of the Ocean SAMP area.

2. Long Island Sound estuarine circulation, driven primarily by the freshwater input of the Connecticut and Thames Rivers, is the major freshwater influence on Block Island Sound and the overall Ocean SAMP area (see Section 230.4). No large rivers or streams flow directly into Block Island Sound because of the terrestrial-based Charlestown Moraine which diverts all surface water flow either to the east to Narragansett Bay, or more generally to the west and into the Pawcatuck River system (Savard 1966).

3. Narragansett Bay is not considered to be a major source of fresh water to the Rhode Island Sound ecosystem, and does not appear to be a significant factor in circulation dynamics (Codiga and Ullman 2010). Shonting and Cook (1970) suggest that freshwater from Narragansett Bay influences Rhode Island Sound, but with a 2 to 3 month lag time; they found the mean salinity of Rhode Island Sound to be inversely related to freshwater runoff into Narragansett Bay. Further study is needed to verify or deny these suggested interactions.

4. Codiga and Ullman (2010) show salinity, which is strongly influenced by freshwater input, in the Ocean SAMP area by season, and at various depths (Figure 2.12). During winter, salinity is higher at bottom than at surface, with higher salinity water occurring with distance moved offshore (Figure 2.12). Salinity decreases during spring, particularly at surface and mid-depth as would be expected due to spring rains and snowmelt runoff into river systems. Summer salinities are very similar to those seen during spring throughout the water column. Fall sees a shift towards increased salinity, particularly at surface and mid-depth, as would be expected during dry late summer and early fall months. Spring and summer see the strongest salinity

differences at horizontal and vertical scales, which corresponds to the occurrence of the seasonal "front" to the south of Block Island (see Section 230.4.1).

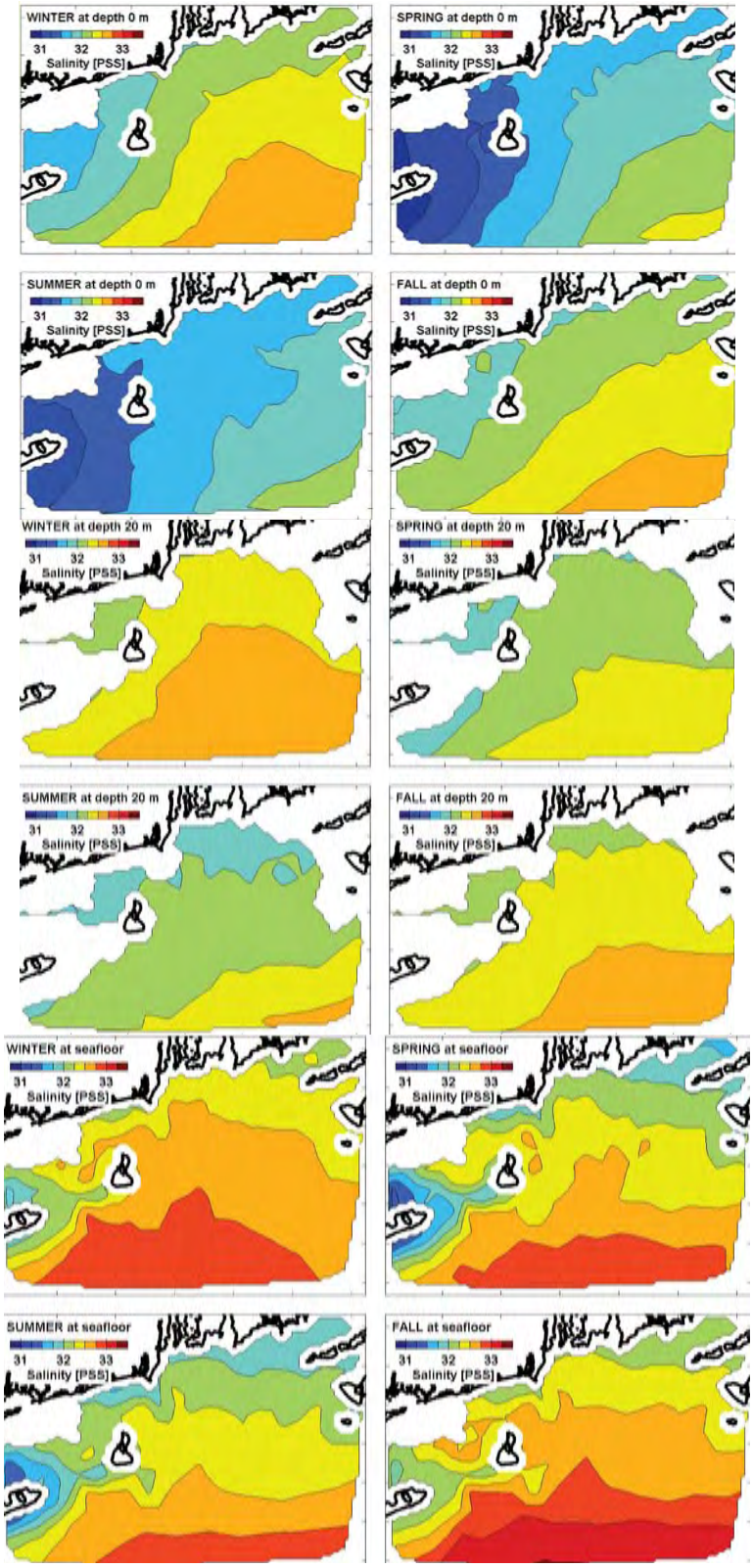


Figure 2.12. Seasonal water salinities at various depths in the Ocean SAMP area based on archived CTD data collected between 1980 and 2007 (from Codiga and Ullman 2010).

5. The Atlantic Multidecadal Oscillation (AMO) is a 65–80 year oscillation in sea surface temperatures in the North Atlantic. There has been a distinct warming trend since 1990, and Enfield et al. (2001) suggest that the AMO is entering a warm phase during which less than normal rainfall is seen. How such a trend may impact freshwater input to Long Island Sound, and hence buoyancy driven circulation between Block Island Sound and the Offshore Ocean SAMP area, is not known. For instance, Merriman and Sclar (1952) found that dominant year classes of butterfish, weakfish and cunner were produced in June and July of 1944, and that the reproductive success of all three species was correlated to high salinity water in Block Island Sound, which was the result of lower than normal freshwater input to Long Island Sound. Further research is needed to better describe the role of freshwater input and seasonal salinity patterns on the ecology of the Ocean SAMP area, and possible impacts to the ecology from changing precipitation patterns as a result of climate change. See Chapter 3, Global Climate Change, for further discussion of changing precipitation patterns in the Ocean SAMP area.

230.3.3. Stratification

1. While winds, tides, and circulation all promote the transport and mixing of water and the constituents contained in it, water column stratification—because of differing water density regimes at surface and at depth—plays an opposing role by setting up the physical conditions that can limit or preclude vertical mixing. A stratified water column is vertically stable, and promotes an accumulation of phytoplankton, which can then grow to bloom proportions (Mann and Lazier 2006). Decomposition of plant matter in the bloom consumes oxygen, and since stratification prevents vertical mixing, hypoxic or anoxic conditions can ensue, to the detriment of marine life. Water column stratification—sometimes strong stratification—sets up in both Rhode Island Sound and Block Island Sound, and over the Offshore Ocean SAMP area as well; stratification appears to be highly seasonal. It has been suggested that Block Island Sound, due to its more vigorous circulation and mixing regimes, is less prone to stratification than Rhode Island Sound. However, observations suggest that strong stratification can occur in either sound (Codiga and Ullman 2010). The onset of stronger winds during the fall tends to break down stratification of the water column in all areas. Further work is needed on this topic to clarify the onset and persistence of stratification events, and to then begin exploration of impacts, if any, to the ecology of these ecosystems. There are however, no reports of water column anoxia or hypoxia for Ocean SAMP waters.

2. Beardsley et al. (1985) report that the outer shelf and continental slope waters are stratified on a seasonal basis—strong (e.g., stable and resistant to breakdown) stratification sets up during summer months, but breaks down in the fall, with the water column remaining well mixed throughout the winter. They found mixing of the water column to 200 m below surface. Codiga and Ullman (2010) also find strong stratification of the water column during the spring and summer, with stratification either weak (e.g., unstable and easily dispersed) or absent during fall and winter, in both Rhode Island and Block Island Sounds. Based on this, it can be noted that stratification appears to be a common, seasonal phenomenon throughout the Ocean SAMP area.

3. Shonting and Cook (1970) found a distinct thermocline in Rhode Island Sound during a survey in July of 1963; surface temperatures were 20°C and bottom temperatures less than 10°C; this is a significant difference and suggests strong stratification of the water column. Shonting and Cook (1970) found the thermocline to be most pronounced on the southern side of Rhode Island Sound, and much less pronounced near shore to the north. They further suggest this might be a function of the tidal currents in areas near the mouth of Narragansett Bay which would mix the water column. The thermocline was virtually eliminated by decreasing temperatures and increasing winds during the fall. Codiga and Ullman (2010) found stratification in the western region of Rhode Island Sound during spring months, and again during most of the summer months as well. Water column sampling at four stations in Rhode Island Sound (December 2002, between Block Island and Brenton Reef) found weak stratification with a fairly homogenous water column with regard to temperature, salinity and dissolved oxygen (U.S. Army Corps 2002). Dissolved oxygen concentrations in both surface and bottom waters however, remained well above the criteria established for highest quality marine waters, suggesting that hypoxia/anoxia may not be a condition typically associated with stratification in the Ocean SAMP area.

4. Freshwater input from Long Island Sound sets up water column stratification just south of Block Island. The area of stratified water expands northward during times of high river discharge, but is seasonal in its nature and breaks down during summer months and/or times of reduced precipitation/river flow. Williams (1969) found the water column to be well-mixed during the winter, with temperatures 1–3°C. During summer months, a strong thermocline developed, with surface water at 20°C and bottom water as low as 10°C. O'Donnell and Houk (2009) note a seasonal cycle to salinity in Block Island Sound, but with greater variability than that observed for water temperature. Figure 2.13 shows seasonal averages for surface and bottom salinity in northwestern Block Island Sound. Times where surface and bottom water salinity are near equal suggest intense mixing events, perhaps from storms, that breakdown and eliminate water column stratification. Wide differences between surface and bottom water salinity, particularly in those times where surface water salinity decreases rapidly, suggest influxes of freshwater from Long Island Sound, with intensified water column stratification a high probability (Figure 2.14). Codiga and Ullman (2010) found winter stratification to be stronger in Block Island Sound than in Rhode Island Sound, largely due to the freshwater influence of Long Island Sound outflow. They also found stratification to be enhanced in eastern Block Island Sound during spring months, again because of the influence of Long Island Sound outflow. In general terms, Codiga and Ullman (2010) found stratification to be consistently the strongest in the western Ocean SAMP area, particularly south of Block Island.

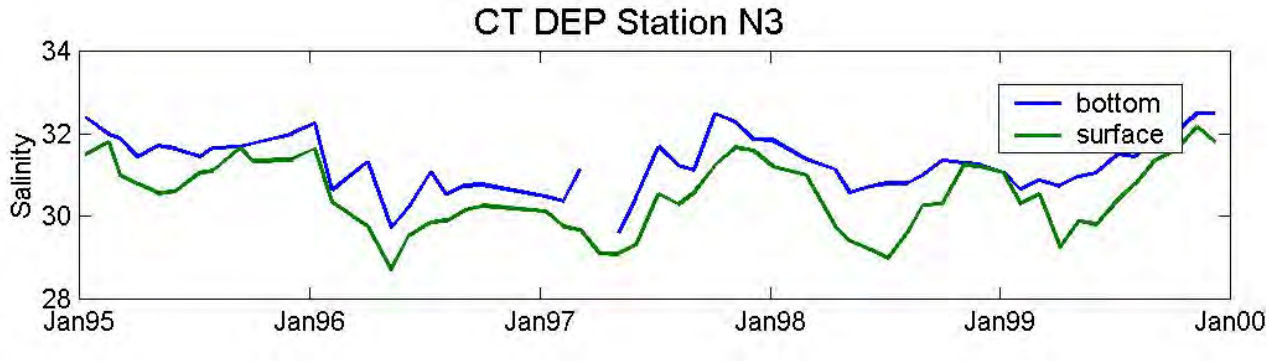


Figure 2.13. Average annual surface and bottom salinity at a station in Block Island Sound (CTDEP No. N3; between NW of BI, ¾ of the way to The Race; from O'Donnell and Houk 2009). Periods where surface and bottom salinities are nearly equal suggest mixing events, while rapid declines in salinity of surface waters suggests increased freshwater input associated with increased runoff in rivers feeding Long Island Sound.

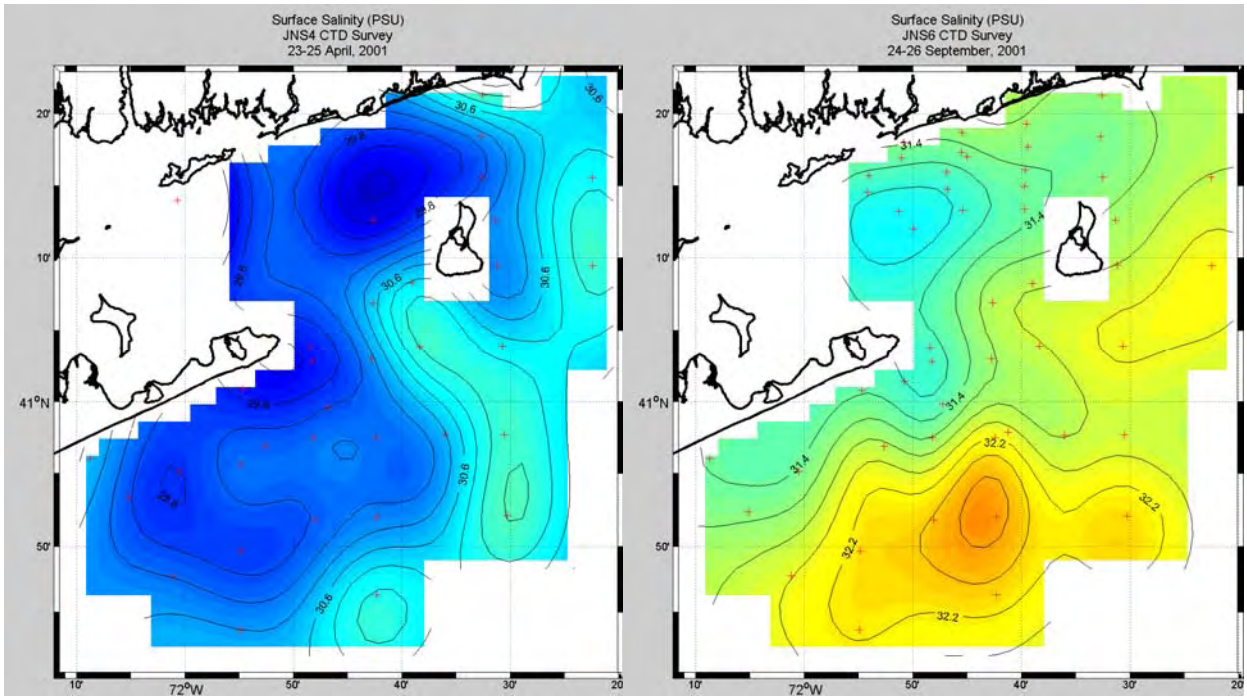


Figure 2.14. Surface water salinity during times of high freshwater discharge (left panel) and low discharge (right panel; from O'Donnell and Houk 2009).

5. During times of low freshwater discharge into Long Island Sound, Ullman and Codiga (2010) have observed intrusion of high salinity water at about 30 m depth in the water column, finding the characteristics of this water to be consistent with those reported by Linder and Gawarkiewicz (1998) for water found on the inside of the Continental Shelf, about 100 km offshore. The impact of mid-depth, high salinity intrusion events on the

ecology of the area has not been studied, but suggests that a strong connection between waters of the offshore Ocean SAMP area and Block Island Sound may result during times of low flow from Long Island Sound.

230.4. Circulation

1. Circulation is a major force shaping the ecology of the Ocean SAMP area, being responsible for the distribution of much of the flora and fauna found in Rhode Island Sound and Block Island Sound. Planktonic organisms and planktonic life-cycle phases (e.g., fish eggs and larval crustaceans) are at the mercy of circulation patterns for dispersal and to take them to suitable settlement sites. Circulation determines areas of food concentration, which in turn largely determines where predators will congregate to feed.

2. Circulation patterns in Rhode Island and Block Island Sound are influenced by temperature and salinity differences in the water column, tidal ebb and flood, and wind shear. Buoyancy driven circulation—circulation that occurs based on the relationship between water temperature and salinity, which together define the density of water, and the differences in water density both vertically and laterally—makes an important contribution to the mean circulation on seasonal and longer timescales (Codiga and Ullman 2010). Tidal ebb and flood is considered to play an important role in creating turbulence and in mixing the water column, while wind-driven currents play a significant role on timescales of a day to several days, particularly during winter in association with storms, but also in summer due to the diurnal sea breeze. For instance, westerly winds during summer increase the exchange of water between Block Island Sound and Rhode Island Sound in the area between Block Island and the Rhode Island coastline. Winter winds on the other hand, which are predominantly from the northwest and stronger than summer winds, promote water column mixing rather than increased water exchange (Gay et al. 2004). This is further supported by the direct observations of Codiga and Aurin (2007) who found the volume exchange of water between Long Island Sound and Block Island Sound to be weakest during winter months.

3. Observed tidal circulation patterns vary considerably between Rhode Island Sound and Block Island Sound. Rhode Island Sound appears to behave as an appendage of the Offshore Ocean SAMP area region, while Block Island Sound behaves, to a large degree, more as an arm of Long Island Sound. Because of significant dynamic interaction with Long Island Sound, it is generally considered that Block Island Sound has a more intensive mixing and circulation regime than Rhode Island Sound (Codiga and Ullman 2010). Codiga and Aurin (2007), through direct observations, found that exchange flow between Long Island Sound and Block Island Sound is strongest during summer months. Figure 2.15 (Mau et al. 2007; He and Wilkin 2006) shows graphical results of two separate circulation studies, one in Block Island Sound and the other in Rhode Island Sound. The panels are joined to provide a view of the general current patterns of the Ocean SAMP area, though scales differ and actual velocities are not directly comparable; they do however show the relative vigor of the circulation in both systems. Current velocity is seen to be vigorous throughout most of Block Island Sound, particularly in the west where influence of The Race is strong, while the majority of the area of Rhode Island Sound is under the influence of relatively mild current speeds, except to the east where it interacts with Vineyard Sound and Nantucket Shoals. Impacts of this major difference between the sounds regarding their ecology are not known. While significant

differences exist between Rhode Island Sound and Block Island Sound, these water bodies are connected and do interact with each other, and with the Offshore Ocean SAMP area region.

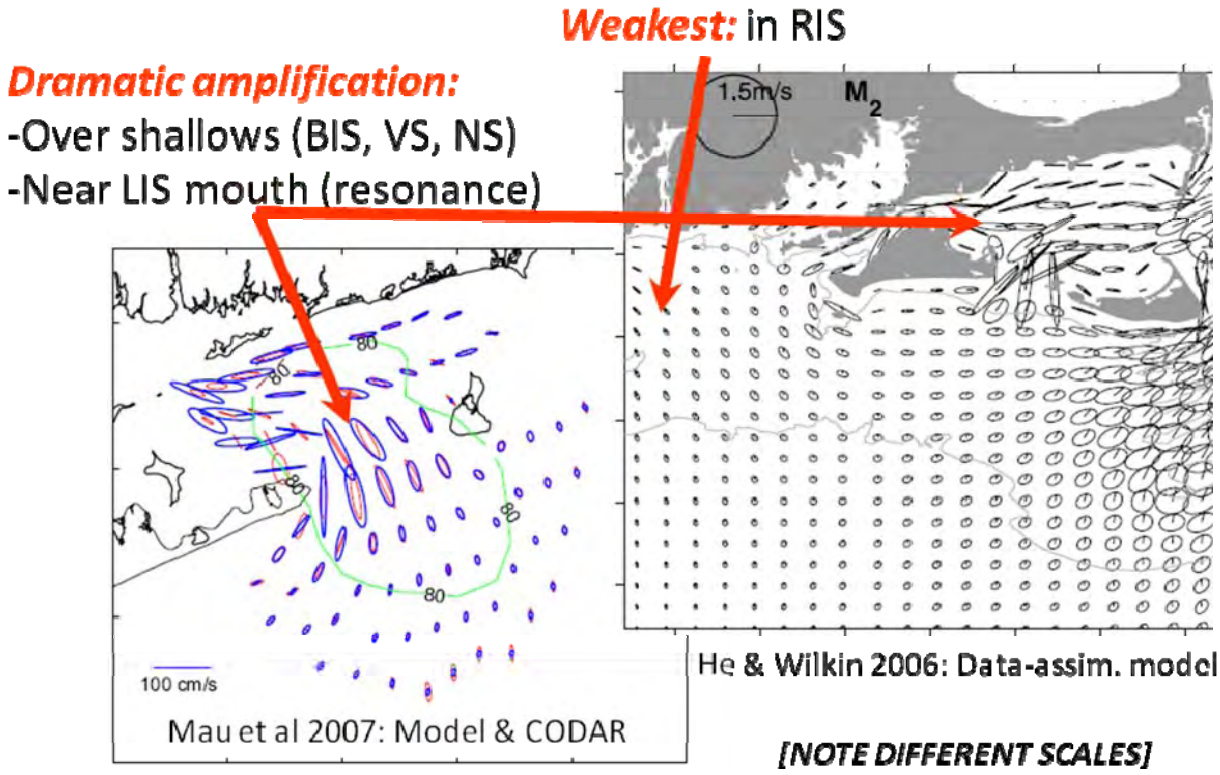


Figure 2.15. Differences in tidal circulation velocities between Rhode Island Sound (RIS) and Block Island Sound (BIS), showing Block Island Sound to be more vigorous and dynamic than Rhode Island Sound. Velocity is greatest over shallow areas and at constricted areas. Note different scales; this does not allow direct comparison between the two diagrams. [VS=Vineyard Sound; NS=Nantucket Shoals]

4. Available data suggests that there is a deep flow into Block Island Sound from the east, running between Point Judith and Block Island, and that a cold current of water flows into the eastern portion of Rhode Island Sound from Nantucket Shoals (Codiga and Ullman 2010). The deep portion of the flow entering from Nantucket Shoals moves largely westward into Block Island Sound while its surface component flows largely southward, joining Long Island Sound flow to form a major coastal current that moves to the southwest, away from the region, over the Offshore Ocean SAMP area and into the Mid-Atlantic Bight (Codiga and Ullman 2010; Beardsley and Boicourt 1981). Kincaid et al. (2003) and Riley (1952) found a generally tending westward flow between Block Island and the Rhode Island coastline that moved into Block Island Sound and could perhaps interact with Long Island Sound water.

5. Based upon findings presented previously, and upon results of their own modeling and research, Codiga (2009) have developed a schematic that shows circulation transport pathways in Rhode Island Sound and Block Island Sound (Figure 2.16). They find minor

interaction between Rhode Island Sound and Narragansett Bay, Buzzards Bay and Vineyard Sound both at surface and at depth. Deep flow from Point Judith, moving westward along the Rhode Island shore and into Block Island Sound is moderate, as are return flows at surface from Block Island Sound into Rhode Island Sound around the north side of Block Island. Moderate flow at the surface (into Block Island Sound) and strong flow at the bottom (into Long Island Sound) is seen through The Race. Moderate flows are seen at depth coming off the Offshore Ocean SAMP area into both Rhode Island Sound and Block Island Sound, with strongest cross-shelf deep flow occurring into Rhode Island Sound along its eastern portion; Codiga (2009) concede that there is limited information for this section of Rhode Island Sound, and that further study is needed. Strong surface flows are observed moving water out of both sounds, generally in a southwestward direction parallel to the south shore of Long Island. Surface water transport out of both sounds and south following the coast of Long Island is a major pathway for water in the Ocean SAMP area to move into the Mid-Atlantic Bight ecosystem.

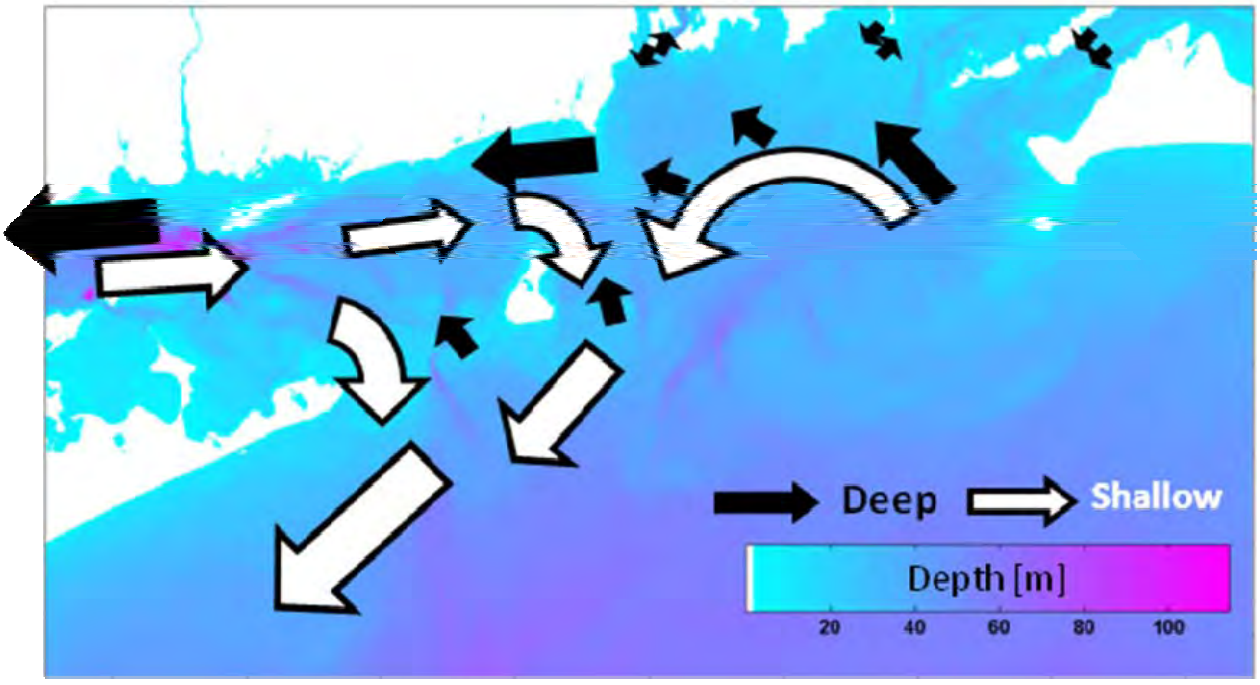


Figure 2.16. Schematic of hypothesized water flow at surface and at depth in the Ocean SAMP area (from Codiga 2009).

6. While Figure 2.16 shows overall patterns of circulation, Figure 2.17 shows a summary schematic diagram of surface and bottom flows on a seasonal basis, based upon best interpretation of observations and model output. Fall and winter show dominant offshore flow out of Rhode Island Sound, with a reversal during spring and summer months; this reversal could promote inshore transport of larval forms produced during winter/spring spawning events. Block Island Sound shows continuous interchange with all adjacent waterbodies, though the interchange is most vigorous in spring and summer when Long Island Sound influence is the greatest. Interaction between Block Island Sound and Rhode

Island Sound is year round, but most intense in spring and summer when freshwater input from Long Island Sound intensifies overall circulation in the Ocean SAMP area.

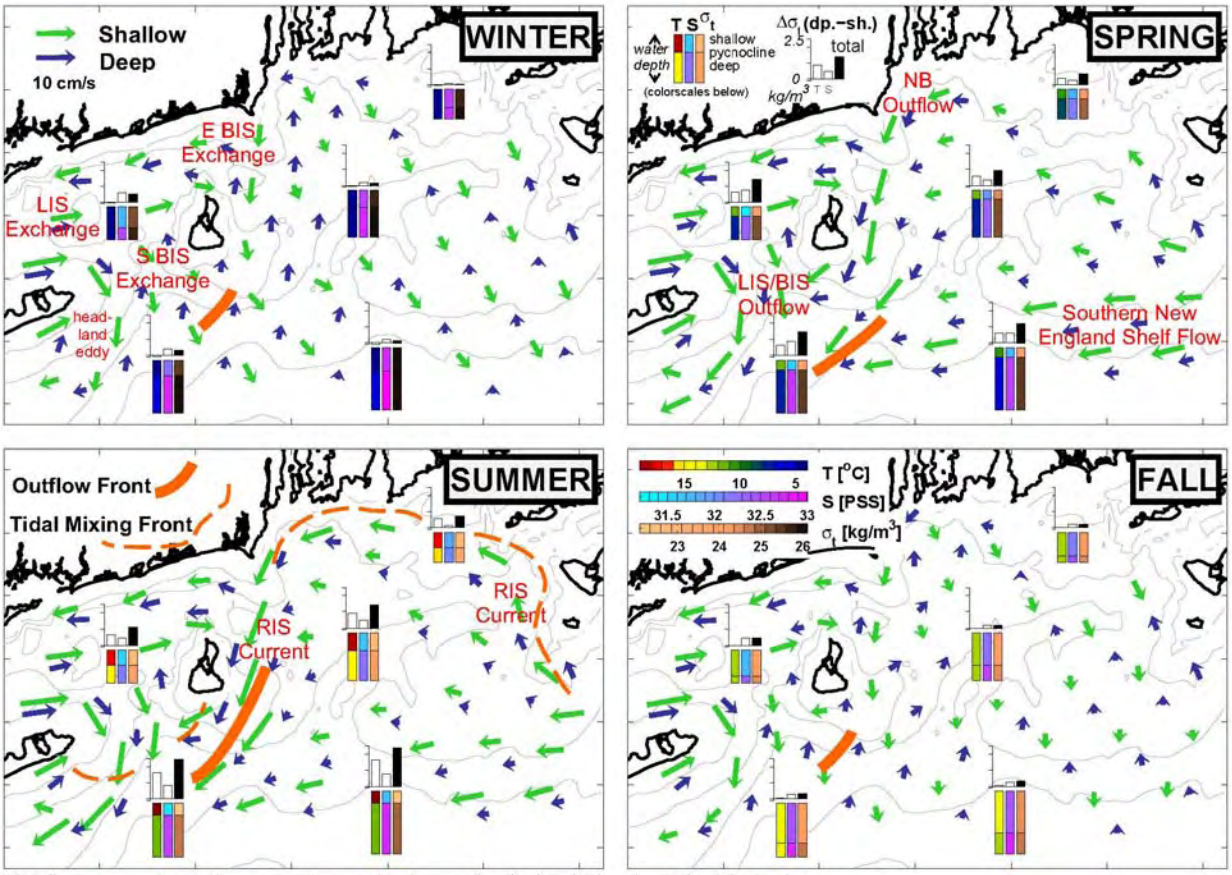


Figure 2.17. Schematic summary, based on observations and model outputs, of currents and hydrography in the Ocean SAMP area; size of arrow indicates magnitude of the flow (from Codiga and Ullman 2010). Histogram inserts show detail of temperature, salinity and density at various sites.

230.4.1. Block Island Sound

1. Circulation in Block Island Sound is largely influenced by interaction with Long Island Sound and the volume of freshwater being received by its major rivers, the Connecticut and Thames, which provide 80% of the freshwater inflow (Gay et al. 2004). The main portal for exchange between Block Island Sound and Long Island Sound is a narrow, deep channel called The Race, which approaches depths of 100 m (Edwards et al. 2004; Gay et al. 2004). Because of the narrowness of the opening, water velocities can exceed 2.68 m sec^{-1} (5.2 knots) on the ebb tide and 2.06 m sec^{-1} (4.0 knots) on the flood (Savard 1966). The Race is an important feature as it allows for the exchange of warmer, nutrient rich, low salinity water from Long Island Sound with colder, saltier water from the Continental Shelf. Codiga and Aurin (2007) suggest that the approximate mean annual volume transport between Long Island Sound and Block Island Sound through The Race is 24,000 m^3 sec^{-1} (Figure 2.18). The

transport is also seasonal in nature, responding to increased freshwater inflow during spring and early summer months. Because of the intense interaction with Long Island Sound, the western portion of Block Island Sound can be considered well-mixed as far as 5–10 km out onto the Offshore Ocean SAMP area region, and to a depth between 20 and 40 m (Edwards et al. 2004). There is a second point of interaction between Block Island Sound and Long Island Sound through an opening between Napatree Point (RI) and the eastern tip of Fishers Island (NY; Figure 2.1) though water depth and current velocities are considerably less than those observed in The Race.

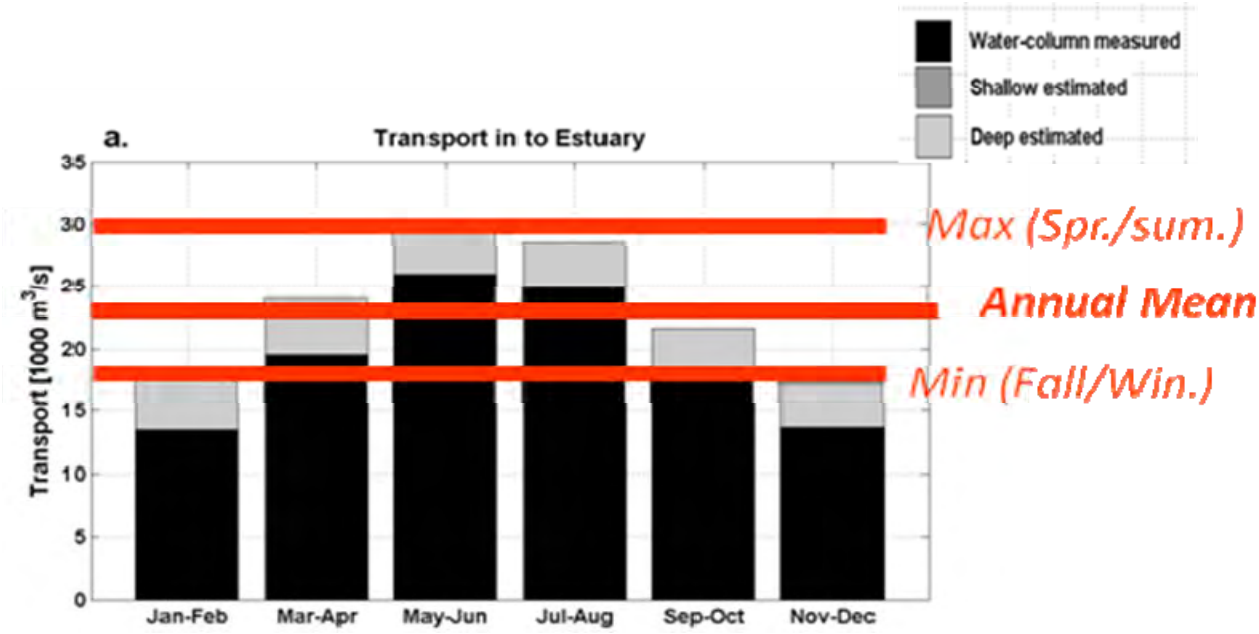


Figure 2.18. Seasonal volume transport from Block Island Sound into Long Island Sound (from Codiga and Aurin 2007).

2. Upon leaving The Race, shallow flow tends southwestward towards the opening to Block Island Sound between Montauk Point and Block Island, with a peak flow of 10–25 cm s^{-1} (Figures 2.15 and 2.16; Ullman and Codiga 2004). This flow is deflected westward along the south shore of Long Island by the Coriolis force, where it moves southward to mingle with southern waters of the Mid-Atlantic Bight ecosystem. This flow is seasonally stratified; strongly so during late spring and early summer due to estuarine flow driven by freshwater input to Long Island Sound. During the spring freshet (e.g., snow melt plus spring rains) this flow is significant, and is referred to as a "jet" which can be detected 5 km south of Montauk Point (Ullman and Codiga 2004). Codiga (2009) hypothesized reports an annual mean volume flow out of Block Island Sound at surface of 24,000 m^3 sec^{-1} onto the Offshore Ocean SAMP area, with a bottom water return from the Shelf into Block Island Sound of 10,000 m^3 sec^{-1}.

3. A sharply delineated boundary, or sharp gradient (e.g., a front), is observed south of Block Island where lower salinity estuarine waters meet saltier continental shelf waters (Edwards et al. 2004; Ullman and Cornillon 2001). The front may represent the outer boundary of

estuarine influence from Long Island Sound on the Offshore Ocean SAMP area (Ullman and Codiga 2004; Ullman and Cornillon 2001). The front is readily noted by a temperature discontinuity, and is seasonal in its nature. Figure 2.17 shows the seasonality of the front; offshore in winter then moving north and intensifying in spring with a strong presence off Block Island during summer months. During summer, the front is strongly set and is often observed to extend from the region northeast of Block Island southwestward, 15–20 km southeast of Montauk Point (Figure 2.19; Edwards et al. 2004; Kirincich and Hebert 2005; Codiga 2005). The influence of this front on the ecology of the sounds is not well known. However, fronts are areas of high biological activity due to nutrient mixing across water masses, which stimulates increased primary production (Mann and Lazier 2006); increased primary production often leads to increased secondary production (Munk et al. 1995). Commercial and recreational fishermen actively seek out the location of the front to help locate specific species and/or areas of greater fish abundance, suggesting the front either acts as an area of food concentration, or as an area of thermal refuge, or both. Roff and Evans (2002) note that distinct, special oceanographic processes that occur at local scales (e.g., a front) create distinctive habitat that is attractive to fish. Worm et al. (2005) correlated sea surface temperature gradients to increased tuna and billfish diversity. Further description of the ecological importance of oceanic fronts can be found in Mann and Lazier (1996).

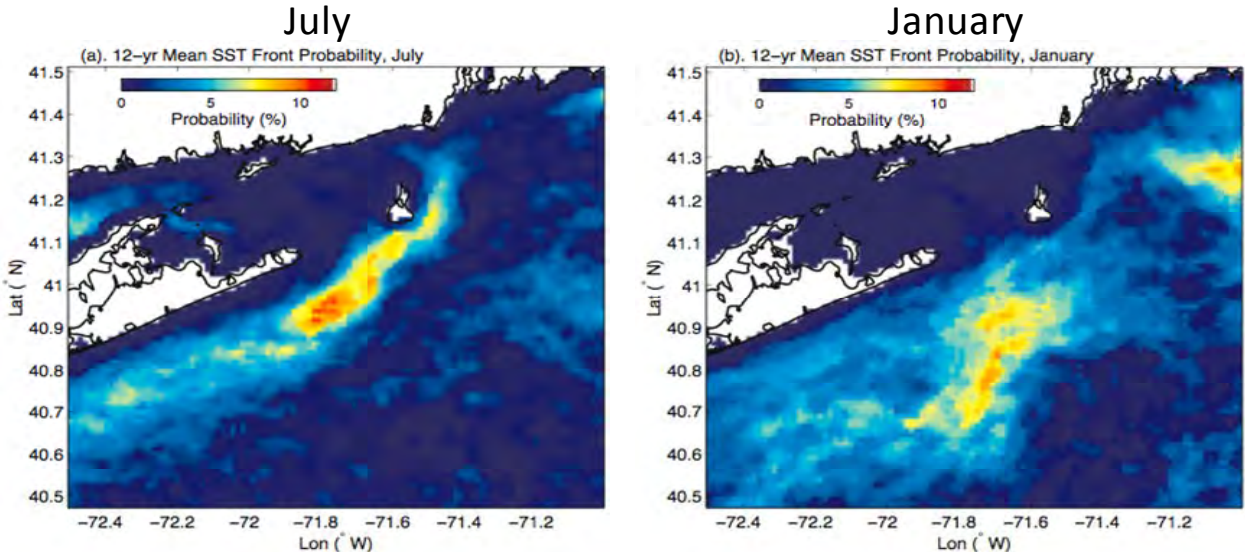


Figure 2.19. Probability of sea surface temperatures occurring along the "front". Averaged 1985-1996. The front is narrow, stable in summer; diffuse, unstable in winter (Ullman 2009).

4. Tidal exchange rates for Block Island Sound and the Offshore Ocean SAMP area have been estimated at a rate of 2.9 x 10^5 m^3 s^{-1} (Codiga and Rear 2004), 3.5 x 10^5 m^3 s^{-1} (Kopplman et al. 1976, using a tidal prism approach) and 6.3 x 10^5 m^3 s^{-1} (Kenefik 1985 using a numerical modeling approach). Williams (1969), at a station located 40 miles south of Fishers Island, measured average tidal flows of 0.75 m s^{-1} on the flood tide (1.46 knots), and 0.55 m sec^{-1} on the ebb tide (1.07 knots), with a maximum recorded flow of 1.08 m s^{-1} (2.1 knots; tidal phase not stated). The volume of water exchange with the Offshore Ocean SAMP area is therefore significant, though velocity of exchange is considerably less than experienced near shore.

The exchange promotes the influx of offshore and southern species into the Ocean SAMP area, as well as promotes dispersal of Block Island Sound species (e.g., planktonic organisms) into offshore waters.

230.4.2. Rhode Island Sound

1. Circulation in Rhode Island Sound is influenced by interaction with Narragansett Bay through the East and West Passages, Buzzards Bay and Vineyard Sound, Nantucket Shoals, Block Island Sound and the Offshore Ocean SAMP area. The East Passage, which has an average depth of 18 m and a maximum depth of 40 m, is the deeper of the two connections to Narragansett Bay and experiences current flows of 20,000 m^3 sec^{-1} on the flood tide and 30,000 m^3 sec^{-1} on the ebb (Kincaid et al. 2003). The West Passage sees current speeds about 60% less than those for the East Passage, on either tide.

2. Shonting (1969) observed bottom currents in Rhode Island Sound flowing at rates of 8–12 cm sec^{-1} and showing little overall variability. Surface currents were found to flow at rates of 15–35 cm sec^{-1}, with an average speed of 22 cm sec^{-1} and with great variability. Surface flows tended towards the west-southwest at speeds of 12–14 cm sec^{-1}, while bottom flows showed a rotary motion in anti-cyclonic swirls that provided little net transport. The rotary motion suggests that bottom water does not effectively aid in benthic transport. However, Shonting (1969) notes that there was no expression of the typical summer sea breeze during the time frame of their survey, and they suggest this may have been an influencing factor which may not be typical of the season. Kincaid et al. (2003) and Hyde (2009), both reported cyclonic flow in Rhode Island Sound, and that it was seasonal in nature. Such a circulation pattern could have significant influence on the ecology of that area of Rhode Island Sound, though further study to verify and describe this phenomenon in greater detail would be needed.

3. First (1972) measured bottom currents at a station located on Cox Ledge in Rhode Island Sound, in 54 m water depth, and found that current flows were generally to the northeast or to the southwest, and that the bottom currents tended to flow according to bottom topography. First (1972) measured a maximum velocity of 20 cm sec^{-1} and an average velocity of 5 cm sec^{-1} along the bottom in that area, and found these flows to be considerably less that those measured at a station just off Point Judith (average velocity of 21 cm sec^{-1} at 15 m water depth).

4. Cook (1966) notes that during the spring there is a non-tidal surface drift to the east and the northwest in Rhode Island Sound, with a northwesterly tending bottom non-tidal drift. Cook (1966) also found a strong westerly flow running between Block Island and Point Judith (see Figure 2.16). During summer, Cook (1966) found a north tending non-tidal drift at the surface, and a northwest bottom drift. During autumn there was southerly drift at surface, but to the north on bottom. Annual average drift rates at the surface were observed to be 2–16 cm sec^{-1}, while on bottom they tended between 0.1 and 3 km day^{-1} (0.1–3.0 cm sec^{-1}).

5. Kincaid et al. (2003) hypothesized upwelling of Rhode Island Sound water in the area of Brenton Reef, and that this water was then advected (movement in a horizontal direction)

into the East Passage of Narragansett Bay. Such an exchange could be an important source of nutrients to lower Narragansett Bay, but needs to be further quantified to determine if and how it influences the ecology of Narragansett Bay.

6. Kincaid et al. (2003) also found a distinct, significant flow during summer time in the eastern portion of Rhode Island Sound that moved to the west, and then southwest, following the coast of Rhode Island (Figure 2.20). Riley (1952) noted a similar westward flow into Block Island Sound between Point Judith and Block Island, as have Codiga and Ullman (2010). During winter months this flow continued, but at a much diminished rate. Kincaid et al. (2003) suggest that a seasonal cyclonic gyre exists in Rhode Island Sound, and that this gyre has significant influence upon dynamic exchange with Narragansett Bay. While a cyclonic gyre the size of Rhode Island Sound is consistent with flow counterclockwise around its periphery, the analysis of model output by Codiga and Ullman (2010), and of current observations in Ullman and Codiga (2010), have both demonstrated that along the southern edge of Rhode Island Sound the flow is westward, which contradicts the idea that flow closes in a distinct gyre as originally suggested by Cook (1966).

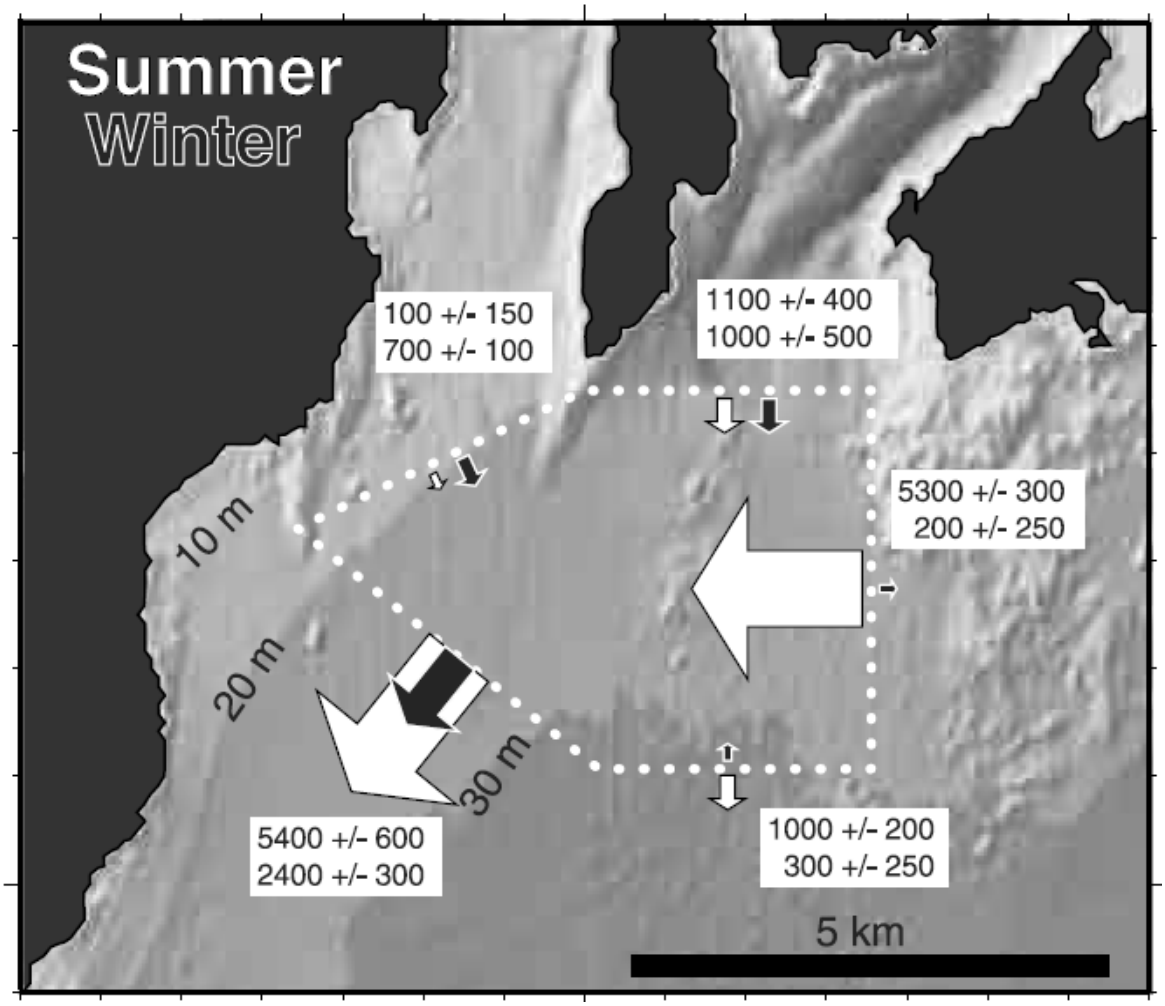


Figure 2.20. Seasonal, tidally averaged volume transport between Narragansett Bay and Rhode Island Sound (from Kincaid et al. 2003) White arrows are for summer flows and black for winter; size of arrow is relative to volume of flow; units are m^3 sec^{-1}.

7. While Signell (1987) found modeled interaction between Rhode Island Sound and Buzzards Bay to be weak, there is intermixing with offshore water in the Cape Cod region. Hicks and Campbell (1952) noted a net flow of water from Buzzards Bay into Rhode Island Sound; in winter the tongue of water was colder than offshore waters. They found a surface water salinity minima of 29.5‰ at the mouth of the West Passage, and a maxima of 32.9‰ on the Offshore Ocean SAMP area region; bottom waters ranged from 31.2–33.0‰. A coastal current flows south of Block Island Sound, entering from the northeastern region of Rhode Island Sound (Figure 2.16; Kincaid et al. 2003). This current flow is at least partially due to water coming around the arm of Cape Cod, moving through Nantucket Shoal and into Rhode Island Sound (Figure 2.7 and Figure 2.16; Shcherbina and Gawarkiewicz 2008). Furthermore, work by He and Wilkin (2006) show current flows moving around the south side of Martha's Vineyard and then into Rhode Island Sound, providing a clear path for water from the north into Rhode Island Sound and the Ocean SAMP area.

Section 240. Chemical Oceanography

1. Over the course of the millennia of its existence, planet Earth has come to a form of equilibrium with the "chemical soup" contained in its soils, waters, oceans, atmosphere, and biota. Nearly all the elements that can be found in "the soup" are essential to sustaining life, though generally in modest quantities and often only in trace amounts and all are continuously recycled through biological, chemical, physical, and geological processes.

2. Toxins are important limiting factors to productivity. In trace amounts, toxins are generally not problematic, but at higher concentrations can lead to chronic or acute symptoms that reduce quality of life for effected organisms, and/or create more serious impacts, such as increased mortality or alteration of reproductive potential.

3. Existing studies do not suggest that toxins are problematic in the benthic sediments of impacted sites in Rhode Island Sound; there are no reported impacted sites (e.g., dredged materials disposal) for Block Island Sound. Since all sources of toxins are anthropogenic and are of external origin (e.g., accidental spill, purposeful placement), it would not be anticipated that the sediments in either ecosystem pose toxic threats to biota or to the ecosystem at large.

240.1. Nutrients

1. Nutrients are critical to the growth of plants, and in the marine environment nitrogen is generally the most critical nutrient as it is often to be found in limiting quantities and thus sets limits to growth. Nutrients, critical elements for sustaining life, are recycled within the ecosystem. Nutrient dynamics are often complicated by biological uptake, as well as interaction with the benthos both biologically and physically, and can be difficult to comprehend even in well-studied ecosystems. Overall, there has been little work completed on nutrient dynamics in either Block Island Sound or Rhode Island Sound, and what has been done has often been conducted close to shore and/or several decades ago. This is an area where further research work is needed since nutrient dynamics set limits to primary production, which in turn strongly influences ecosystem make up and function.

2. Ramp et al. (1988) report a net transport of shelf water from Nantucket Shoals to the west, eventually flowing to the Mid-Atlantic Bight as described previously. Ramp et al. (1988) suggest that 39–53% of the nitrogen reaching the Mid-Atlantic Bight moves in this flow. Given that there is interaction between the waters flowing south along the shelf (Loder et al. 1998; Figure 2.7 and Figure 2.16) and the waters of the Ocean SAMP area, particularly Block Island Sound, this may be an important source of nitrogen to Rhode Island Sound and Block Island Sound, though further study is needed.

3. While often more limiting in freshwater systems, phosphorus is a required nutrient for growth of plants in marine systems. Riley (1952) found phosphate concentrations at a maximum in mid-winter in Block Island Sound, with a rapid decline during the time of the spring phytoplankton bloom; it was suggested that phosphate was not a limiting nutrient in Block Island Sound waters. Similar work has not been published for Rhode Island Sound.

4. Staker and Bruno (1977) sampled nutrients in Block Island Sound (Table 2.1). The stations were relatively close to shore (south side of Long Island and near Gardners Island) and in shallow water (15 m and 6.5 m, respectively), so it is unclear how representative these measurements might be for more central areas, such as between Block Island and Montauk Point. These researchers conclude that overall, nutrient concentrations were highest in the autumn and near zero/undetectable in late spring and early summer. Phosphate was found not to be a limiting nutrient to growth in the Block Island Sound ecosystem and in agreement with Riley (1952); nitrate and nitrite may become limiting seasonally, mainly during the time period of late May to early July.

Table 2.1. Nutrient concentrations measured in Block Island Sound (Staker and Bruno 1977).

Nitrate (NO_3)	*Concentration*	*Time*
	10 µM	Nov to Jan
	3–4 µM	March and April
Nitrite (NO_2)		
	6 µM	October
	0 µM	Summer
	4–5 µM	September
Orthophosphate (PO_4)		
	1.8 µM	November
	1–2 µM	July

5. Oviatt and Pastore (1980) sampled the concentration of various nutrients in Rhode Island Sound (Sta.16 at the mouth of Narragansett Bay; Sta.17 just outside the mouth) on a seasonal basis (Table 2.2). Unfortunately not all measures can be readily compared to those for Block Island Sound because of timing differences, but orthophosphate (PO_4) concentrations appear to be similar for the one area of overlap for samples taken in November (Table 2.1), and are in general agreement with one another.

Table 2.2. Nutrient concentrations measured in Rhode Island Sound by Oviatt and Pastore (1980; estimated from graphs in original report–highest concentration within a time span is given).

	Concentration (µM)		
Ammonia (NH_3)	*Sta. 16*	*Sta. 17*	*Time*
		0	Jan–May
	1	1.5–2	Jun–Aug
	3–4	2–2.5	Nov–Dec
Nitrite + Nitrate (NO_2 + NO_3)			
	6	6	Jan
	1–2	5	Feb
	0.5	0.5	Mar
	5	4	Apr
	0	1–2	May–Aug
	6	6	Nov
	12	10	Dec
Orthophosphate (PO_4)			
	1–2	1–1.5	Jan–Aug
	1.5	1.5–2	Nov–Dec
Silicate (SiO_4)			
	1.5	1.5	Feb–Mar
	7	4	Apr
	4	5	May–Jun
	16	18	Jul
	6–7	10–11	Aug
	7	8	Nov
	20	18	Dec

6. The nutrient data are too meager to draw any firm conclusions regarding the trophic status (e.g., eutrophic, oligotrophic) of the Ocean SAMP area. This is an area where further work is needed. However, slightly lower primary production measures (see Section 250.1.1) than is seen for adjacent waters suggests that perhaps nutrient availability may be limiting.

240.2. Toxins

1. The Ocean SAMP area is not industrially developed, does not receive direct discharges of municipal or industrial wastes, and is not the regular recipient of refuse or other disposed materials. As such, toxins in the environment would be expected to non-problematic in the Ocean SAMP area. However, Rhode Island Sound has received dredged materials from Narragansett Bay on several occasions, and was the site of an oil spill in the 1990s. Dredged materials often contain various contaminants that in general, will be limited in their realm of impact to the containment site once the disturbance from placement has diminished. Furthermore, contaminants would mainly be restricted to the sediments and impacts would tend to be restricted to the benthos. If benthic sediments are disturbed however, whether through natural (e.g., turbulent mixing due to storm activity) or human induced means (e.g., seafloor disturbance), then contaminants could be put into suspension in the water column where they could directly impact the pelagic ecosystem, or be dispersed and settle in other areas, possibly impacting the benthic ecosystem. Dredge materials disposal sites in Rhode

Island Sound are at a depth where bottom sediment could be mobilized during hurricane events (e.g., see Section 230.1; First 1972). It is also possible that sediment reworking by infaunal invertebrates (e.g., living in the sediments) could mobilize toxins into the food web where bioaccumulation could become problematic. However, based upon toxicity testing at both dredged materials disposal sites and oil spill impacted areas, it appears that environmental toxins are not a significant threat to the Ocean SAMP ecosystem.

2. The Rhode Island Sound Disposal Site (RISDS), designated in December 2004 and located in Rhode Island Sound, has been used for the disposal of dredged materials. The 3.24 km^2 site, with water depths from 36 to 39 m, is located at 41° 13.850' N, 71° 22.817' W (NAD 83; Figure 2.21). The site lies approximately 21 km south of the entrance to Narragansett Bay and is within the Separation Zone for Narragansett Bay Inbound and Outbound Traffic Lanes. Approximately 3.4 million m^3 of sediment from the Providence River (primarily from the Federal Navigation Project) were disposed of at this site.

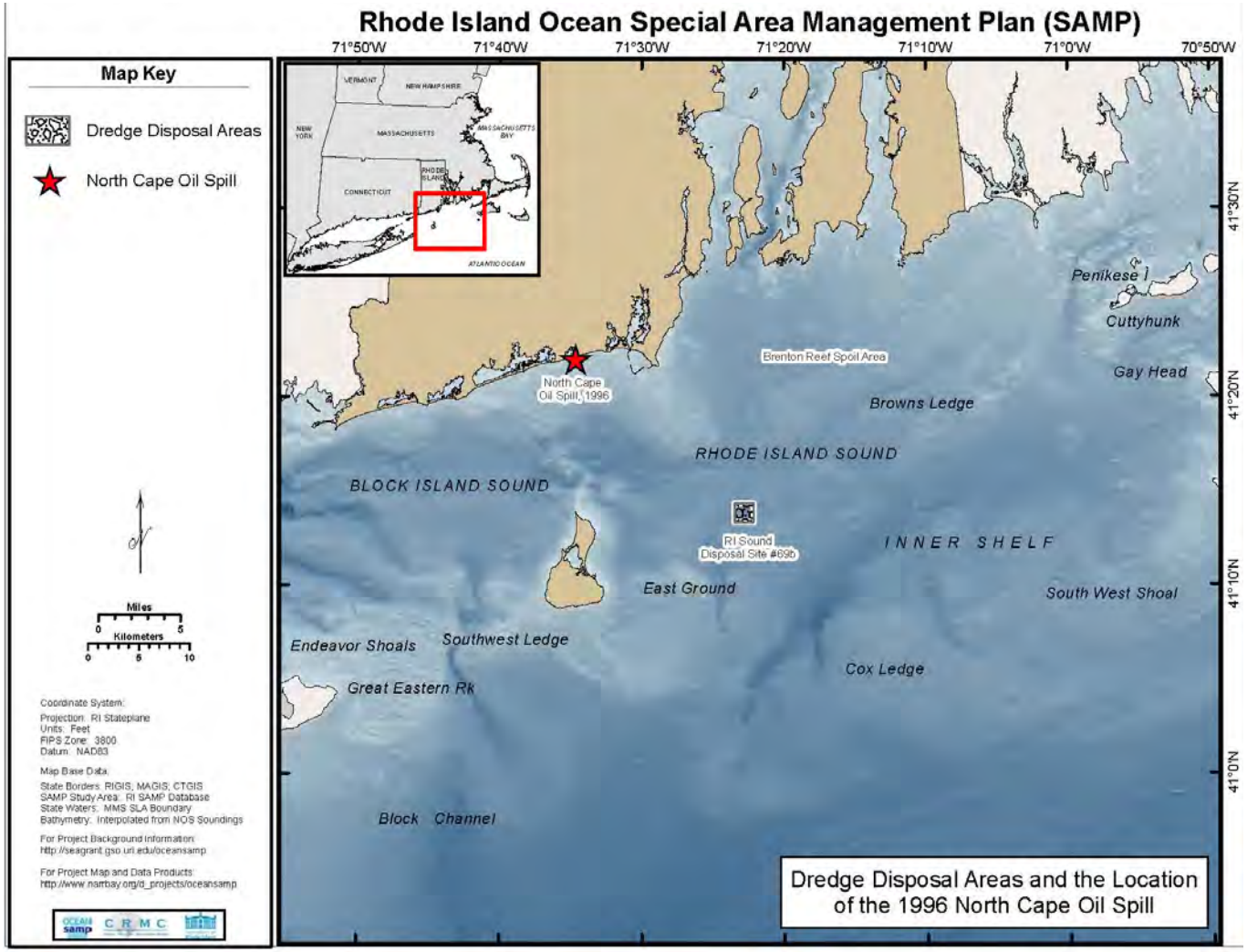


Figure 2.21. Dredged materials disposal sites, and location of the *North Cape* oil spill.

3. The Brenton Reef Disposal Site (Figure 2.21) has been extensively used for the disposal of dredged materials from Rhode Island waters, mainly from the dredged navigation channel in Narragansett Bay, with the last dumping at the site occurring in the 1970s. Battelle (2002a) conducted a study to test toxicity levels at the Brenton Reef and Rhode Island Sound disposal sites, and 2 stations between the two sites, and found that species composition among the various sites, both inside and outside of the dredged materials disposal areas, were not significantly different from one another, suggesting that benthic community recovery from the disturbance event has occurred.

4. Measurement of metals concentrations (Ag, As, Cd, Cr. Cu, Ni, Pb, Se, Zn) in the water column at four sample stations (same stations as those for Battelle 2002a) in Rhode Island Sound found detectable levels, but at concentrations that were well below ambient Rhode Island Department of Environmental Management water quality criteria for toxic pollutants (U.S. Army Corps 2002). Similar results were found for organic and inorganic contaminants (PCBs, Pesticides, Hg) at the four sample sites.

5. On January 19, 1996, the barge *North Cape* spilled more than three million liters of No. 2 fuel oil, a relatively light, readily aerosolized petrochemical, into Rhode Island Sound off Matunuck (Figure 2.21). The plume of oil moved to the east with the greatest impact being seen in the area around Point Judith. Studies by Ho (1999) showed that toxicity in the sediments at a heavily impacted site were small (3% ± 6% mortality for the amphipod *Ampelisca abdita*) after nine months. It is not clear if hydrocarbon concentrations occur at levels of concern in the sediments at this point in time, though it seems unlikely that toxicity levels would be of concern given the time that has elapsed since the spill occurred.

Section 250. Biological Oceanography

1. The unique geological, physical, and geographic characteristics of the Ocean SAMP area provide conditions for making it suitable to a suite of organisms spanning all trophic levels. Living phytoplankton and other photosynthetic organisms are limited to the light-penetrated upper layers of the water column where they convert sunlight into organic matter. Zooplankton convert phytoplankton into animal matter (e.g., protein) which fuels upper levels of marine ecosystem food webs from bait fishes to apex predators. Microbes are responsible for much of the decomposition of dead organisms, recycling nutrients and making them once again available for uptake by plants and animals both in the water column and the benthos.

2. Primary production takes place in the presence of light, and therefore plants are limited to the sunlit layer of the water column (e.g., the photic zone). Depth to which light can penetrate the water column is therefore an important factor in production. Ayers (1950) took water clarity readings in Block Island Sound using Secchi disks; measures of 4.3 m were found near Mount Prospect on Fishers Island and 6.1 m near Great Salt Pond during winter months. During summer, Secchi depths at the same stations were 2.4 m near Fishers Island and 4.6 m off Great Salt Pond. Secchi disk readings were taken in Rhode Island Sound during the months of February and March by Hicks and Campbell (1952); average readings were 6 m with a maximum of 10 m. In all cases transparency decreased with closeness to shore. Decreased transparency in shallow waters close to shore may be due to increased particulates, nutrients and/or primary production in the water column. This suggests a photic zone of 10 m or less, with light penetration decreasing seasonally during summer months.

3. Richardson and Schoeman (2004), based on trends observed in the Northeast Atlantic Ocean, note that warming waters have tended to increase phytoplankton standing stock in cold waters, but decreased it in warmer waters. It is not clear, given that the Ocean SAMP area overlaps two distinct bio-regions, how warming waters due to climate change will impact phytoplankton populations, and if any impact would be in a positive or negative direction.

250.1. Plankton

1. There appear to be correlations between phytoplankton species composition in Narragansett Bay and Rhode Island Sound, though more work is needed to prove and clarify that correlation, as well as to research trends for species shifts over time. Recent findings of Nixon et al. (2010) suggest that surface waters of Rhode Island Sound contain more phytoplankton than those of Block Island Sound, though in summer when the water column is stratified this relationship appears not to hold; this pattern does not hold for primary production (see 250.1.1). Primary production is seasonal in the Ocean SAMP area, and production values are generally similar to though slightly lower than those of adjacent areas, which agrees with findings of Nixon et al. (2010). As is noted for Narragansett Bay, Rhode Island Sound appears to be experiencing a less consistent winter–spring phytoplankton bloom, though again more research is needed to verify and clarify this observation, and define its importance to the overall ecology of the area. Nixon et al. (2010) have found evidence for a fall bloom in Ocean SAMP waters, a bloom which was not seen to occur in

Narragansett Bay. Zooplankton species composition was found to be seasonal, and heavily influenced by change in salinity and/or temperature in the water column; distinct species changes were noted in warm vs. cool years, dry vs. wet years. Influx of the ctenophore *M. leidyi* had significant impact on the zooplankton community of Narragansett Bay, though similar study has not been conducted in Rhode Island Sound so it is unclear if similar interaction is occurring. Differences between Rhode Island Sound and Block Island Sound regarding zooplankton control of phytoplankton stocks was suggested, but has not been studied in a comparative sense, nor is it known if ctenophore outbreaks have influenced zooplankton–phytoplankton interactions in Rhode Island or Block Island Sound. Very preliminary comparison (Deevey 1952a,b; Kane 2007) suggests zooplankton dominant species have not changed over the past 50 to 60 years, nor has the seasonality of at least some dominant species. Rigorous analysis however, needs to be undertaken before this can be stated with any degree of surety.

2. Plankton is the collection of organisms that live in the water column and are subject to oceanic currents for their distribution. The organisms making up the plankton range from microscopic plants and animals to larger organisms with limited mobility, such as jellyfishes. The plankton makes up a crucial source of food for marine ecosystems, and in general, forms the foundation of marine food webs.

3. Since the distribution of plankton is determined by the movement of oceanic water masses via current flows, tidal movement and wind-induced flow, understanding plankton distribution can be simulated through circulation models and/or observed circulation patterns (see Section 230.4). The generalized schematic of circulation in the Ocean SAMP area (Figure 2.16) may provide a reasonable first-order estimate for probable plankton transport pathways. Other forces, wind in particular, will play a role in transport at smaller/local scales within the larger Ocean SAMP area.

4. Seventy-five species were recorded during a 1954-1955 survey of phytoplankton (Smayda 1957); nine diatoms and four flagellates were found to account for 94% of the total phytoplankton abundance in Narragansett Bay. Riley (1952) found nine genera constituted 98% of the total number of phytoplankton cells in Block Island Sound in 1949. While it is not well known how closely species composition for phytoplankton matches between Narragansett Bay and Rhode Island Sound, both studies show that in both locations the majority of the overall "crop" consists of a relatively few species. However, recent changes in the plankton dynamics of Narragansett Bay are related to climatic warming (Sullivan et al. 2008). Given the lack of recent data on phytoplankton species composition in the Ocean SAMP area, it is not clear if change similar to that seen in Narragansett Bay is underway. Changes in zooplankton composition (see Section 250.1.3) suggest a need for research in this area.

250.1.1. Phytoplankton Productivity

1. Plants have the all-important function of trapping sunlight, a very abundant yet dilute form of energy, and converting it into organic matter (in the form of plants) that is a more concentrated (though less abundant) form of energy that then becomes the foundation for most food webs. Measurement of plant production, referred to as primary production,

provides an indication of how fertile, or how much food is being produced, in a given area and perhaps over a given unit of time. Primary production is often reported in units of mg m^{-3} (milligrams per cubic meter), which indicates the amount of organic plant matter produced (dried to remove the weight of water, which is substantial) in a given area or volume of water. Primary production is also often reported in units of g C m^{-2} day^{-1} (grams of carbon per meter square per day), which is the mass of carbon (the basic building block of organic matter) produced in a given area and over a given time span.

2. The New York Ocean Science Laboratory initiated a general survey of the physical and chemical characteristics of Block Island Sound and adjacent waters with the intention of creating a baseline data bank (Hollman 1976; Staker and Bruno 1977). Staker and Bruno found chlorophyll *a* (the green pigment contained in primary producers) concentrations that were highly seasonal, and varied from near zero to 9.94 µg l^{-1}. The species *Thalassiosira nordenskioldii* was numerically dominant in the samples, but *Skeletonema costatum* and *Ceratium tripos* presented a larger biomass in the community. Of interest is that Staker and Bruno (1977) found *Ceratium tripos* (a dinoflagellate) to be very abundant in the phytoplankton community during their survey, while Riley and Conover (1967) only found this species in 2 samples during their previous surveys. No causality for the difference was stated. Staker and Bruno (1977) also found that *Thalassiosira nordenskioldii* was more abundant than reported in previous surveys. It cannot be deduced from these limited data if a change in the ecosystem occurred, or if the variability is due to small sample size, though it does point to a need for new research and better knowledge in this area.

3. Riley (1952) found that phytoplankton abundance generally increased with depth to a maximum at 10–20 m. Riley also noted a spatial trend towards reduced phytoplankton concentrations with distance south; concentrations were half as much near Block Island than they were near Watch Hill, and there was no indication of a bloom at the site south of Block Island. Riley further noted that phytoplankton concentrations in Block Island Sound were higher than those found to the east in Rhode Island Sound, or to the south in the Offshore Ocean SAMP area. It is likely that the dynamic interaction with Long Island Sound promotes higher primary production in this area, perhaps bringing additional nutrients from land-based sources in Connecticut, though this has not been quantified.

4. Smayda (1973) reported net primary production of 300 g C m^{-2} yr^{-1} for Block Island Sound, which he found comparable to Long Island Sound and Narragansett Bay, though less than that found for continental shelf waters. Smayda (1957) noted that *Skeletonema costatum* comprised 81.2% of the total phytoplankton population in lower Narragansett Bay, which is on par with Riley's (1952) estimate of 83.5% for this species. Outside of this pairing, there was not good matching between the less abundant phytoplankton species in lower Narragansett Bay and outside waters. Smayda (1957) suggested that Narragansett Bay might be a source of phytoplankton for outside waters via the westward current flow from the mouth of the bay towards Long Island Sound. If this is so, broad overlap of species would be expected between Narragansett Bay and Rhode Island Sound, but this comparative research has not been conducted. Given similarities between various former studies (e.g., Smayda 1957 and Riley 1952), and divergence or change in later studies (e.g., Smayda 1973), this is an area where further research would be useful for improved understanding of relationships

between Narragansett Bay and Rhode Island Sound, as well as within the overall, larger Ocean SAMP area phytoplankton community.

5. Hyde (2009), using ocean color remote sensing data, estimated phytoplankton average annual biomass and productivity for the past 10 years for the Rhode Island Sound and Block Island Sound area as 1.07 mg m^{-3}. Primary production estimates for the Ocean SAMP area ranged from 143 to 204 g C m^{-2} d^{-1} and were comparable to, though slightly lower than, primary production measurements for nearby regions (Table 2.3). Sampling at four stations in Rhode Island Sound found chlorophyll *a* concentrations of 6 to 9 μg l^{-1} (U.S. Army Corps 2002), which is comparable to those noted by Staker and Bruno (1977) for Block Island Sound. They are also consistent with oceanic systems and slightly lower than an average estimate of phytoplankton production on continental shelves (Mann 2000), and are consistent with Hydes' assessment. Nixon et al. (2010) found that chlorophyll concentrations above 4.5 μg l^{-1} were unusual but more common in Rhode Island Sound than in Block Island Sound, with most common concentrations ranging between 0.5 and 1.0 μg l^{-1}. For Rhode Island Sound, Nixon et al. (2010) found production over the span of October 2009 to April 2010 to be between 86 and 91 gC m^{-2} d^{-1}, and 87 gC m^{-2} d^{-1} for Block Island Sound. Figure 2.22 shows annual phytoplankton growth (via chlorophyll *a*) in the Ocean SAMP area over a decadal span of time. While there is year-to-year variability, a general trend of increased production closer to shore is apparent. Nearshore waters will be shallower, better mixed, closer to nutrient sources, and warmer than offshore waters, all factors which promote increased productivity. No trend over time is visibly apparent from this time series data set, though statistical analyses are lacking to make any further judgment.

Table 2.3. Comparison of the range of primary production (g C m^{-2} d^{-1}) in Ocean SAMP waters with nearby ecosystems (adapted from Hyde 2009); production in the Ocean SAMP area is comparable to, though slightly lower than, nearby coastal systems.

Ecosystem	Production	Reference
Ocean SAMP	143–204	Hyde (2009)
Narragansett Bay	160–619	Oviatt et al. (2002)
Massachusetts Bay	160–570	Keller et al. (2001); Oviatt et al. (2007); Hyde et al. (2008)
Cape Cod Bay	231–358	Hyde et al. (2008)
Boston Harbor	211–1087	Keller et al. (2001); Oviatt et al. (2007)
New York Bight	370–480	Malone and Chervin (1979)
Mid-Atlantic Bight	260–505	O'Reilley et al. (1987); Mouw and Yoder (2005)
Georges Bank	265–455	O'Reilley et al. (1987)
Gulf of Maine	260–270	O'Reilley et al. (1987)

6. The diatom *Skeletonema costatum* was found to be abundant in Long Island Sound, comprising nearly 72% of the total population, but being almost nonexistent in Vineyard Sound, suggesting a possible west-east gradient in abundance across the Ocean SAMP area (Lillick 1937; Riley 1952). Riley (1952) found *Skeletonema costatum*, *Thalassionema*

mitzachioides and *Rhizosolenia setigera* to be dominant species, and that nine genera made up 98% of the phytoplankton counted.

7. Staker and Bruno (1977) found 125 species of phytoplankton over the course of their 13-month study; *Bacillariophyta* and *Pyrrophyta* were the most abundant groups, with *Chrysophyta*, *Chlorophyta*, *Cyanophyta* and *Euglenophyta* well represented. *Skeletonema costatum* was found to be the numerically dominant phytoplankton species, while *Thalassiosira nordenskioldii* and *Ceratium tripos* were dominant regarding biomass. These findings are consistent with those of earlier surveys noted above; there is however, little contemporary comparable species data for the Ocean SAMP area, so current species dominance is not known.

250.1.2. Phytoplankton Seasonality

1. Riley (1952) conducted 12 surveys during 1949 that counted phytoplankton cells and analyzed plant pigments in surface waters. A phytoplankton minimum was seen in mid-winter and mid-spring, with a bloom in February and smaller blooms during mid-summer. Deevey (1952a) suggested that phytoplankton seasonality was driven by physical oceanographic processes rather than by zooplankton grazing. The characteristics of phytoplankton seasonal cycles in Block Island Sound appear to be common in neritic temperate waters; a midwinter minimum, a small and early spring bloom, and a moderate abundance during late summer (Riley 1952). Riley also found 80% of the phytoplankton species to be either littoral or neritic species (see Section 250.1.3. for definitions).

2. Contemporary measures of primary production and chlorophyll *a* concentrations in the Ocean SAMP area show fairly consistent peaks during late fall and early spring, with a distinct and significant fall bloom (Figure 2.22). However, no clear, consistent winter-spring bloom is seen (Hyde 2009), which is a deviation from historical observations. Rhode Island Sound seems to be mimicking Narragansett Bay in its loss of a consistent annual winter-spring diatom bloom; causes for this are not clear, but suggests that large-scale forces (e.g., changing climate) may be at work. Chlorophyll *a* concentrations and primary production show a fairly consistent minimum during summer months, which is in general agreement with nutrient availability patterns noted previously (Section 240.1).

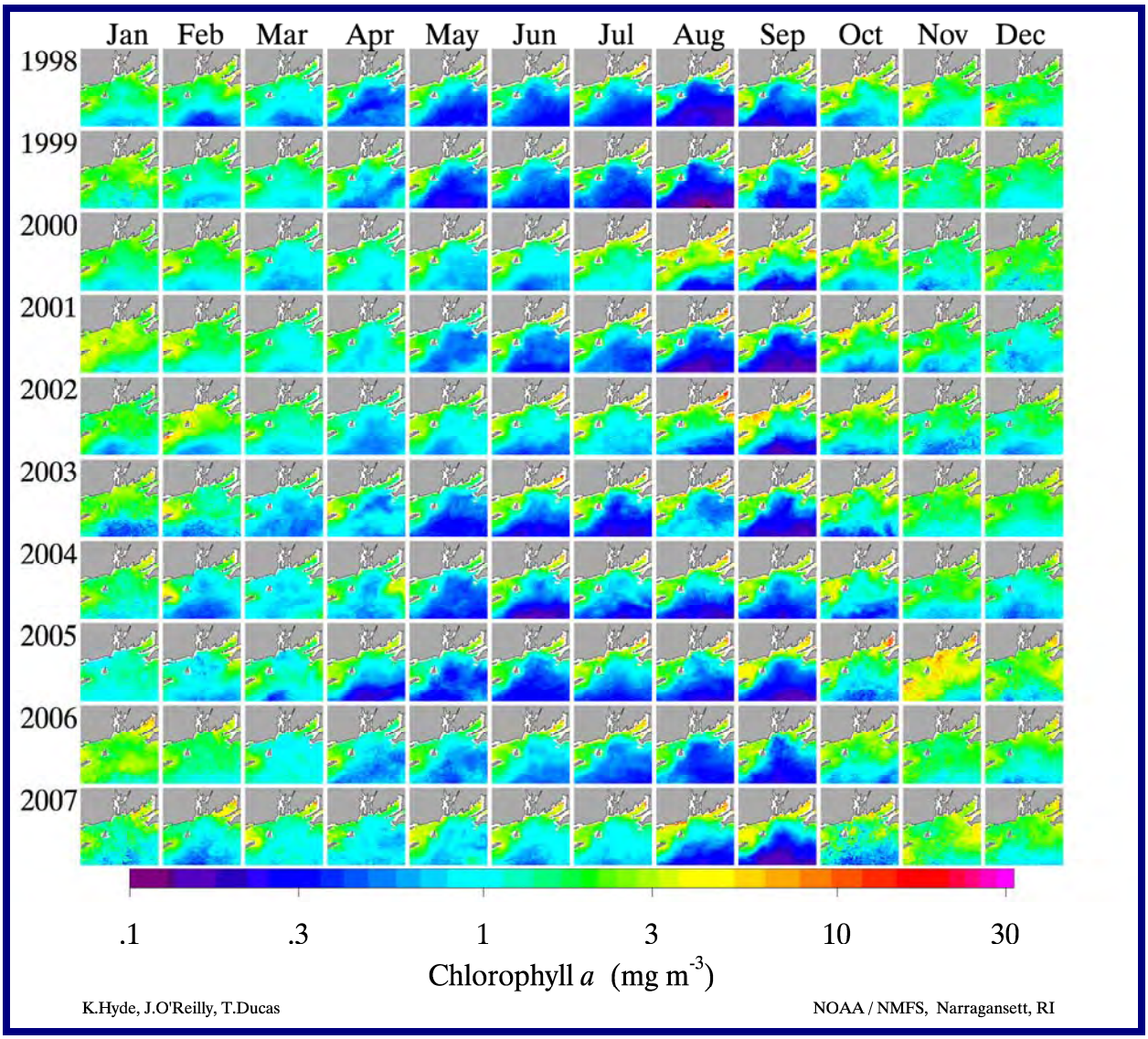


Figure 2.22. Monthly averaged chlorophyll *a* concentrations, 1998 through 2007, in the Ocean SAMP area (from Hyde 2009). There is distinct seasonality, as well as greater phytoplankton growth nearshore where shallower water, increased nutrient availability, and warmer waters all combine to improve growing conditions.

250.1.3. Zooplankton

1. Zooplankton are important components of marine ecosystems as they convert plant matter (phytoplankton) into protein that then fuels higher trophic levels of the food web. Long-term change in the zooplankton community of the Ocean SAMP area is not readily apparent based on existing data, suggesting stability in this food web component.

2. Deevey (1952a) found that the zooplankton community of Block Island Sound was a mix of oceanic (from beyond the continental shelf), neritic (from the continental shelf area), littoral (from sheltered waters and bays) and estuarine species (from areas were salinity varies widely over short periods of time). In essence, Deevey (1952a) considered the area to act as

an intermediary, or "mixing basin," for various adjacent environments. It is possible that this unique mixture of species may facilitate species interactions (predator-prey relationships, competition, etc.) and alternative food-web structures that may not occur in other environments, though this has not been studied.

3. This unique zooplankton community changes seasonally. Deevey (1952a,b) furthermore found that there was a distinct zooplankton maxima that occurred in mid-winter, with seasonal lows in early spring and again in late autumn. There was a seasonal progression where native species (e.g., littoral species and larval forms of bottom invertebrates) dominated the zooplankton community from January through July; then from August through December the number of species doubled due to an influx of Atlantic Ocean water containing myriad warm water, non-native species from farther south. Given current trends of warming waters, such a phenomenon as this could be important in promoting an influx of southern, warm water species to the Ocean SAMP area.

4. Species composition of the zooplankton changed with salinity (Deevey 1952a). For instance, the copepod *Centropages typicus* was dominant in surface waters, but then its abundance declined as salinity levels declined. During the 1945 and 1946 surveys, Deevey (1952a) reported no midsummer zooplankton maximum (e.g., a population increase between spring and fall minima) as a result of reduced salinity in Block Island Sound, which was noted at both surface and at depth and was suggested to be a result of an increase in freshwater input to Long Island Sound during that time. Increased water column stratification was also observed over the same time frame as was the observed shift in composition of the zooplankton community, though no causality was implied. The zooplankton community is dynamic and changes with temperature and salinity changes, which in turn may influence the presence and abundance of upper trophic level species in the area, though this has not been studied.

5. Important types of zooplankton in Block Island Sound (in 1949) included copepods, cladocerans, pelagic tunicates, larval forms of bottom invertebrates, and ctenophores (Deevey 1952b). In another report, Deevey (1952a) describes some of the important zooplankton assemblages and community members:

    a. Copepods—*Centropages typicus*, a neritic species, was found year round in Block Island Sound but responded negatively to declining salinity, with an apparent threshold at 30‰. This species was a dominant community member throughout the survey period. *Centropages hamatus*, a littoral/neritic species at the southern edge of its range, was important over the course of the survey period. *Acartia tonsa*, a littoral species very common in Narragansett Bay, became more abundant in Block Island Sound waters during late summer as numbers of *C. typicus* declined. It is not known if warming temperatures due to changing climate have altered the abundance of this species in Block Island Sound.

    b. Cladocerans—*Podon leuckarti* was found during late spring and comprised about 20% of sample tows during that time. *Podon intermedius* was found during summer and fall in varying numbers. *Evadne normanni* was found only in the later part of the study and

not in large numbers. However, this species appeared to favor lowered salinities and could be an important community member under reduced salinity conditions.

c. Other—Larval forms of *Balanus balanoides* (common barnacle) were common during the winter and spring. Early larval forms of a *Lysiosquilla* stomatopod that appears to be common but not well known for Block Island Sound, probably living a reclusive life style in deep burrows, was common during late summer/early fall. Pelagic tunicates were common during later summer, with various jellyfish developmental stages abundant spring through summer. Various southern species that had traveled north on the Gulf Stream, as well as northern species, were found in the tows but only as stragglers and were considered unimportant in the zooplankton community overall.

6. Zooplankton can be voracious grazers on phytoplankton and are capable of limiting production available for consumption by other species (as in Narragansett Bay; Riley 1952, Martin 1965). Riley (1952) did not see any correlation between zooplankton grazing and phytoplankton abundance, and therefore concluded that zooplankton grazing did not control the size of the phytoplankton population at any time in Block Island Sound. Riley's conclusion however, was based on Deevey's findings (1952a,b) for Block Island Sound, and those may not apply to adjacent waters. Further research in this area could alleviate confusion, and perhaps better define the role of zooplankton grazing on phytoplankton stocks in the Ocean SAMP area.

7. There has not been much work published on the zooplankton of Rhode Island Sound, so a sample station located at the mouth of Narragansett Bay is considered as a proxy for at least that area where it meets Rhode Island Sound. Zooplankton abundance peaked in February, April and July during surveys conducted 1959-1962 (Martin 1965). Later studies showed that zooplankton abundance declined to almost zero in late summer and fall as seen in surveys conducted 1972-1973 (Hulsizer 1976), though Martin (1970) found that *Skeletonema* abundance declined coincident with an increase in the abundance of the ctenophore *Mnemioposis leidyi*. Ctenophores can be voracious consumers of *Skeletonema* and other zooplankton. Martin (1970) noted the importance of this ctenophore in controlling zooplankton abundance, though this species was not noted to increase during Martin's earlier study (1965). *Acartia tonsa, A. clausi* and *Pseudoclanus minutus* were the major species of zooplankton present in later surveys (Hulsizer 1976). Ctenophores have a strong, but apparently inconsistent, influence on zooplankton abundance and composition in the Ocean SAMP area.

8. Marine Resources Monitoring, Assessment and Prediction Program (MARMAP; Kane 2007) zooplankton data collected at a suite of stations in Rhode Island Sound and Block Island Sound between 1978 and 2007 provide a contemporary look, and show a seasonal progression of dominant species (Table 2.4). The most abundant zooplankton types throughout the year are copepods, which make up 82% of the total number of zooplankton sampled in winter, 76% in spring, 63% in summer and 70% in fall. Species abundances reported here are in general agreement with those of Deevey (1952a, b), suggesting no long-term shift in dominant zooplankton species during the previous 50 to 60 years. Seasonal shifts noted by Deevey (1952a; e.g., *Acartia tonsa*) also appear to have remained stable over that same 50 to 60 year time frame.

Table 2.4. MARMAP Ocean SAMP area zooplankton data collected since 1978 (Kane 2007). The number of stations sampled has decreased from a high of 28 (1980) stations to 11 stations (2007; lowest = 2 stations in 1998).

		Percent of Total Number			
Taxa	**Common name**	**Winter Jan-Mar**	**Spring Apr-Jun**	**Summer Jul-Sep**	**Fall Oct-Dec**
Centropages typicus	copepod	32.6	7.0	27.2	49.7
Pseudocalanus spp.	copepod	33.4	28.7	11.6	1.7
Temora longicornis	copepod	5.1	19.3	5.3	1.7
Appendicularia	free swimming tunicates	8.5	11.8	2.4	3.3
Calanus finmarchicus	copepod	2.1	10.5	7.9	1.2
Penilia avirostris	cladoceran	0.0	0.0	13.9	12.3
Acartia spp.	copepod	1.1	1.7	5.0	8.1
Echinodermata	larvae of sea stars, urchins, etc.	2.0	0.1	8.1	4.7
Centropages hamatus	copepod	1.6	5.5	3.1	1.3
Paracalanus parvus	copepod	6.1	0.2	1.5	6.5
Salpa	tunicates	0.0	0.0	5.6	6.1
Gastropoda	larvae of snails, etc.	3.1	1.0	3.7	0.7
Evadne spp.	cladoceran	0.2	4.2	1.2	0.2
Acartia longiremis	copepod	0.3	2.7	1.6	0.2
Chaetognatha	arrow worms	0.9	1.6	1.5	1.9
Cirripedia	larvae of barnacles	2.9	2.6	0.0	0.1
Evadne nordmanni	cladoceran	0.0	3.1	0.3	0.4

9. At a scale of the Northeast U.S. Continental Shelf, trends for increasing total annual zooplankton biomass since the early 1980s have been noted (NOAA National Marine Fisheries Service n.d.). A species shift since 1990 has also been seen, with smaller-bodied taxa becoming more prominent (Kane 2007). A shift in seasonality for some species, such as *Calanus finmarchicus*, to expressing peak abundance earlier in the season, and holding that peak further into the season was also observed. These trends are noted for the entire northeast shelf region, and so it can be presumed that these apply to the Offshore Ocean SAMP area region, though such change is not readily apparent based on existing data for the Ocean SAMP area; robust study on this topic has not been undertaken however. Since zooplankton are at the base of the food chain and a source of energy for myriad species, it can be expected that temporal changes in zooplankton abundance and species composition may propagate up the food chain influencing abundances of higher trophic level species.

250.1.4. Microbes

1. Microbial ecology is relatively unstudied in the Ocean SAMP area, though some work has been undertaken in neighboring Narragansett Bay (Marston 2008; Staroscik and Smith 2004). Those findings are presented here as a potential, though not proven, proxy for Rhode Island Sound, given there is no other known information to consider. Further research is needed to determine if the use of Narragansett Bay microbial communities as a proxy to Rhode Island Sound is reasonable and correct.

2. Several studies suggest that bacterial and phytoplankton mortality due to viruses is comparable to mortality due to zooplankton grazing, and if so, this could be an important

influence on community composition (Wommack and Colwell 2000; Brussaard 2004; Suttle 2005; Weinbauer and Rassoulzadegan 2004; Marston 2008). Viruses are known to be abundant and diverse in productive coastal waters (Fuhrman 1999; Wommack and Colwell 2000; Weinbauer and Rassoulzadegan 2004; Marston 2008). Abundances of cyanophages (viruses that infect cyanobacteria, namely *Synechococcus* in Rhode Island waters) are comparable and exhibit similar seasonal patterns in Rhode Island Sound as are seen in Narragansett Bay (Marston 2008), with viral abundance peaking during summer months first in Rhode Island Sound, followed by a peak in Narragansett Bay. Furthermore, Richardson and Schoeman (2004) suggest that warming marine waters, due to changing climate, may initiate a shift from phytoplankton-based food webs to microbial-based food webs. Though no published work on microbes in the Ocean SAMP ecosystem was found, it is important to consider due to the potential to influence the amount of primary production available for consumption by higher trophic level species (i.e., zooplankton, fish, shellfish).

3. Staroscik and Smith (2004) found a high correlation between temperature and bacterial abundance, but that it was also seasonal, with abundance being highest in spring and reduced in the fall. The peak of bacterial production, measured at 68 g C m^{-2} yr^{-1}, was in late June and early July, where it remained high until water temperatures began to decline in September. Staroscik and Smith (2004) found it likely that temperature, grazing, viral lysis, and substrate availability all play a role in bacterioplankton production. Their sample station was located in lower Narragansett Bay, at the dock at the University of Rhode Island Graduate School of Oceanography; it is not known how well the observed patterns translate to Rhode Island Sound waters.

250.1.5. Fish and Invertebrate Eggs and Larvae

1. The ichthyoplankton of the Ocean SAMP area is rich and varied, showing strong seasonality for various species, no doubt linked to reproductive cycles. Report of a circulation gyre in Rhode Island Sound requires further research (see Section 240.1) to determine its influence on the ecology of the area, and how this affects larval transport throughout the area and the water column, if at all. There appear to be changes in the species found over time, but the data were not collected in a fashion that promotes direct comparison, suggesting another avenue for research, particularly in light of the impacts of climate change; more detailed analysis of the MARMAP (Richardson et al. in press) data might provide improved understanding of fish species shifts in the Ocean SAMP area (see Section 250.3).

2. Many fishes and invertebrates spend some portion of their life cycle as planktonic organisms, with tides and ocean currents, as well as behavior dictating their vertical and horizontal distribution. Spending time adrift in the plankton is an important life history strategy that promotes dispersal of populations into new areas as well as improving the chance that some larvae will settle in suitable habitat. For instance, rock crab larval forms can be advected tens of kilometers over short time spans (Clancy and Cobb 1997).

3. The timing of reproduction generally coincides with conditions most favorable to a species survival, whether it is seasonal winds that promote circulation patterns that concentrate food, or water temperatures that best promote growth of larvae and juveniles. Alteration of the pattern and/or timing of seasonal events can alter the abundance and/or distribution of

species. For example, changes in dominant copepod assemblages have been noted on both sides of the North Atlantic Ocean with increasing water temperatures (Beaugrand et al. 2002); corresponding patterns have been found for Atlantic cod (greater numbers of cod during shifts to larger copepods and fewer cod during shifts to smaller-sized copepods; Beaugrand et al. 2003; Hays et al. 2005).

4. It is interesting to note that Shonting (1969) observed bottom waters in Rhode Island Sound that moved in a rotary fashion, providing little overall positive transport in any given direction. Hyde (2009) also suggests the existence of gyre-like circulation in Rhode Island Sound, and if so then this could restrict interaction with Narragansett Bay, though she found that the probability of larval transport into Narragansett Bay from Rhode Island Sound was directly related to proximity to the mouth of the bay. Modeled results by Codiga and Ullman (2010) suggest that deep flow is weak but consistently onshore during fall and winter months, and mainly east to west flowing during spring and summer (see Figure 2.16 and Figure 2.17). Therefore, it is likely that larvae and eggs trapped in bottom waters may be primarily contained in the gyre-like circulation of Rhode Island Sound mitigating transport outside of the Ocean SAMP area, though this topic needs more focused study to draw robust conclusions as it is unclear if a true gyre exists, as has been hypothesized.

5. Pfieffer-Herbert (2009) found that ichthyoplankton (fish eggs and larvae) may have undergone a shift in species composition over time. Figure 2.23 suggests that the Narragansett Bay–Rhode Island Sound interface area has seen a decrease in the bay anchovy (*Anchoa mitchellii*) since the late 1980s, with none being found during surveys in the late 1990s. Cunner (*Tautogolabrus adspersus*) has increased in abundance over that same time span; other species change has also occurred (e.g., other in Figure 2.23). Interestingly, Collie et al. (2008) have noted a decrease in adult cunner in the same general area over the past 10–15 year time span. Further work is clearly needed to update these findings with contemporary data, and to relate these to changes in the fish community (see Section 250.3).

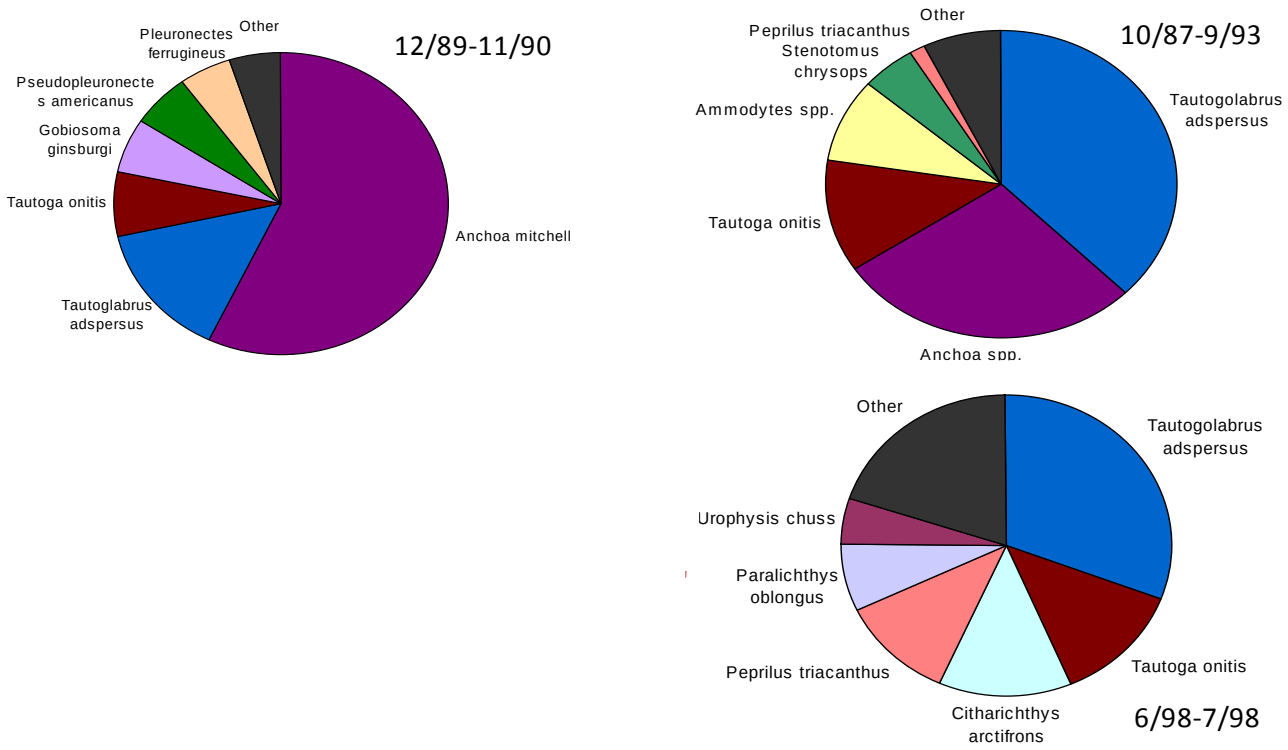


Figure 2.23. Ichthyoplankton abundance at the mouth of Narragansett Bay/Rhode Island Sound at various points in time (from Pfieffer-Herbert 2009).

6. Katz et al. (1994) found that modeled passive drift from the offshore Ocean SAMP area into Rhode Island Sound would move lobster larvae towards shore, and that if active swimming by the larvae were accounted for, the larvae could readily reach the shoreline (Figure 2.24). Given this finding, it can be presumed that actively swimming larvae, though it would be highly species specific, could utilize current flows in the Offshore Ocean SAMP area region as an effective population dispersal mechanism to inshore habitats. Based on known current patterns for Rhode Island Sound, this would be particularly true for areas located in the eastern portion of Rhode Island Sound.

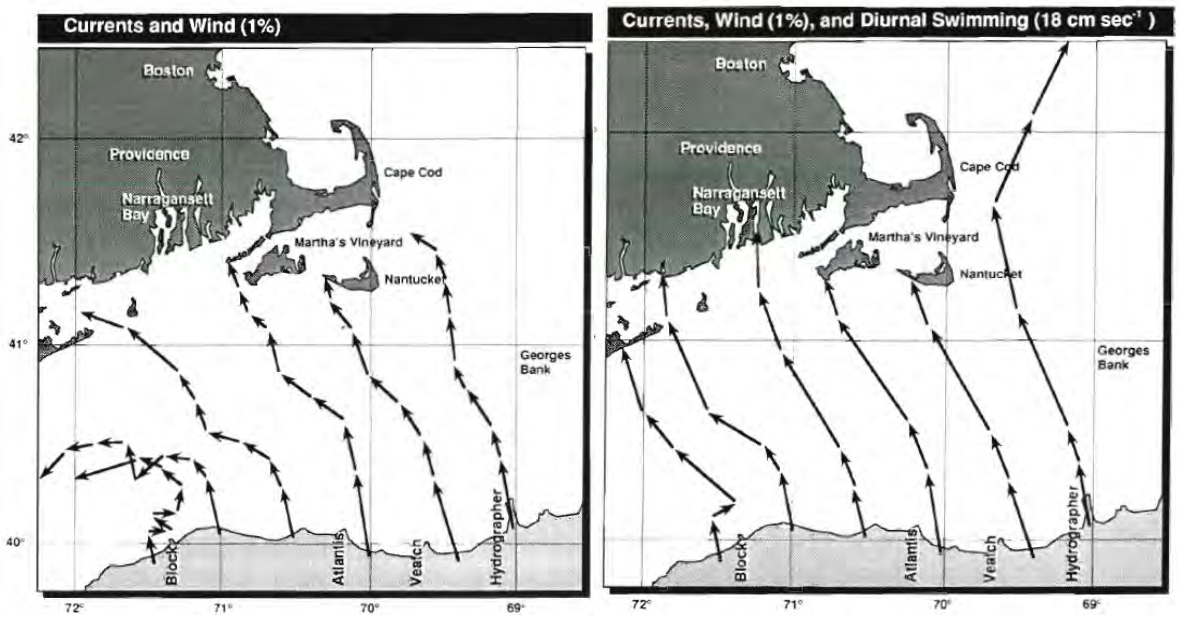


Figure 2.24. Lobster larval transport from the edge of the Continental Shelf into Rhode Island Sound and Block Island Sound (from Katz et al. 1994).

7. Merriman and Sclar (1952) conducted surveys of fish eggs and fish larvae in Block Island Sound, and found a seasonal assemblage of species represented (Table 2.5). Mackerel and weakfish were the most abundant species, and it was suggested these species spawn in Block Island Sound. Pipefish, sea horse, brassy sculpin, lumpfish, wrymouth and goosefish were all considered to be accidentals. Merriman and Sclar (1952) considered scup to have only limited spawning area in Block Island Sound, and that tautog were generally a more inshore species and less common to Block Island Sound waters. Hake and yellowtail flounder were common, but the lack of eggs and larvae suggested that they spawn elsewhere. While fluke were found, Merriman and Sclar (1952) noted this species was a more southerly spawner. They also suggested that mackerel, cod, butterfish, weakfish and cunner were the only fish with pelagic eggs that spawn in Block Island Sound with any regularity and abundance. Silver, squirrel and white hake, and yellowtail flounder, were considered to spawn to the east and southeast of Block Island Sound; tautog and windowpane flounder were suggested to spawn inshore in shallow waters.

Table 2.5. Seasonality of fish eggs and larvae in Block Island Sound (Merriman and Sclar 1952).

Month	Eggs	Larvae
January	Cod	Herring, Long-horn sculpin
February	Cod	Cod, Long-horn sculpin
March	Cod	Cod, Long-horn sculpin
April	Mackerel	Lumpfish, Wrymouth, Cod, Long-horn sculpin, Brassy sculpin, Hake, Yellowtail flounder
May	Mackerel, Butterfish	Lumpfish, Cod, Hake, Yellowtail flounder, Brassy sculpin, Mackerel, Butterfish
June	Goosefish, Cunner, Butterfish, Mackerel, Weakfish	Hake, Mackerel, Cunner, Butterfish, Yellowtail flounder, Windowpane flounder
July	Cunner, Butterfish, Weakfish	Sea horse, Pipefish, Hake, Windowpane flounder, Yellowtail flounder, Scup, Tautog, Whiting, Weakfish, Butterfish, Cunner
August	Cunner, Butterfish, Weakfish	Hake, Yellowtail flounder, Butterfish, Cunner, Whiting, Weakfish
September	Butterfish, Weakfish	Herring, Hake, Butterfish, Whiting, Weakfish
October	Weakfish	Herring, Hake, Butterfish, Whiting, Weakfish
November	Cod	Herring, Hake, Whiting, Fluke
December	Cod	Herring, Fluke

8. The Marine Resources Monitoring, Assessment and Prediction Program (MARMAP; Richardson et al. in press) collected ichthyoplankton samples at a suite of stations in Rhode Island Sound and Block Island Sound between 1978 and 2007. These data are presented in Table 2.6, and show distinct seasonality with regard to species abundances. While there are differences in sample area (Block Island Sound (Merriman and Sclar 1952) vs. Ocean SAMP area (Richardson et al. in press)), there are distinct differences in the predominant species sampled. For instance, sand lance (*Ammodytes*) is a species not mentioned in the Merriman and Sclar (1952) survey, yet it is the most abundant winter species in the MARMAP data. Cod, a very prevalent species in the Merriman and Sclar data, is not mentioned in the MARMAP data. It would be of interest to undertake more specific treatment of the MARMAP data, doing various analyses that would check for species shifts over time for comparison to Pfeiffer-Herber (2009) findings, and to changes in fish abundances (see

Section 250.3). Further research is needed to explore differences and/or correlations between these data sets, and to examine other variables that may be influencing these species shifts.

Table 2.6. MARMAP (Richardson et al. in press) ichthyoplankton data collected since 1978. The number of stations sampled has decreased from a high of 28 stations (1980) to 11 stations (2007; lowest = 2 stations in 1998).

		Percent of Total Number			
Taxa	**Common name**	**Winter Jan-Mar**	**Spring Apr-Jun**	**Summer Jul-Sep**	**Fall Oct-Dec**
Ammodytes	sand lance	97.5	1.1	0.0	43.6
Scomber scombrus	Atlantic mackerel	0.0	72.9	0.1	0.0
Urophycis	hake	0.0	0.0	25.1	4.6
Tautogolabrus adspersus	cunner	0.0	0.7	26.8	0.0
Citharichthys arctifrons	Gulf Stream flounder	0.0	0.0	19.0	1.8
Paralichthys dentatus	summer flounder/fluke	0.0	0.0	1.5	23.1
Merluccius bilinearis	silver hake	0.0	0.9	7.8	6.1
Limanda ferruginea	yellowtail flounder	0.2	15.8	0.1	0.0
Scophthalmus aquosus	windowpane flounder	0.0	3.4	1.5	4.3
Peprilus triacanthus	butterfish	0.0	0.0	5.1	0.3
Etropus	smallmouth flounder	0.0	0.0	3.1	3.4
Hippoglossina oblonga	four spot flounder	0.0	0.0	4.7	0.1
Clupea harengus	Atlantic herring	0.0	0.0	0.0	6.6
Bothidae	left eye flounders	0.0	0.0	0.3	4.9
Tautoga onitis	tautog/blackfish	0.0	0.2	2.3	0.0
Etropus microstomus	smallmouth flounder	0.0	0.0	1.9	0.8
Enchelyopus cimbrius	fourbeard rockling	0.0	2.4	0.7	0.4
Pseudopleuronectes americanus	winter flounder	2.2	2.6	0.0	0.0

250.1.6. Harmful Algal Blooms

1. Harmful Algal Blooms (HABs) are a rapid increase and accumulation of toxic or otherwise harmful phytoplankton in a specific area and in quantities that pose threats to ecosystems and/or human health. Concentrations of algae in the water column can exceed thousands of cells per milliliter, and depending upon the organism involved, can discolor the water to create a “red tide” or “brown tide” event. Harm to the ecosystem can result from massive die-off of phytoplankton, which during microbial-mediated decomposition depletes oxygen in the water column leading to hypoxic (very little oxygen) or anoxic (no oxygen) conditions which can be stressful and/or lethal to aquatic organisms. *Alexandrium fundyense*, a common species of harmful algae in New England waters causes paralytic shellfish poisoning (PSP) in humans when contaminated shellfish are consumed, and has been responsible for the closure of shellfish beds to protect human health (Anderson et al. 2005).

2. Red tides are a frequent occurrence along the coast of Maine, and are becoming more common in Massachusetts waters (Anderson et al. 2005); warming waters due to changing climate have been reported as at least partially responsible for the increasing occurrence of HABs (Bricker et al. 2008; see also Chapter 3, Global Climate Change, Section 330.1).

HABs have also been shown to be triggered by increases of nutrients from outside sources (Smayda 2008), such as increased anthropogenic or atmospheric inputs of nitrogen (Paerl et al. 2002). Typically, bloom events occur in summer months when water is warmest and phytoplankton production highest. While HABs have not been documented in the Ocean SAMP area, there are a high number of potentially harmful species present (Hargraves and Maranda 2002), and therefore the Ocean SAMP area should not be considered immune to such threats, particularly given changing climate and noted warming trends.

250.2. Benthic Ecosystem

1. The Ocean SAMP area is located at the boundary region of two biogeographic provinces, also known as eco-regions—the Acadian to the north and the Virginian to the south (see Section 200 for descriptions)—with direct, broad connection to the Atlantic Ocean. The dynamic oceanography of the Ocean SAMP area, coupled with its geologic history and geographic juxtaposition, shapes the nature and dynamics of the existing benthic communities. Although there have been several surveys of the benthic fauna, and recently some detailed studies in selected areas, most done in impacted areas such as dredge material disposal sites, there is relatively little contemporary information on benthic communities. Consequently, our understanding of spatial and temporal dynamics, and the implications for ecosystem functioning, are somewhat rudimentary as well as fragmented.

2. The benthic environment is an important element of coastal marine ecosystems. The benthos provides structure for myriad organisms, such as polychaetes and amphipods, to colonize the substrate, add organic matter to the sediments, and provide a source of food for benthic invertebrates and fishes. The benthos also plays an important role in nutrient cycling within marine systems. The benthic environment is further used in the disposal of wastes, and the Ocean SAMP benthos has functioned in this capacity as a site for the disposal of dredged materials from Narragansett Bay. The Ocean SAMP area was also the site of an oil spill, and though the scale of the spill was small, it was considered locally to be a significant disturbance event.

3. Benthic communities in the Ocean SAMP area are largely dominated by various species of benthic, tube-dwelling amphipods (LaFrance et al. 2010). The bivalve *Nucula*, as well as various species of polychaetes, mysids and cumaceans, fill out benthic community species composition. Rhode Island Sound and Block Island Sound share many species, but research survey work by LaFrance et al. (2010) suggests that benthic habitat in Block Island Sound is more variable than in Rhode Island Sound, and that Block Island Sound is more diverse (11 phyla and 156 genera vs. 8 phyla and 75 genera, respectively). LaFrance et al. (2010) suggest that fundamental differences in habitat make up and utilization exists between Block Island Sound and Rhode Island Sound, though they admit their present findings cover only a small section of each of these large ecosystems. Further such research will provide greater understanding of sediment type–species relationships, which at present are only tenuously known. Having this information would greatly assist in a better understanding of the ecology of the region, and could be a start towards the development of ground-truthed benthic habitat maps for the Ocean SAMP area.

4. Several contemporary side-scan surveys have been made in Rhode Island Sound in relation to dredged materials site monitoring (Battelle 2003c), and also independently by the U.S. Geological Survey (McMullen et al. 2007; 2008). There was also a survey that was conducted in the western portion of Block Island Sound (Poppe et al. 2006), and very recent benthic surveys of small portions of Block Island Sound and Rhode Island Sound by LaFrance et al. (2010). These side-scan surveys reveal high resolution details of the sedimentary patch structure of the sea floor in Rhode Island Sound and Block Island Sound. This benthic patch structure is quite complex and comprised of a variety of topographic features shaped by the dynamic sedimentary environments (erosional, sorting and reworking, and transport, see Section 210; LaFrance et al. 2010). The biologic sampling and field ground-truthing needed to correlate side-scan imaging to benthic habitat types and probable species assemblages has only recently begun, but will provide a very useful ecological assessment and resource management tool as it is conducted and results are released.

5. Based on observed benthic change between surveys completed in 1991 and 1994, Driscoll (1996) suggested that anthropogenic effects have greater impact on reworking benthic surface sediments in Block Island Sound than large storms after finding an increase in the distribution and density of trawl door scars caused by fishing gear dragged across the seafloor in their survey area. Fishing can have local impacts on habitat as well as more wide-spread impacts on species biodiversity due to re-suspension of particulates, chemical impacts causing changes in nutrient cycling, and biological impacts from changes in species composition (DeAlteris et al. 2000). Of interest to note is that the dominant benthic invertebrates of the Ocean SAMP area—tube-dwelling, ampeliscid amphipods—appear to do well in disturbed areas; it is unclear if fishing activity that disturbs the bottom is having either a positive or negative impact, if any, on these species. LaFrance et al. (2010) found that benthic habitat areas comprised of highly mobile sediments tended to have low diversity and low abundances, suggesting that organisms found in these habitat types must be able to withstand repeated disturbance events. This is an area were further study is needed to better determine the impacts, both positive and/or negative, of disturbance events, both natural and of anthropogenic origin, on benthic communities and the ecosystem as a whole.

6. Maps of benthic habitat can be an important element in understanding ecosystem dynamics, but are challenging to develop. While various classification schemes have been proposed, most existing schemes are based on physical factors such as bathymetry, sediment grain size, sediment texture and/or topographic features. LaFrance et al. (2010) provide a summary description of the various approaches to mapping benthic habitats, their pluses and minuses, and limitations. Regardless of the scheme, the intent is to assist in the identification of habitats of key importance to the ecosystem, and to guide both future research efforts as well as management initiatives. Several proxy maps have been developed for use in considering the ecology of Rhode Island and/or Block Island Sounds using sediment composition, and most recently "surface roughness," a basic measure, interpreted from sidescan sonar imaging, of the unevenness of the seafloor bottom topography.

7. Figure 2.25 shows benthic geological environments, and genus-defined benthic geological environments, as interpreted from side scan imagery, sub-bottom profile imagery, sediment samples, and underwater video surveys reported by LaFrance et al. (2010). Zajac (2009) developed a first order compilation of benthic species–sediment type relationships (Table

2.7) based on the published literature. There appears to be basic agreement in distribution of some types, for example *Byblis* (bottom panel) in coarse sand and gravel areas (top panel), while for others, *Ampelisca* for example, the agreement is less clear. Further mapping such as that conducted by LaFrance et al. (2010) will help to better define the benthic environment of the Ocean SAMP area, and may allow for comparison to past surveys that may have accurately identified the geographic location of sample sites. The survey results of LaFrance et al. (2010) are in general agreement with past survey findings that tube-dwelling amphipods are the most abundant benthic organism. LaFrance et al. (2010) suggest that the large mats created by tube-dwelling amphipods are valuable benthic habitat that provides a positive influence on the benthic ecosystem.

Table 2.7. First approximation of species preferences, based on the published literature, for habitats in the Ocean SAMP area (adapted from Zajac 2009).

Sediment Type	Species Association
Silt & Silty Sand	Amphipod–*Ampelisca agassizi, A. Vadorum*; Bivalve–*Nucula proxima*
Coarse Sand/ Sand–Gravel	Amphipod– *Byblis serrata, Acanthohaustorius millsi*; Polychaete–*Aricidea catherinae*
Mud	Amphipod– *Leptocheirus pinguis*

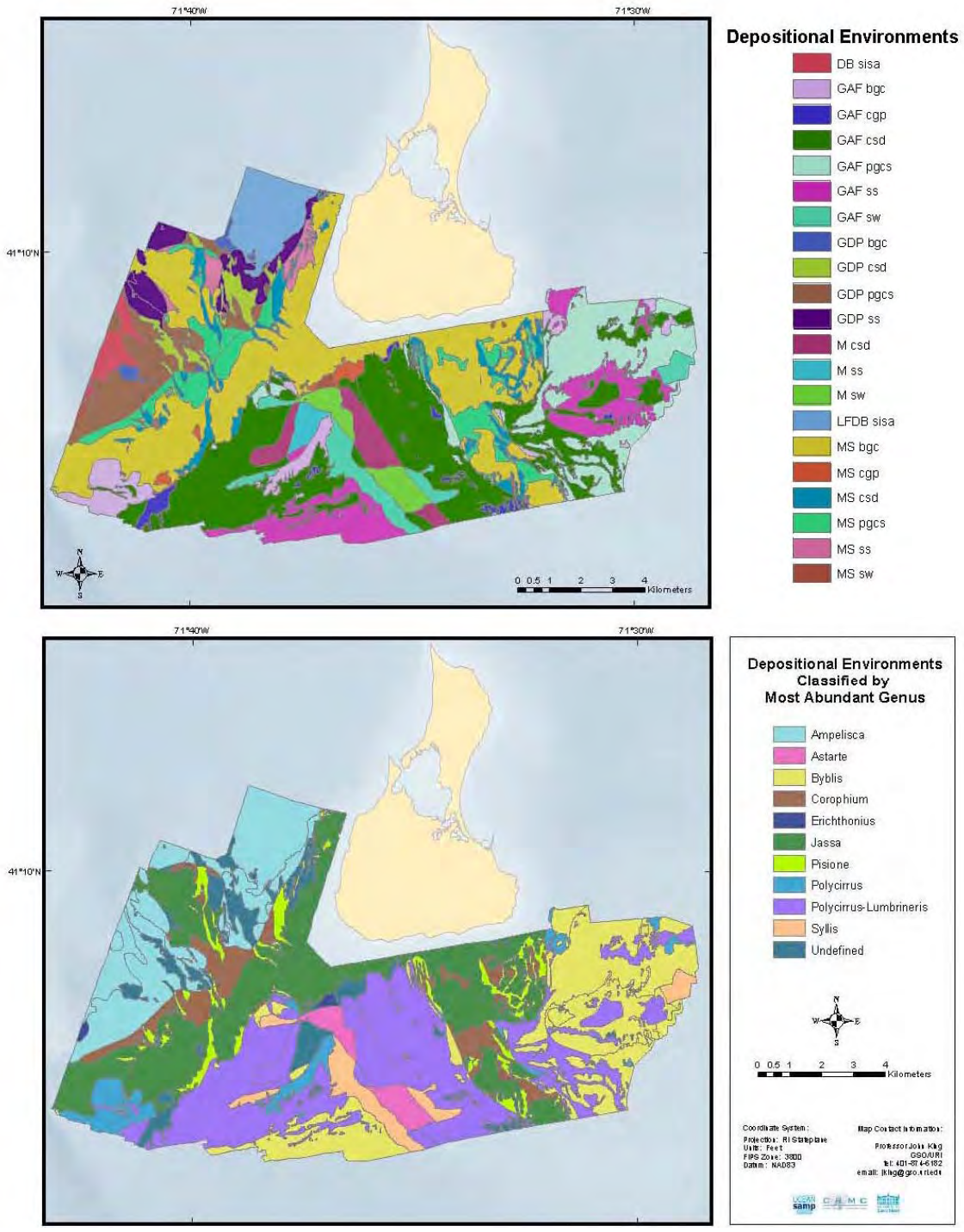


Figure 2.25. Benthic geological environments (top) and genus defined benthic geological environments (bottom) in a select portion of Block Island Sound (LaFrance et al. 2010). Top panel key: DB=Depositional Basin; GAF=Alluvial Fan; GDP=Glacial Delta Plain; M=Moraine; MS=Moraine Shelf; LFDB=Lake Floor/Depositional Basin; sisa=silty sand; bgc=boulder gravel concentrations; cgp=cobble gravel pavement; csd=coarse sand with small dunes; pgcs=pebble gravel coarse sand; ss=sheet sand; sw=sand waves.

8. Habitat diversity promotes species diversity—the more complexity a habitat contains the greater the number of species the habitat can generally support (Eriksson et al. 2006). A potential proxy for habitat complexity in marine benthic ecosystems could be surface roughness. The presumption is that the rougher the bottom, the greater the vertical complexity, which could be equated with the promotion of increased species diversity. King and Collie (2010) have developed a first-order interpretation of bottom roughness from sidescan sonar images for the Ocean SAMP area (Figure 2.26). Until further interpretation accompanied by groundtruthing occurs, increased surface roughness, as shown in Figure 2.26, should be considered only as providing the potential for habitat that promotes increased species diversity and/or abundance. Initial findings by LaFrance et al. (2010) suggest that the relationship between surface roughness and habitat diversity appears to vary according to the scale at which surveys are conducted and the accompanying statistical routines used to interpret the relationship. They find that a relationship does exist between surface roughness and habitat diversity, though it is clear that further research needs to be conducted, at appropriate scales, to elucidate how this relationship relates to species abundances and uses of the various benthic habitats in the broader Ocean SAMP area. Malek et al. (2010) also found a trend towards greater habitat complexity, but only for Block Island Sound, based on acoustically derived surface roughness interpretation, but again suggesting that more research is needed to further verify and build upon these findings.

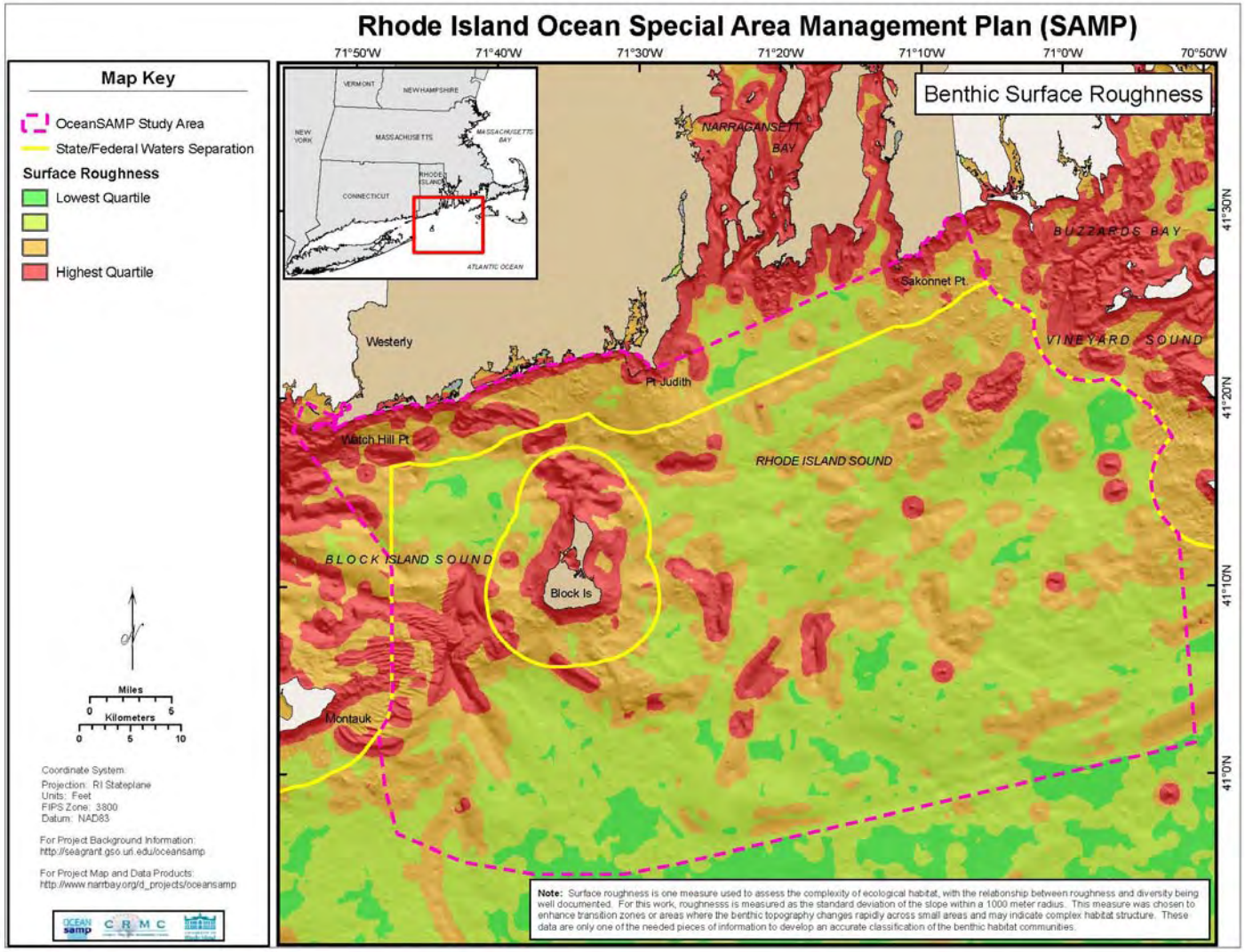


Figure 2.26. Benthic surface roughness as a first approximation proxy for habitat complexity in the Ocean SAMP area (King and Collie 2010).

9. The Rhode Island Sound Disposal Site (RISDS), located in Rhode Island Sound approximately 17 km south of Point Judith (Figure 2.21), received four million cubic meters of dredged materials removed during the Providence River and Harbor Maintenance Dredging Project between April 2003 and January 2005. Wilson et al. (2009) found that sediment in the disposal site often had a black coloration, but low dissolved oxygen concentrations (e.g., hypoxic conditions) were not found. Wilson et al. (2009) also found that species diversity in the disposal site was lower than nearby reference sites, but noted that the benthic community was recovering relatively rapidly with Stage II (intermediate, post disturbance community) and III (stable equilibrium community) infauna present in abundance three to four years post-disturbance.

10. Dredged materials from the Providence River channel had been disposed of in Rhode Island Sound previously at a site 4 miles south of Newport at the mouth of Narragansett Bay (Figure 2.21; Saila et al. 1972). Between December 1967 and September 1970, approximately 8.2 million cubic yards of dredged materials were deposited on this site. The benthic community structure described by Saila et al. (1972) at reference sites is similar to those noted by Wilson et al. (2009), suggesting recovery of the benthic ecosystem from the disposal disturbance event at this site as well.

11. A spill of No. 2 fuel oil occurred in the nearshore Ocean SAMP area (Figure 2.21) during January of 1996 and toxicity levels detrimental to benthic invertebrates were found in the sediments immediately following the disturbance. It is unclear if toxicity threats to benthic invertebrates continue to exist, but based on the time span since the spill it could be assumed that it would be minimal; Ho (1999) found rapid recovery of the benthic community within the year following the spill. It is not known if ecological impact might occur from the disturbance of sediments in areas previously impacted by the spill.

250.2.1. Invertebrates

1. Invertebrate species make up a large proportion of the biota found in the benthic ecosystem, and they play an important role as a food source for fishes, and for birds in shallow waters. The invertebrate community is often quite patchy, largely because of the highly diverse nature of the sediment types that have been transported, sorted, and deposited in specific areas on the seafloor landscape. Sediment type is an important determinant regarding the form of benthic community that will exist in marine aquatic ecosystems. The patchwork nature of the benthic community similarly sets the stage for the distribution of fishes and larger organisms.

2. The dominant benthic invertebrates of the Ocean SAMP area tend to be several species of amphipods that inhabit a variety of habitat types in a patchy distribution. Bivalves, polychaetes and mysids are also significant components of the benthic invertebrate fauna of the Ocean SAMP region.

3. Theroux and Wigley (1998) conducted an expansive survey (geographically), but those data are now more than a decade old, and at a scale too broad for specific use in the Ocean SAMP area. Given contemporary reports of rapid ecological change as a result of changing climate,

follow-up work for comparative purposes would be an asset in understanding the ecology of the Ocean SAMP area.

4. Published accounts suggest that the macrobenthic fauna in the Ocean SAMP area is comprised of several species groups that show varying affinities to certain bottom types (adapted from Zajac 2009; see Table 2.7). There appears to be possible seasonality, as well as change due to sediment transport and reworking, though separation of the two has not been attempted:

    a. Steimle (1982) found that there was an assemblage associated with silty fine sands dominated by several species of ampeliscid amphipods (e.g., *Ampelisca agassizi*) and the nut clam, *Nucula proxima.*

    b. An assemblage found in coarser sands was dominated by several other amphipod species (e.g., *Byblis serrata, Acanthohaustorius millsi*) and several polychaete species (e.g., *Aricidea catherinae*). This latter assemblage was fairly distinct in February, but by September, assemblages at the sandy and gravely stations were more variable.

    c. Steimle (1982) noted that the assemblages he found were similar to those defined by Pratt (1973) for different sediment types but did vary, likely due to complex topography and sediment patch structure as shaped by oceanographic processes.

    d. Steimle (1982) suggested that benthic communities were relatively stable over decadal periods, as the assemblages found in 1976 were similar to those found in the late 1940s.

    e. Hale (2002) reviewed this earlier work as well as studies conducted by the U.S. Environmental Protection Agency (EPA) as part of the Environmental Monitoring and Assessment Program in the early 1990s and by the National Marine Fisheries Service (NMFS) (Steimle 1990; Theroux and Wigley 1998) for the area around Block Island. In general, the benthic communities described in these studies were similar to those found in previous surveys, with dominant species including several amphipods, the bivalves *Nucula*, *Mytilus*, and *Arctica* and several polychaete species, including *Prionospio steenstrupia*, *Nephtys incisa*, and *Clymenella torquata*. The relative dominance of these species varied with geographic location, sediment type, and organic content (Hale 2002).

    f. LaFrance et al. (2010) found that in samples from both Block Island Sound and Rhode Island Sound that small surface burrowing polycheates of the genus *Lumbrineris* where the most broadly distributed, followed by small surface burrowing amphipds of the genus *Unciola* and large deep burrowing polycheates of the genus *Glycera*. With regards to abundance, LaFrance et al. (2010) found the tube-swelling amphipod genus *Ampelisca* to be the most abundant, followed by *Leptocheirus*, also a tube-dwelling amphipod.

5. The American lobster (*Homarus americanus*) is a large, scavenging, benthic invertebrate living in the Ocean SAMP area, and is of great commercial importance in the region. See

Chapter 5, Commercial and Recreational Fisheries, for detailed life history or the American lobster.

250.2.1.1. Block Island Sound

1. Savard (1966) noted a gravel/sandy-gravel cover on the ridge (moraine) running between Montauk Point and Block Island, the ridge and shallow area to the north of Block Island, and in the deep channels of western Block Island Sound. Silty-sand was found to cover most of the east-central plain of Block Island Sound and the protected shallows east of Gardners Island. Sand was found to cover most of the western and central areas of the sound, and the floor of the channel that cuts through the Montauk–Block Island ridge. Patches of gravelly-sand or silty-sand were found scattered throughout the sandy-bottomed area. Savard also found that mean sediment size decreased with distance from shore toward the center of Block Island Sound, with coarsest sediments found along the Montauk–Block Island ridge and parallel to the Rhode Island shore in the northern portion of Block Island Sound. Well-sorted sediment was found in southwestern Block Island Sound near Cerberus Shoal, moderately-sorted sediment was found north of the Montauk–Block Island ridge and in western Block Island Sound. Savard did not collect biological data and so species mapping to sediment type cannot be done until sediment–species relationships are better defined.

2. Steimle (1982) found the amphipods *Ampelisca agassizi* and *A. vadorum*, and a bivalve, *Nucula proxima*, to dominate silt and silty-sand sediments. Steimle (1982) noted that, based on previous reports of benthic fauna of Block Island Sound, that *Ampelisca* has dominated the benthic fauna for at least half a century, suggesting that the benthic community had been somewhat stable over that time frame. Work from Byron and Link (in press) on diet composition of fish species suggest that benthic communities have been stable across the entire Northeast Atlantic Shelf ecosystem, which includes the Ocean SAMP area, for the past 30 years despite widespread disturbance to the benthic habitat by both natural and anthropogenic forces.

3. Smith (1950) found the amphipod *Leptocheirus pinguis* to be very well adapted to muddy bottom areas in Block Island Sound. He found the tubes to be quite easily constructed and not very permanent—individual amphipods were seen to leave a burrow and build a new one when needed rather than travel back to an existing tube, suggesting the species to be quite mobile and adaptable. Smith (1950) suggests that fish trawl disturbance on the bottom does not harm this species of amphipod, and in fact suggests that such disturbance enhances conditions by putting detritus into the water column where it can be accessed as food; loss of dwelling tube was not problematic for this species.

4. Deevey (1952a) conducted limited sampling of benthic organisms during surveys. She found ampeliscid amphipods to be very abundant in bottom samples, more so than any other types except for the caprellid amphipod *Aeginella longincornis*. The mysid, *Neomysis americana*, was found to be very abundant in Block Island Sound during late summer, as were various species of cumacean. The decapods *Crangon septemspinosus* and *Dichelopandalus leptocerus* were abundant during fall months. All of these species are important prey items for many fish species residing and migrating through the Ocean SAMP area.

5. Sediments composed of coarse sand and/or gravel had distinct fauna of mixed amphipods and polychaetes, which often varied seasonally (Steimle 1982). Steimle considered this finding as showing the patchiness of the benthic habitats in Block Island Sound and that it was a reflection of the complex topography. Steimle's Table 1 (Steimle 1982) provides a full listing of benthic invertebrates sampled during the survey conducted; Steimle also noted that the species assemblage found resembled those reported from the inner continental shelf and/or other sounds in New England, and as reported by Pratt (1973).

250.2.1.2. Rhode Island Sound

1. Wilson et al. (2009) found reference sites in Rhode Island Sound to be typical of shallow-water New England benthic habitats, and that they were dominated by the bivalve *Nucula annulata*; the amphipods *Crassicorophium crassicorne, Ericthonius fasciatus, Ampelisca agassizi, Unciola irrorata,* and *Lepthocheirus pinguis;* and sabellid polychaetes; there is considerable similarity in species with those reported for Block Island Sound.

2. Benthic infaunal studies were conducted in Rhode Island Sound as part of the U.S. Army Corps of Engineers' Long-term Dredged Material Disposal Site Evaluation Project at four sites in 2001, and at two sites in 2003 (Battelle 2002a, 2003a; adapted from Zajac 2009):

    a. In 2001 all four sites were numerically dominated by the amphipod, *Ampelisca agassizi,* and the clam, *Nucula annulata*—comprising approximately 54 percent of the total infaunal abundance—and had relatively high abundances of the annelid worms, *Polygordius* sp., *Tharyx acutus, Oligochaeta* spp., *Ninoe nigripes, Levinsenia gracilis,* and *Exogone hebes*; the crustaceans *Byblis serrata* (Amphipoda) and *Eudorella pusilla* (Cumacea); and the clam *Nucula delphinodonta* (Battelle 2002a).

    b. Classification analyses indicated that almost all sampling stations at all four sites showed a 60 percent similarity. The exception was two sampling stations at one of the sites just south of Narragansett Bay, both of which had relatively high silt content and these were only roughly 25 percent similar to the other sites. There were no other distinct clusters of sites, but there was some clustering of stations within sites, suggesting that benthic infaunal communities in Rhode Island Sound may not vary greatly over scales of tens of kilometers. Any variations that may occur may be due to small-scale differences in sea floor structure or other processes (Zajac 2009).

    c. An additional survey was conducted in 2003 at one site overlapping with one of the 2001 survey sites. The infaunal communities found were generally similar to those found in 2001 (Battelle 2003a), although there were some differences that might be attributed to seasonal variation. In addition to benthic grab samples, candidate disposal sites were surveyed using sediment profiling imagery. The data collected were analyzed using a disturbance/succession model developed by Rhoads et al. (1978) and Rhoads and Germano (1986). Using this model, the analyses suggest that the successional stages of the communities vary considerably over relatively small spatial scales (Battelle 2002b; 2003b), suggesting frequent disturbance events.

3. The ocean quahog (*Arctica islandica*) and sea scallop (*Placopecten magellanicus*) are large bivalves found in the Ocean SAMP area (see Chapter 5, Commercial and Recreational Fisheries, for distribution and life history characteristics). Both species are found broadly throughout the area, often at high densities. As filter feeding bivalves, these organisms are capable of filtering large volumes of water and reducing particulate matter and plankton concentrations; the impact of feeding habits on the Ocean SAMP area ecology, however, are not known.

250.3. Fishes

1. There is a diverse and dynamic fish community in Ocean SAMP area waters, as recent work by Malek et al. (2010) suggests: Rhode Island Sound was found to have greater fish abundance and higher fish biomass than Block Island Sound, which corroborates a similar finding by Nixon et al. (2010) who suggest this to be so because Rhode Island Sound appears to have higher primary productivity than does Block Island Sound. Malek et al. (2010) also find that Block Island Sound has greater fish community diversity than does Rhode Island Sound. Malek et al. (2010) further found that a community of larger, more evenly distributed fish are found at depth, while shallow waters contain more diverse communities of smaller fish. Finally, Malek et al. (2010) found a strong relationship between benthic habitat complexity and demersal fish community diversity, with complex habitats containing greater fish diversity. In considering fish community ecology in the Ocean SAMP area, it must be recognized that this community has been manipulated, and perhaps ecologically altered, by commercial and recreational fisheries practices that have taken place historically. It is therefore not fully possible to determine what fish community make up may have been in the past relative to what we see at present.

2. The structure of the fish community in the Ocean SAMP area has undergone recent major change from a community dominated by demersal (near bottom) species to one dominated by pelagic (water column) species (Collie et al. 2008). A corresponding trend towards fish species with a preference for warmer water temperatures suggests that broad-scale warming trends may be a significant driving force of this fundamental ecosystem level change. These shifts are noted not only for commercially harvested species, but for species of non-commercial value as well. More research is needed to understand how other ecosystem variables outside of water temperature are being altered over time, and how the Ocean SAMP ecosystem at large is responding (see also Chapter 3, Global Climate Change, Section 330.1).

3. Fish play an important role in food web dynamics as higher-order predators within the ecosystem. Fish utilize the abundant stocks of producers—phytoplankton—and lower-order consumers such as zooplankton, converting their organic matter into larger “packages” of high-quality protein that then become available as food to birds, marine mammals, and large fishes and apex predators such as tuna and sharks. Fish are an important food and an important element of the economy of the state of Rhode Island with regard to both commercial and recreational fisheries. This chapter considers fish from the perspective of their role in the ocean ecosystem; for information on fisheries and the life histories of

important commercial and recreational species, see Chapter 5, Commercial and Recreational Fisheries.

4. Circulation and salinity play a role in fish species distribution and abundance. For instance, Merriman and Sclar (1952) noted a correlation between salinity in Block Island Sound and years of heavy spawning for at least certain species of fish. In one year of their survey the salinity in Block Island Sound was 2‰ higher than in other years, which corresponded to being a year during which a heavy spawn was noted. Similar heavy spawning was not seen in other years when salinities tended to be lower. Merriman and Sclar (1952) found that precipitation and runoff were both lower during the year of high salinity/heavy spawning. Three years later they noted an increase in the catch of weakfish (a species with high reproductive success during the high salinity event), again suggesting correlation between these events. Merriman and Sclar (1952) noted however, that there were not enough data to make correlations with a large degree of certainty, though they did suggest causality. Bohaboy et al. (2010) find that season is a strong determinant of both fish diversity and fish abundance in the Ocean SAMP area, with fall having greater numbers of fish present than during spring.

5. Food is a major determining factor in maintenance of healthy populations, and the importance of the benthic ecosystem as a food source to fish populations in the Ocean SAMP area is not trivial. Smith (1950) found that bottom invertebrates made up 81% of the total food of bottom fishes in Block Island Sound. Squid made up another 7.1% of the total, and fish comprised the remaining 11.9%. In fact, Smith (1950) found that only 25% of the bottom invertebrates sampled were *not* important as sources of food for fishes in Block Island Sound. Of the bottom invertebrates eaten by bottom-dwelling fishes, 90.2% were crustaceans, 3.5% were annelids, and the remainder a mix of hydrozoans, gastropods, echinoderms and other organisms. The amphipods *Leptocheirus pinguis* and *Unciola irrorata*, the crab *Cancer irroratus*, and the shrimps *Crangon septemspinosa* and *Upogebia affinis*, made up 78% of the biomass eaten by the bottom fishes sampled.

6. Amphipods are very abundant benthic invertebrates, and are important members of the Ocean SAMP benthic community, providing an abundant, accessible food source to the fish community. Smith (1950) found that crustaceans in general made up about 90% of the bottom invertebrates eaten by fish, with amphipods making up 60%. One amphipod species—*Leptocheirus pinguis*—made up 46% of the bottom invertebrates eaten by fish in Block Island Sound.

7. Despite their abundance, Smith (1950) found some very selective, preferential feeding on amphipods by several species of fish. For instance, sculpin preferred to prey upon male *Leptocheirus pinguis* amphipods, while skates showed no preference. Smith (1950) provides an in-depth evaluation of amphipod–fish predator–prey relationships and how they affect population ecology of the amphipod species.

8. While amphipods may provide the primary source of food to bottom-feeding fishes, other species are also taken as food and are important contributors to the Ocean SAMP area food web. The rock crab (*Cancer irroratus*) was the second most important food source for bottom fishes, but only immature forms (to 5 cm carapace width) were eaten (Smith 1950).

The mysid *Neomysis americana* was found to be both abundant and important as a fish food item, particularly for sea robins (Richards et al. 1979). The hydroid *Obelia articulata* was found by Smith to be an important springtime source of food for flounder.

9. In a fisheries survey in Block Island Sound conducted by Smith (1950), the following benthic fishes were found to be the most abundant: common skate (*Raja erinacea*), big skate (*Raja diaphanes*), winter flounder (*Pseudopleuronectes americanus*), windowpane flounder (*Lopnopsetta aquosa*), whiting (*Merluccius bilinearis*), longhorn sculpin (*Myoxocephalus octodecimspinosus*), eel pout (*Macrozoarus americanus*) and the common sea robin (*Prinotus carolinus*). Chapter 5, Commercial and Recreational Fisheries, provides a brief overview of seasonality and biomass estimates for a variety of commercially important/valuable species found in the Ocean SAMP area, as well as individual life history descriptions. Chapter 5, Section 520 also provides a table that gives a first order identification of the various habitat requirements of commercially important/valuable species in the Ocean SAMP area. These data are not site specific; until benthic sediment/habitat mapping is completed for the Ocean SAMP area benthic habitat affinities for fishes cannot be addressed with surety.

10. Brown (2009), based on Northeast Fisheries Science Center trawl survey results (fall sampled since 1963, spring since 1968, winter and summer since 1992), found 119 species of fishes and 9 species of crabs; 55 species occurred in less than 1% of the tows. Table 2.8 shows the percentage of tows containing various species, while Table 2.9 shows the biomass of various species taken in the same tows. Some species, winter flounder for instance, appear to be broadly distributed (e.g., found in 89% of the tows) but only in very small numbers (e.g., 3.2% of the total biomass). Others, spiny dogfish for instance, appear to be very numerous, but found in dense concentrations rather than scattered about.

Table 2.8. Percent occurrence of species landed in trawls taken in Block Island Sound (from Brown 2009).

Species	Percent of Tows
Winter flounder	89.0
Little skate	83.8
American lobster	77.1
Windowpane flounder	72.2
Silver hake	65.0
Winter skate	53.1
Longhorn sculpin	52.8

Table 2.9. Percent biomass of species landed in trawls taken in Block Island Sound (from Brown 2009).

Species	Percent Biomass
Spiny dogfish	41.0
Little skate	14.3
Winter skate	8.4

Ocean pout	5.0
Scup	3.9
Winter flounder	3.2
Loligo squid	2.3

11. Sanders (1952) noted an interesting use of the Ocean SAMP area as a winter refuge for Atlantic herring (*Clupea harengus*). In a survey of Block Island Sound, the species was present from January to mid-March, but in two distinct groups: spent adults (e.g., post-spawning) and immature adolescents. The spent adults were dominant through early February, at which point immature adolescent fishes dominated. Of interest is that Sanders (1952) notes that the herring restricted their distribution to a narrow band of the coldest water just south of Block Island, between 2 and 4°C, dispersing widely once waters warmed; the fish did not feed often while in the coldest water, but did switch to a totally planktonic diet once dispersed from the cold water refuge. Sanders (1952) suggests the fish use this as an adaptive strategy to slow metabolism over the winter months to conserve energy. Once the herring began feeding again, a large copepod, *Pseudocalanus minutus*, made up 70% or more of the food items ingested, and was noted to be the food of preference for the Atlantic herring in Block Island Sound waters.

12. Brown (2009) characterizes the major demersal (e.g., living near but not necessarily on the bottom) and pelagic fish and invertebrates as residents or migrants of the Ocean SAMP area (Figure 2.27). The majority of the pelagic species are seasonal users of the area, with most of those arriving during spring and leaving during the fall. Relatively few major species are resident in the Ocean SAMP area. This suggests that the overall fish community of the Ocean SAMP area largely follows a seasonal cycle of abundance. These findings are corroborated by recent research by Bohaboy et al. (2010) in the Ocean SAMP area. Water temperature and food availability are no doubt major elements in shaping fish abundance patterns, both of which also exhibit strong seasonality. In general terms, early spring sees the start of a major influx of migratory species to the area, reaching a maxima in later summer then declining throughout the fall season. This pattern is similar to those noted for zooplankton and ichthyoplankton communities.

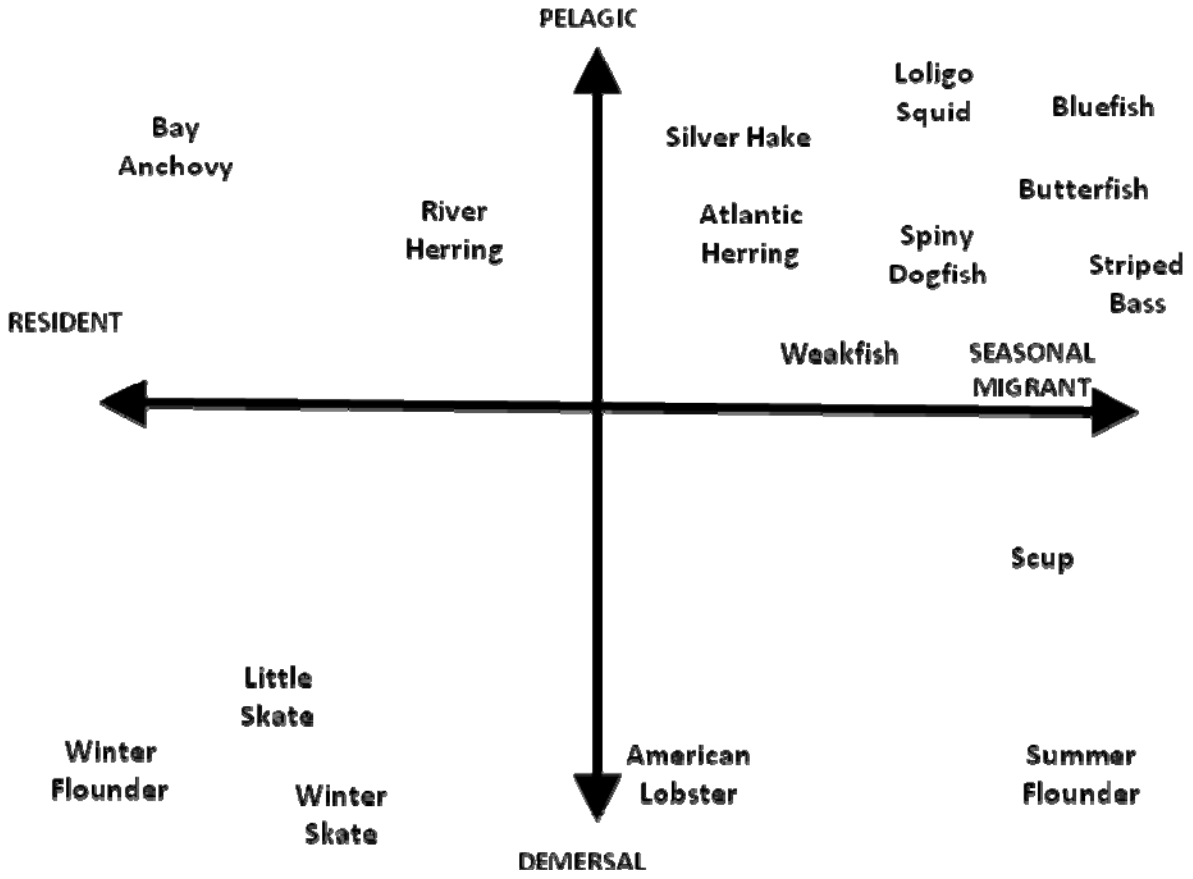


Figure 2.27. Seasonal composition of major fish and invertebrate species in the Ocean SAMP area (from Brown 2009).

13. While surveys have shown the seasonal nature of the migrations of fishes into and out of the Ocean SAMP area, Collie et al. (2008) have found a more fundamental shift in species abundances that have significant implications at ecosystem scales. Collie et al. (2008) have found a progressive shift in the species composition of the fish community at a sampling station located in Rhode Island Sound at the mouth of Narragansett Bay. Demersal fishes dominated in the 1960s, but during the 1970s benthic invertebrates (e.g., lobster, crabs) increased dramatically in abundance (Figure 2.28). During the 1980s, a major rise in the abundance of pelagic fishes and squid was noted, and by 1994, 50% of the species sampled were pelagic species. Though some demersal fish species have recently increased in abundance, the fish community remains dominated by pelagic species in the sampling area and there is no indication that species composition is moving towards that seen in the 1960s (e.g., dominated by demersal fishes). This is a fundamental shift in ecosystem composition, and effects upon the larger ecosystem are not known. Figure 2.29 shows increase and decrease of various species at the mouth of Narragansett Bay, again reinforcing the species shift from demersal to pelagic species. Figure 2.30 shows change over time for several species; squid and the little skate have undergone particularly dramatic increases in population size in recent times.

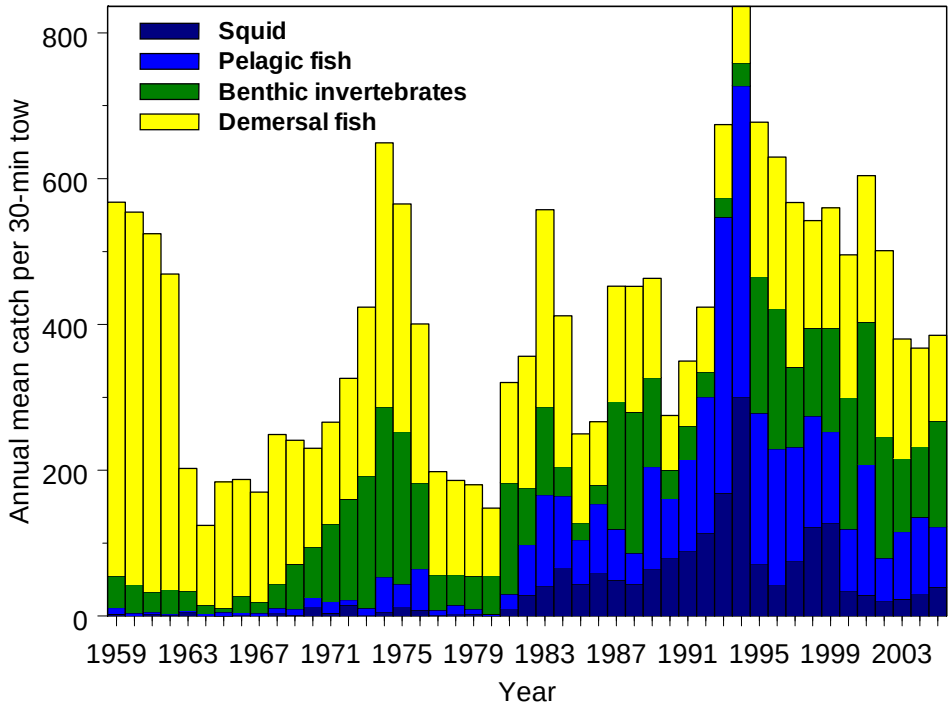


Figure 2.28. Trawl catches at Whale Rock at the mouth of Narragansett Bay/Rhode Island Sound (from Collie 2009), showing the increase in pelagic fish and squid since 1980.

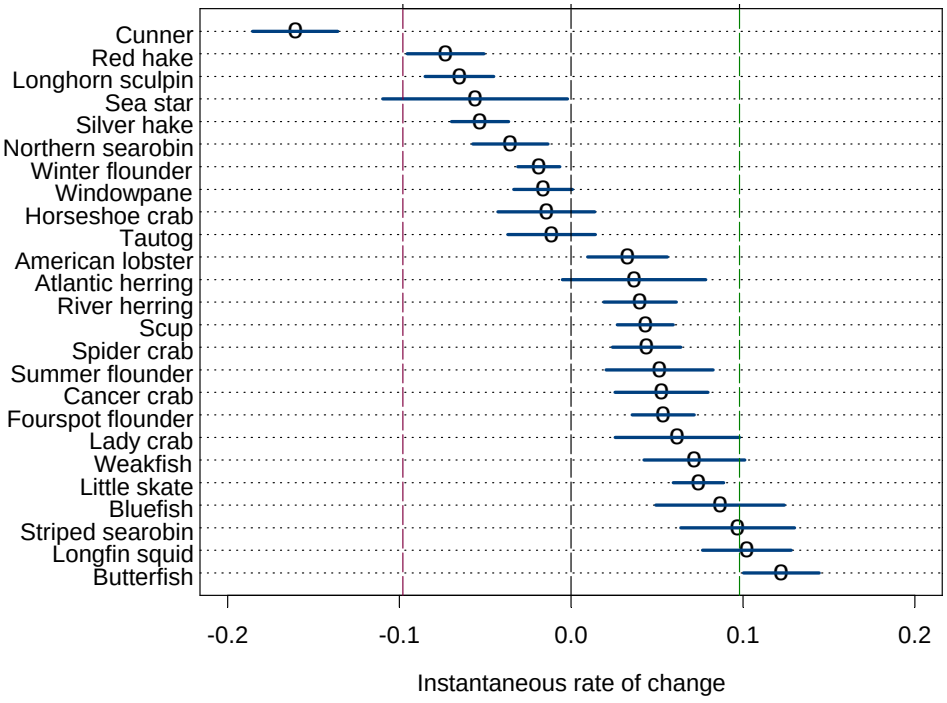


Figure 2.29. Rate of increase/decrease of species collected at Whale Rock at the mouth of Narragansett Bay/Rhode Island Sound (from Collie 2009). Left of 0.0 is decreasing in abundance, to the right increasing.

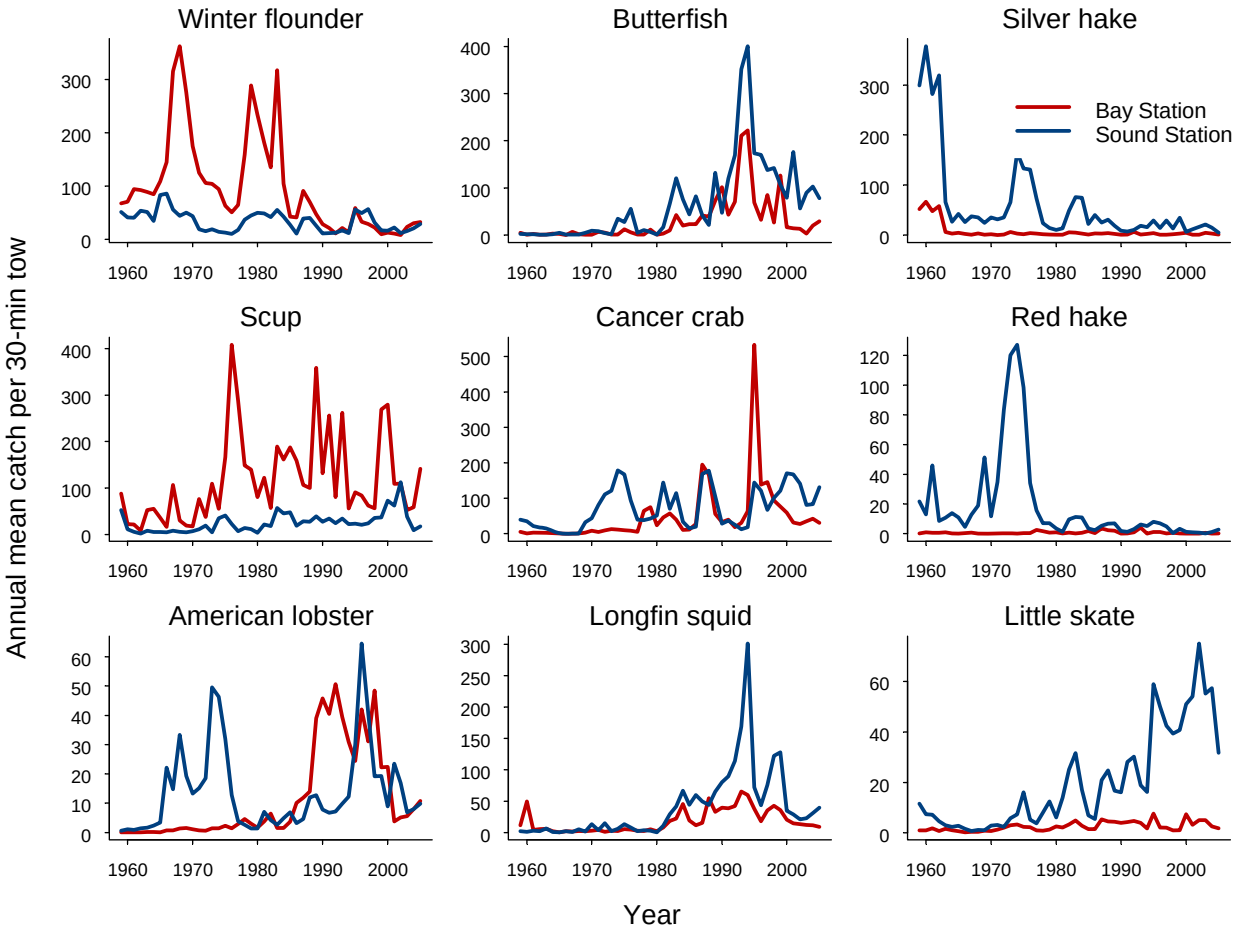


Figure 2.30. Annual mean abundance of nine species collected at Whale Rock at the mouth of Narragansett Bay/Rhode Island Sound (from Collie 2009).

14. Collie et al. (2008) also found a decrease in body size of the fish species represented, and that species composition tended towards ones with preference for warmer water temperatures (Figure 2.31). This may be indicative of regional shifts in fish species as a result of changing climate, particularly warmer water temperatures (Nye et al. 2009). Collie et al. (2008) noted that they expect a continuation of the shift to warm water pelagic species, perhaps over time developing a fish community more similar to that of Delaware Bay or Chesapeake Bay. Perry et al. (2005) have documented similar shifts in both commercially and non-commercially valuable fish species, with an average latitudinal shift in distance of 175 km (108 mi; range from 48 km (30 mi) to 403 km (250 mi)). Some species, cod for instance, may move further northward while southern species and migrants might become more abundant; winter flounder in particular will be more vulnerable and may undergo reduction in its distribution and availability in the area (Rose 2005).

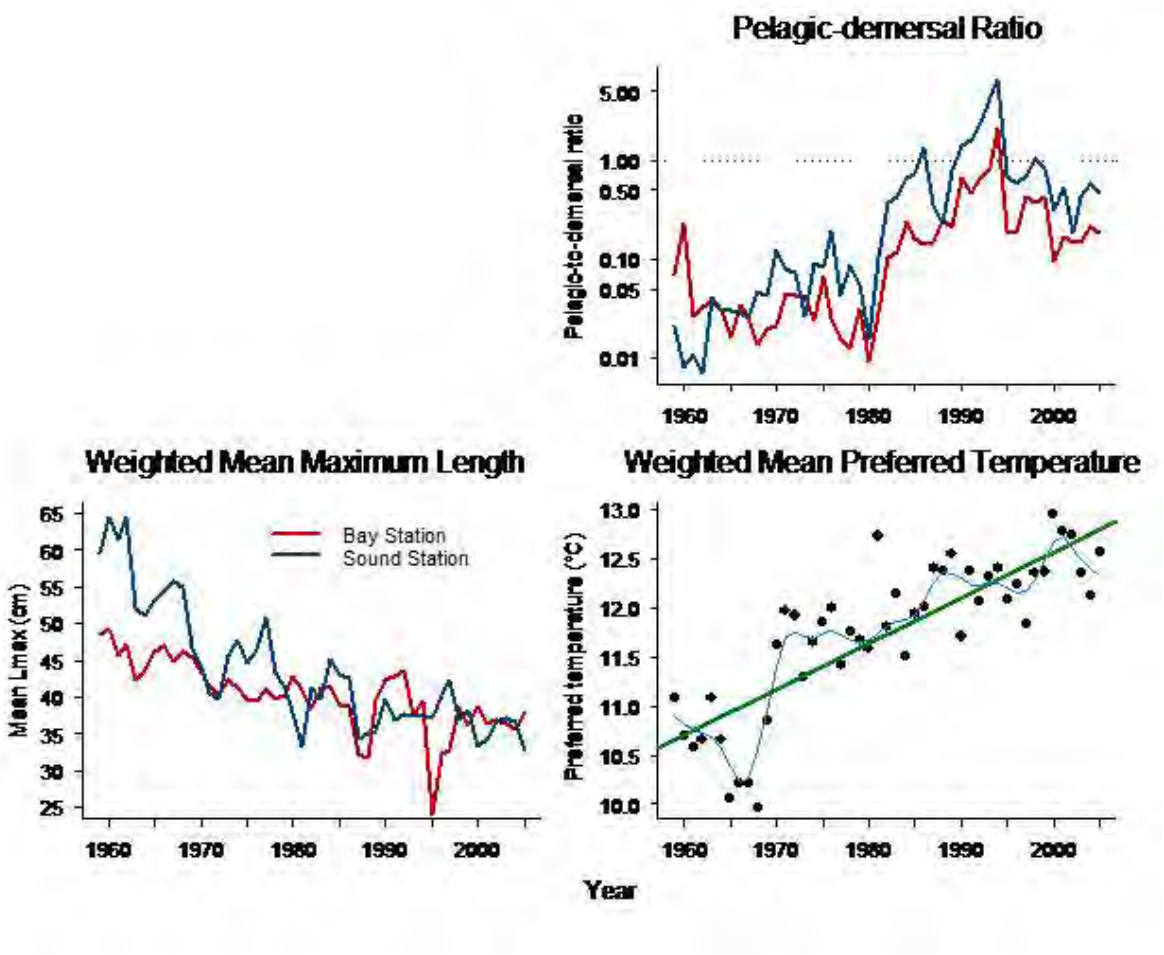


Figure 2.31. Community metrics for long term trawl samples collected at Whale Rock at the mouth of Narragansett Bay/Rhode Island Sound. Note the distinct decrease in fish length and the increase in preference for warmer water temperatures (from Collie 2009).

15. Similar change in fish community composition is being noted at various scales and geographic locations. Nye et al. (2009) took an in-depth look at the potential impacts of changing climate on fisheries in the Northeast Atlantic, and found that 24 of the 36 stocks assessed had a statistically significant response to warming water temperatures. The waters over the Continental Shelf have undergone a 10-year span of consistent warming, with the largest change being noted in bottom waters. Based on findings from analysis of a continuous, 40-year trawl survey (1968–2007), Nye et al. (2009) suggest several basic responses to climate change: a shift in distribution of the species to the north (e.g., range expansion for warm-water species; range contraction for cold-water species) or a vertical shift in species distribution to deeper water (e.g., cold-water species). Cold-water species that are at the southern extent of their range, for example cod, will be most impacted and may decline in abundance (Frank et al. 1990; Drinkwater 2005; Nye et al. 2009). Alewife, American shad, silver hake, red hake and yellowtail flounder all have exhibited range contraction. Cusk, a species that uses Block Island Sound as an important nursery area (Fahay 1992), is a species noted to be at particular risk as it is at the southern edge of its range in the Ocean SAMP region (Nye et al. 2009). Nye et al. (2009) also found the

relationship to hold for species with little or no commercial value (e.g., sea ravens, longhorn sculpin). These overall trends are of significant importance in the Ocean SAMP area as it is at the geographic boundary of two distinct eco-zones and change may be dramatic. While these changes are already noted, other change, such as increased early life mortality due to increased temperatures, or changed circulation patterns as a result of warming that transport eggs and/or larvae to unfavorable habitat, could significantly impact fish populations in the Ocean SAMP area. This is an area that is open for new research efforts.

250.4. Marine Mammals

1. Marine mammals—whales, dolphins, seals—are large predators within the Ocean SAMP ecosystem. Toothed whales, dolphins and seals are typically fish and squid eaters, entering the Ocean SAMP area on either an occasional or seasonal basis. Baleen whales also feed on schooling fishes, though some baleen whales, the right whale for instance, feeds exclusively on patches of zooplankton. Changes in distribution and/or abundance of marine mammal prey items—squid, fish, zooplankton—as a result of changing climate, may influence the distribution and abundance of marine mammals in Ocean SAMP waters. See Chapter 3, Global Climate Change, Section 330.1 for further details.

2. Available data results from sightings, strandings, and/or fishery bycatch data (Kenney and Vigness-Raposa 2009). There are 50 species of marine mammals known from the North Atlantic Ocean (Kenney and Vigness-Raposa 2009), and all are protected under the U.S. Marine Mammal Protection Act. In addition, some marine mammals are classified as endangered or threatened, and therefore protected under the U.S. Endangered Species Act. Single manatees have been sighted in Rhode Island waters, but can be considered as stragglers from southern waters.

250.4.1. Cetaceans

1. Cetaceans include whales, dolphins, and porpoises; they largely use only the water column component of the Ocean SAMP area, following and feeding upon various prey items. Due to their large size, they are capable of consuming large quantities of fish and plankton. Kenney and Vigness-Raposa (2009) report thirty (30) cetaceans in the Ocean SAMP area: ten (10) that can be considered common to abundant, four (4) considered as regularly noted, and sixteen (16) as rare (Table 2.10).

Table 2.10. The occurrence of marine mammals and sea turtles in Continental Shelf waters, which includes, but is not restricted to, waters in the Ocean SAMP area. (Kenney and Vigness-Raposa 2009).

Species	Occurrence
North Atlantic right whale	Common
Humpback whale	Common
Blue whale	Rare
Fin whale	Common
Sei whale	Regular
Bryde's whale	Rare
Minke whale	Common
Sperm whale	Common
Pygmy sperm whale	Regular
Dwarf sperm whale	Rare
Northern bottlenose whale	Rare
Cuvier's beaked whale	Rare
Blainville's beaked whale	Rare
Gervais' beaked whale	Rare
Sowerby's beaked whale	Rare
True's beaked whale	Rare
Beluga whale	Rare
Harbor porpoise	Common
Long-finned pilot whale	Common
Short-finned pilot whale	Rare
Killer whale	Rare
False killer whale	Rare
Risso's dolphin	Common
Atlantic white-sided dolphin	Common
White-beaked dolphin	Regular
Common bottlenose dolphin	Common
Short-beaked common dolphin	Common
Striped dolphin	Regular
Atlantic spotted dolphin	Rare
Pan-tropical spotted dolphin	Rare
Harbor seal	Common
Gray seal	Common
Harp seal	Common
Hooded seal	Regular
Ringed seal	Rare
West Indian manatee	Rare
Leatherback sea turtle	Common
Loggerhead sea turtle	Common
Kemp's ridley sea turtle	Regular
Green sea turtle	Rare

2. For baleen whales, Kenney and Vigness-Raposa (2009) report that fin, humpback and minke whales occur year round throughout continental shelf waters, but all are relatively rare in the Ocean SAMP area. Figure 2.32 shows relative abundances of various species of baleen whales

in the Ocean SAMP area. Right whales, a particularly endangered species with approximately 400 individuals remaining, can be common offshore during spring and fall migration, but are not common in the Ocean SAMP area. However, in one event in April 2010, nearly 100 right whales were spotted feeding in Rhode Island sound, indicating that they do sometimes appear within the Ocean SAMP boundary area (Northeast Fisheries Science Center 2010). Waters outside of the Ocean SAMP area see greater abundances of marine mammals, with the fin whale being the most common, and with some visitation into the Ocean SAMP area during summer months with sightings primarily in deeper waters. Baleen whales appear to utilize the area to the east of Nantucket Sound/Vineyard Sound more heavily than they do the Ocean SAMP area (Figure 2.32).

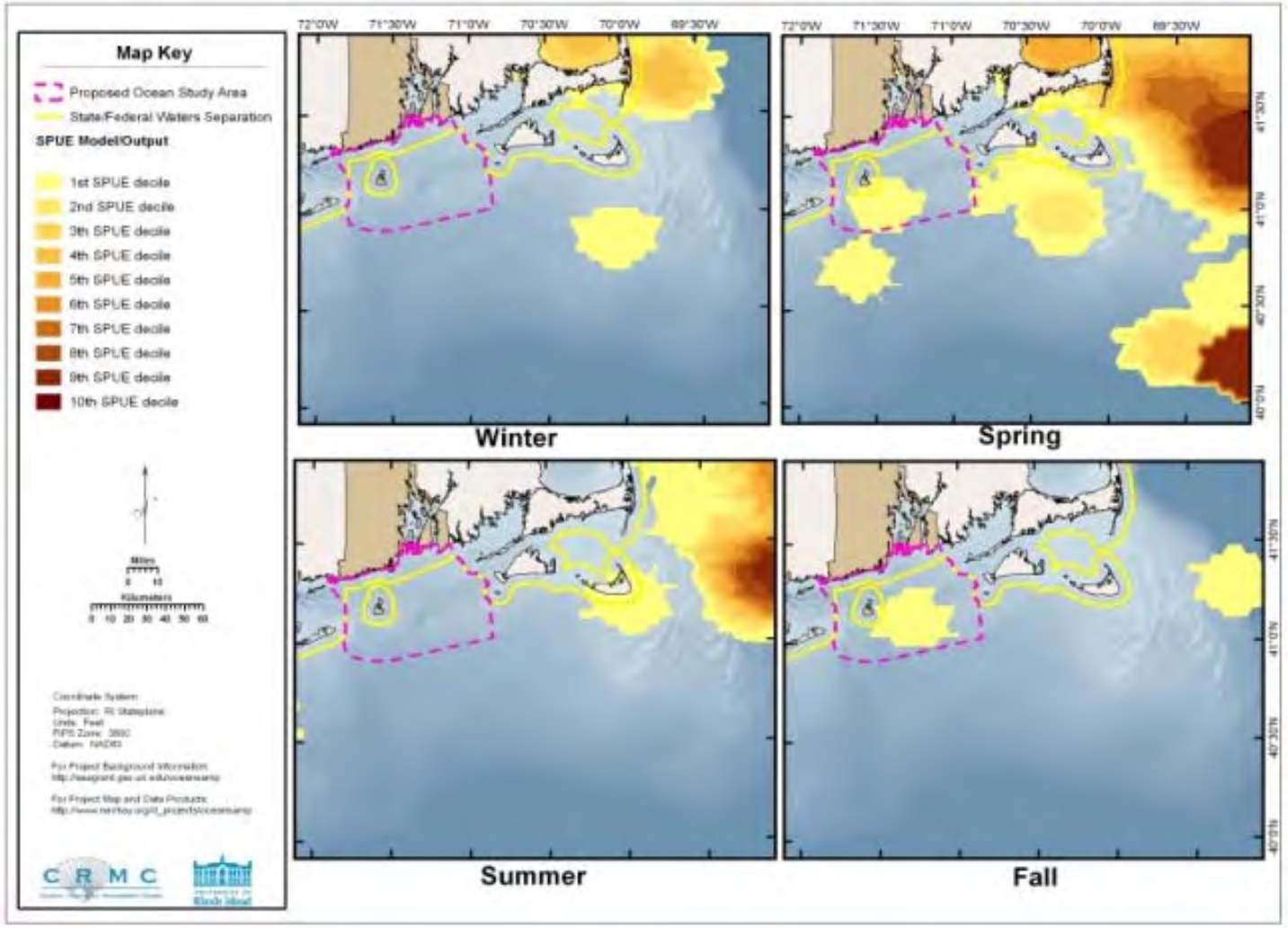


Figure 2.32(a). Modeled seasonal relative abundance patterns of right whales in the Ocean SAMP area, corrected for uneven survey effort (from Kenney and Vigness-Raposa 2009). Darker areas on the map represent areas of higher abundance; the darker the color the greater the relative abundance.

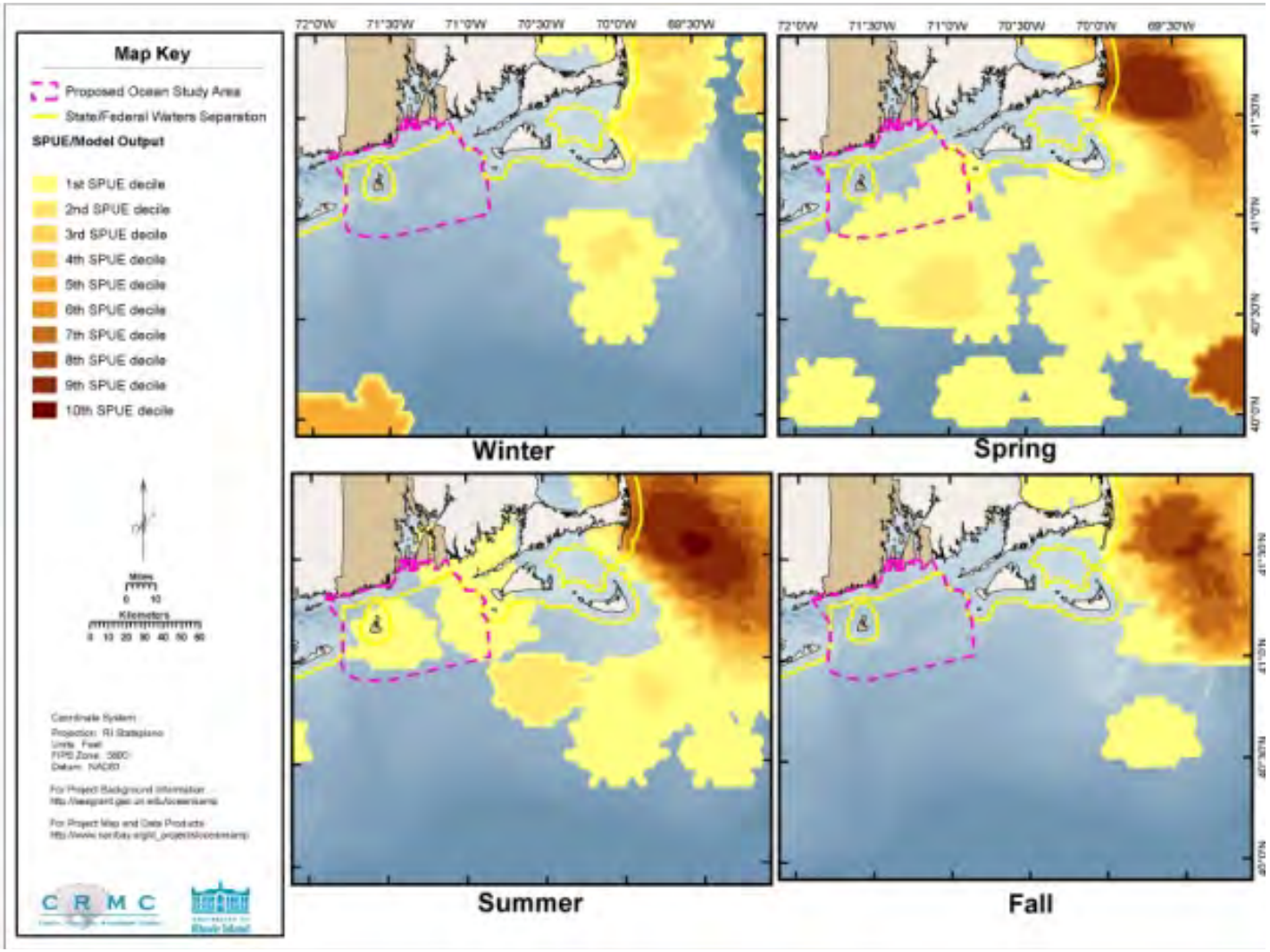
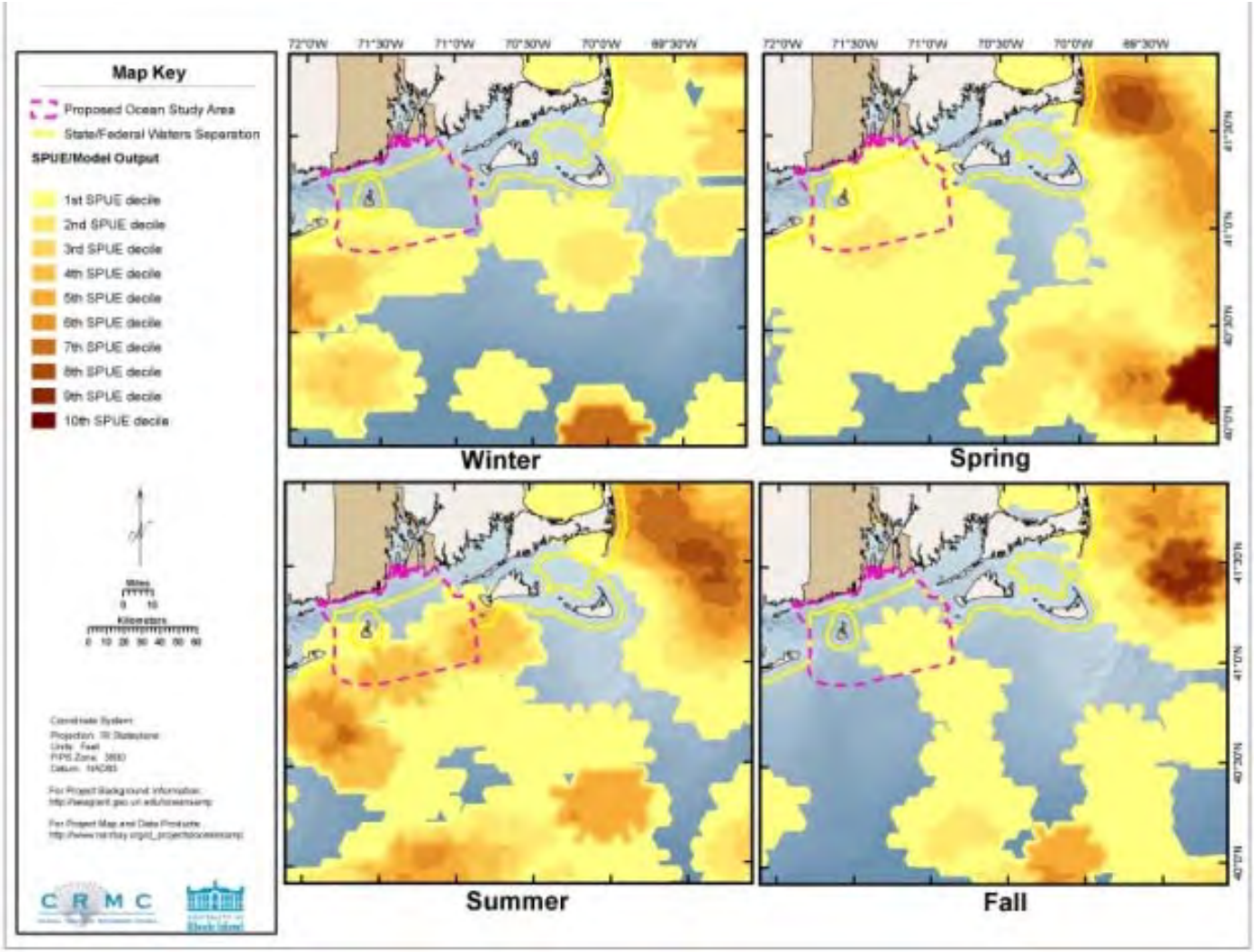


Figure 2.32(b). Modeled seasonal relative abundance patterns of humpback whales in the Ocean SAMP area, corrected for uneven survey effort (from Kenney and Vigness-Raposa 2009). Darker areas on the map represent areas of higher abundance; the darker the color the greater the relative abundance.



2.32(c). Modeled seasonal relative abundance patterns of fin whales in the Ocean SAMP area, corrected for uneven survey effort (from Kenney and Vigness-Raposa 2009). Darker areas on the map represent areas of higher abundance; the darker the color the greater the relative abundance.

3. For toothed whales, the harbor porpoise is the most common, along with the common dolphin and the Atlantic white-side dolphin; pilot whales are also found on occasion in Ocean SAMP area waters, but are more generally found farther offshore. Figure 2.33 shows relative abundances of various species of toothed whales in the Ocean SAMP area. Toothed whales appear to utilize the area to the east around Nantucket Sound/Vineyard Sound, and offshore waters over the Continental Shelf, more heavily than they do the Ocean SAMP area (Figure 2.33).

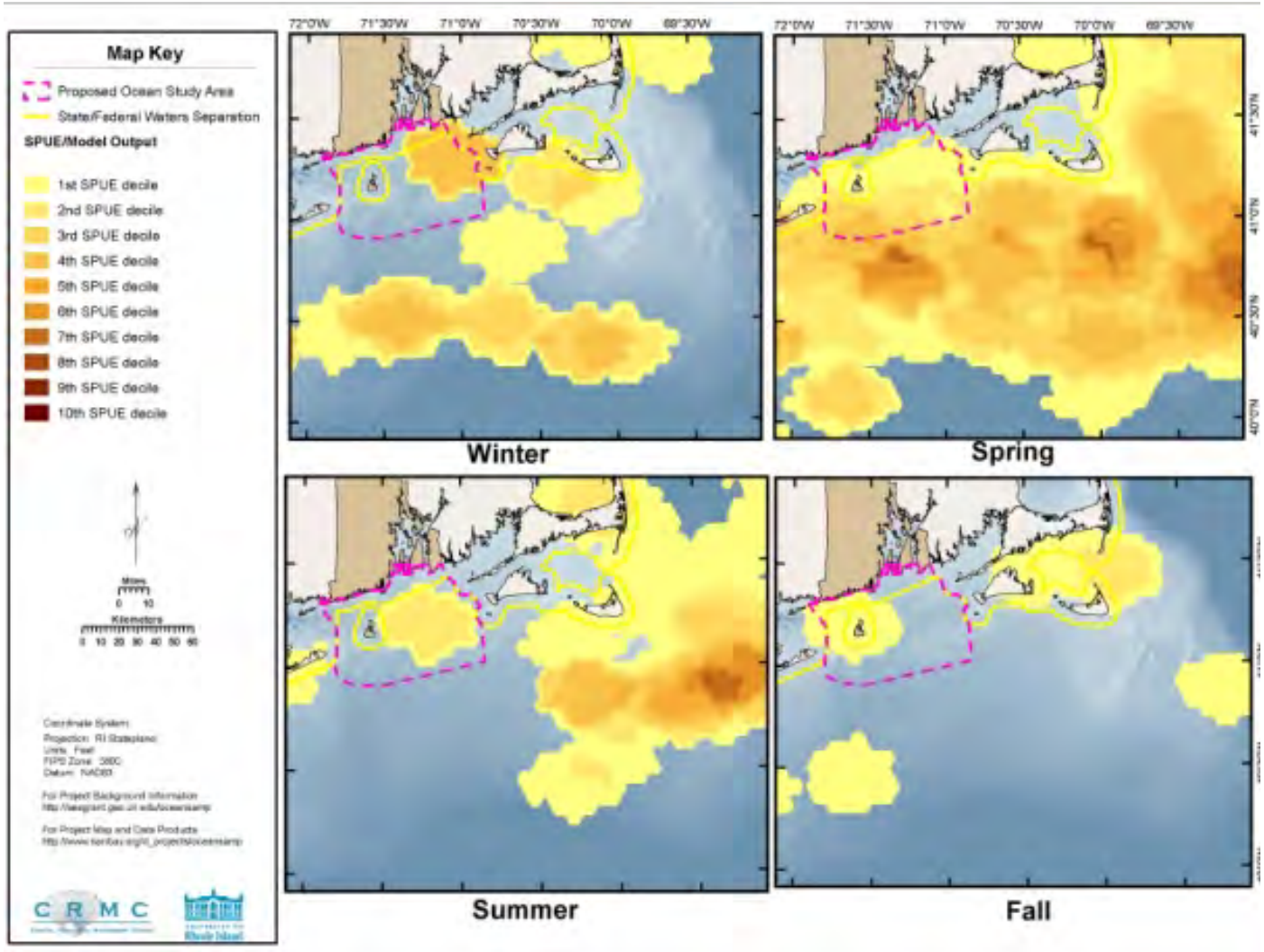


Figure 2.33(a). Modeled seasonal relative abundance patterns of harbor porpoise in the Ocean SAMP area, corrected for uneven survey effort (from Kenney and Vigness-Raposa 2009). Darker areas on the map represent areas of higher abundance; the darker the color the greater the relative abundance.

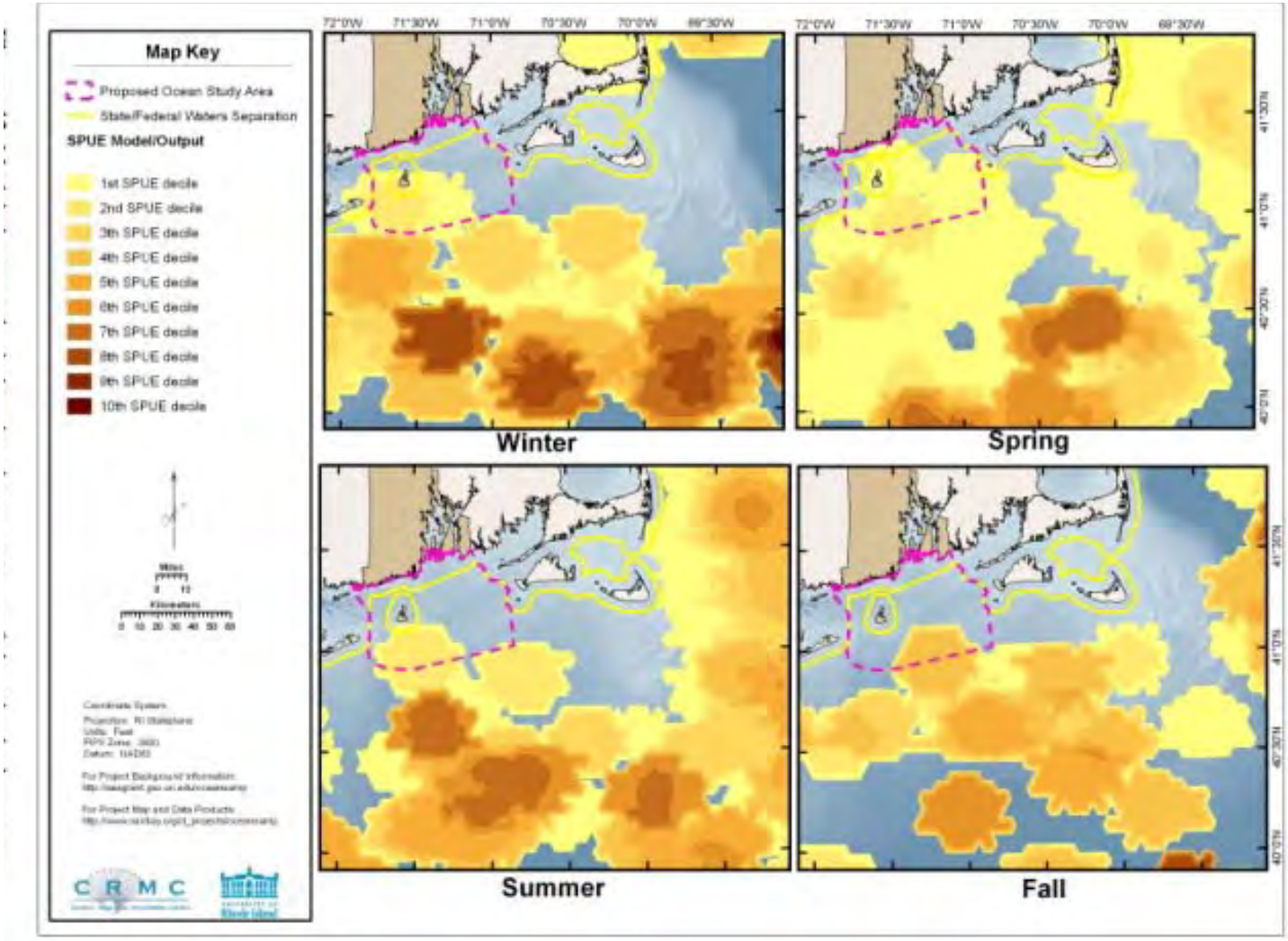


Figure 2.33(b). Modeled seasonal relative abundance patterns of common dolphin in the Ocean SAMP area, corrected for uneven survey effort (from Kenney and Vigness-Raposa 2009). Darker areas on the map represent areas of higher abundance; the darker the color the greater the relative abundance.

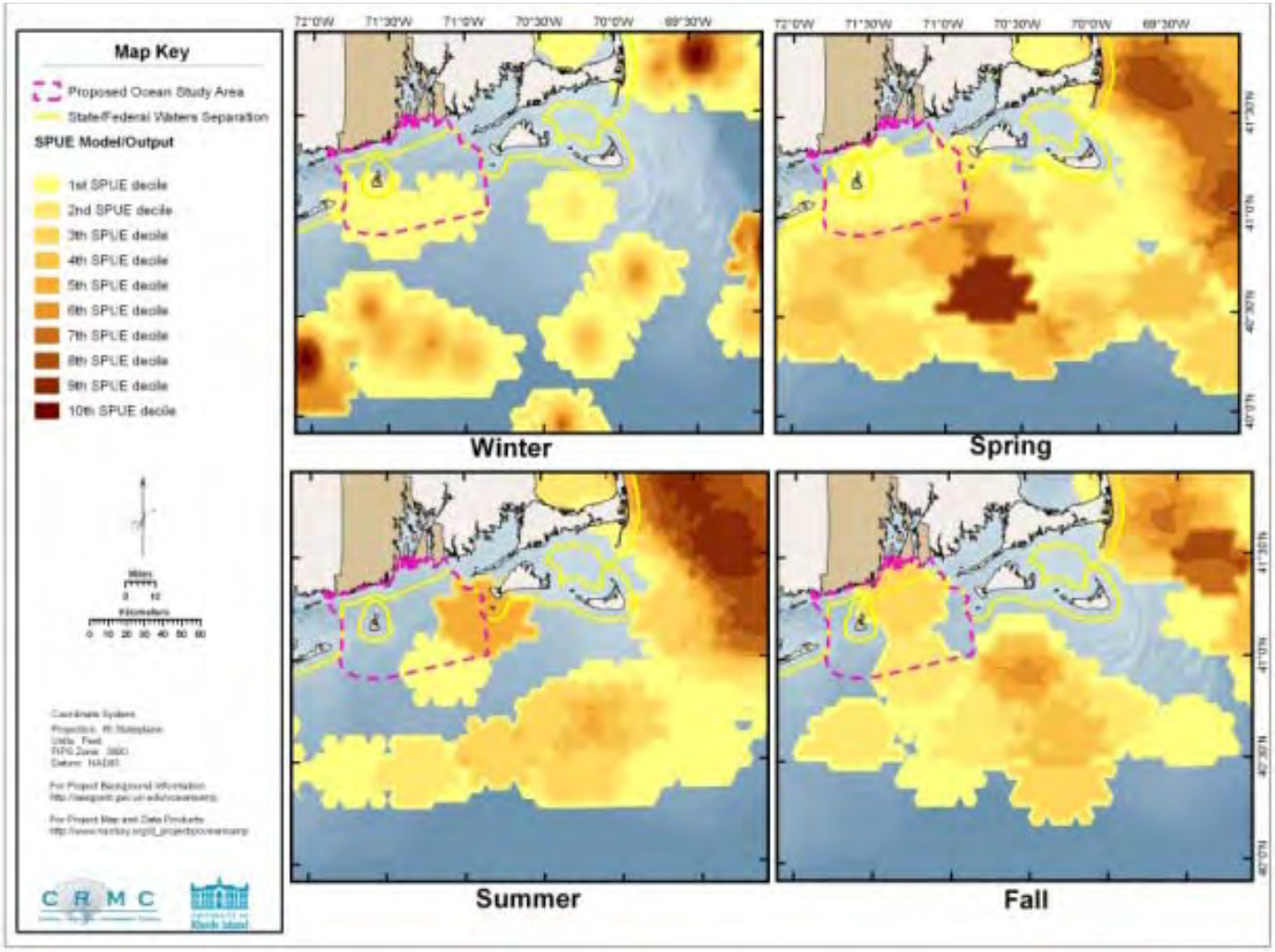


Figure 2.33(c). Modeled seasonal relative abundance patterns of Atlantic white-sided dolphin in the Ocean SAMP area, corrected for uneven survey effort (from Kenney and Vigness-Raposa 2009). Darker areas on the map represent areas of higher abundance; the darker the color the greater the relative abundance.

250.4.2. Pinnipeds

1. Pinnipeds are seasonal users of the Ocean SAMP area, and unlike cetaceans, pinnipeds also utilize the terrestrial environment, largely as "haul-out" sites used for resting. While fish are the predominant prey item of pinnipeds in this area, they have a very broad diet that includes many invertebrate species. Kenney and Vigness-Raposa (2009) report five (5) seals in the Ocean SAMP area: three (3) can be considered common, one (1) as regular, and one (1) as rare (Table 2.10). Of these species, only the gray seal and harbor seal are common, with the later being most common in the Ocean SAMP area, particularly along Block Island.

2. Harbor seals are seasonally abundant in the region from fall through spring—generally late September to early May—with numerous known haul-out sites around Narragansett Bay and on Block Island (Figure 2.34), which is the major haul-out area within Ocean SAMP boundaries. There are 6 major haul out sites on Block Island, two which are heavily used (mean # seals using the site is 8, with a maximum greater than 30) and the remaining four less so (mean # seals using the site is 1, with a maximum greater than 5), with none being located on the southern side of the island (Schroeder 2000). Harbor seals are rarely seen more than 20 km from shore, and mainly frequent bays, estuaries and inlets (Schroeder 2000). No specific food studies have been conducted on harbor seals in Rhode Island, but Payne and Selzer (1989) found sand lance to be an important food on Cape Cod. Williams (1999) found hake to be important in the Gulf of Maine, as did Wood (2000) along the mid-coast region of Maine. Olesiuk et al. (1990) found harbor seals to be opportunistic feeders, taking advantage of whatever food items are readily and easily available, though Payne and Selzer (1989) noted a preference for small schooling fishes when available, but that they will shift prey species rapidly in response to prey availability.

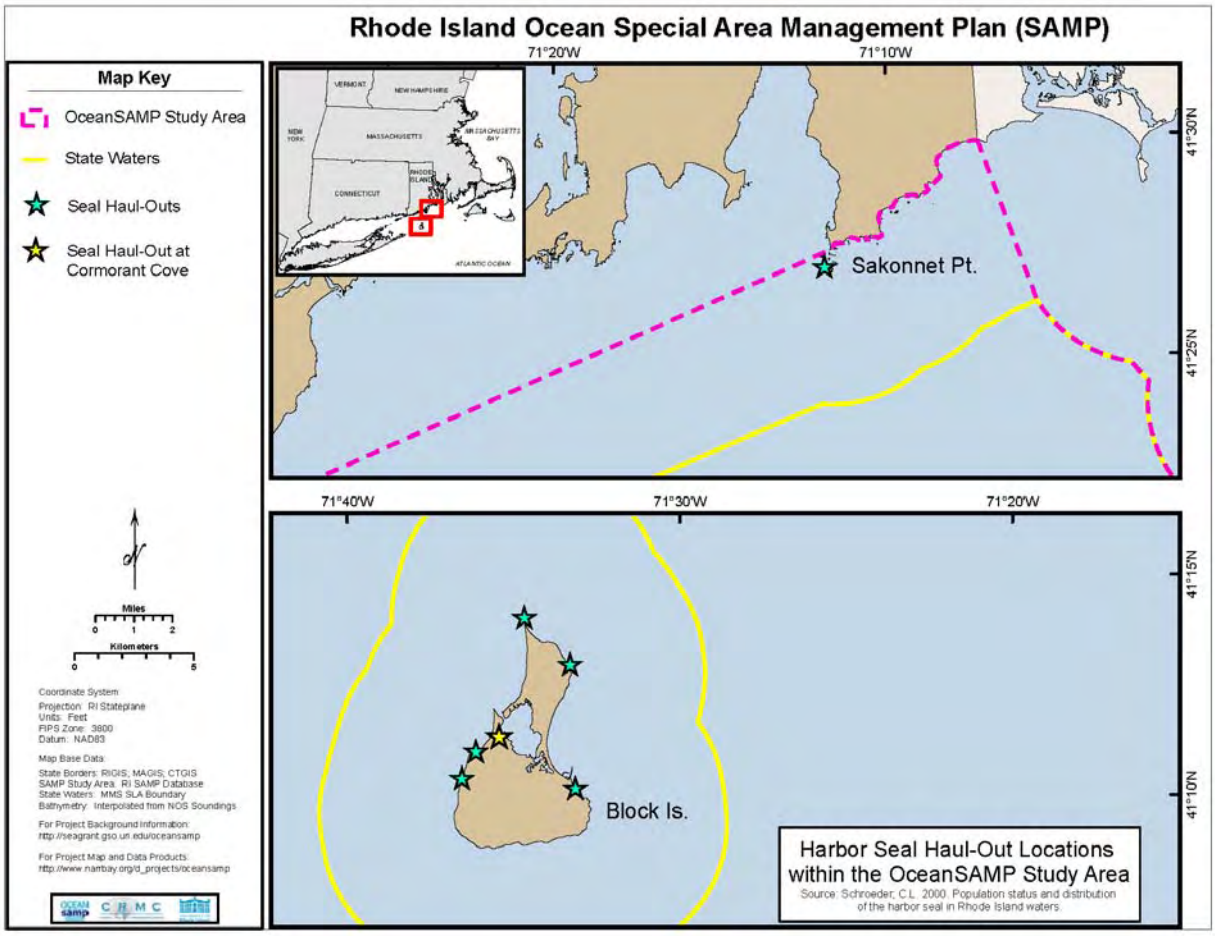


Figure 2.34. Harbor seal haul-out sites. Yellow star area on Block Island is a major seal haul out area.

3. Gray seals (*Halichoerus grypus*) are a more northerly species that ranges into southern New England waters on a seasonal basis. Ridoux et al. (2007), who studied the diet of gray seals in European waters, found them to maintain a diet of mainly fish and cephalopods, with fish making up 96% of the diet by number and 98.6% by mass. In Canadian offshore waters, Bowen and Harrison (1994) found that gray seals had a feeding range of about 80 km, and that foods eaten mimicked the prey items available. They found that by weight, sand lance made up nearly 81% of the diet, cod 11%, silver hake about 3% and flatfish and other gadoid fishes the remainder. A similar study by Bowen et al. (1993) found that herring, cod, sand lance, silver hake and squid made up 88%, by weight, of gray seal diet on the Scotian Shelf of Canada. Bowen and Harrison (1994) noted differences in gray seal diets near shore and offshore, but this could be attributed to prey availability.

250.5. Sea Turtles

1. Sea turtles are reptiles that have taken up an oceanic existence. Terrestrial resources in the Ocean SAMP area are not utilized, and sea turtles are not known to breed or nest in these waters. Available data results from sightings, strandings, and/or fishery bycatch data (Kenney

and Vigness-Raposa 2009). There are six species of sea turtles known from the North Atlantic Ocean (Kenney and Vigness-Raposa 2009). All six sea turtles are classified as endangered or threatened, and therefore protected under the U.S. Endangered Species Act.

2. Kenney and Vigness-Raposa (2009) report four (4) species of sea turtles in the Ocean SAMP area: two (2) can be considered common, one (1) as regular, and one (1) as rare (Table 2.10).

3. Kenney and Vigness-Raposa (2009) report details for leatherback sea turtles, noting that sightings generally occurred in continental shelf waters, not in the Ocean SAMP area. Those leatherback turtles that do visit the Ocean SAMP area feed upon jellyfishes and other gelatinous prey items. The few turtles that are found offshore of the Ocean SAMP area are sighted mostly in the summer and early fall. Figure 2.35 shows the seasonal relative abundance of leatherback turtles in the Ocean SAMP area, showing the probability for visitation in the area is highest during summer and fall months. Chapter 3, Global Climate Change, Section 330.1 provides information on possible impacts of changing climate on sea turtles in the Ocean SAMP area.

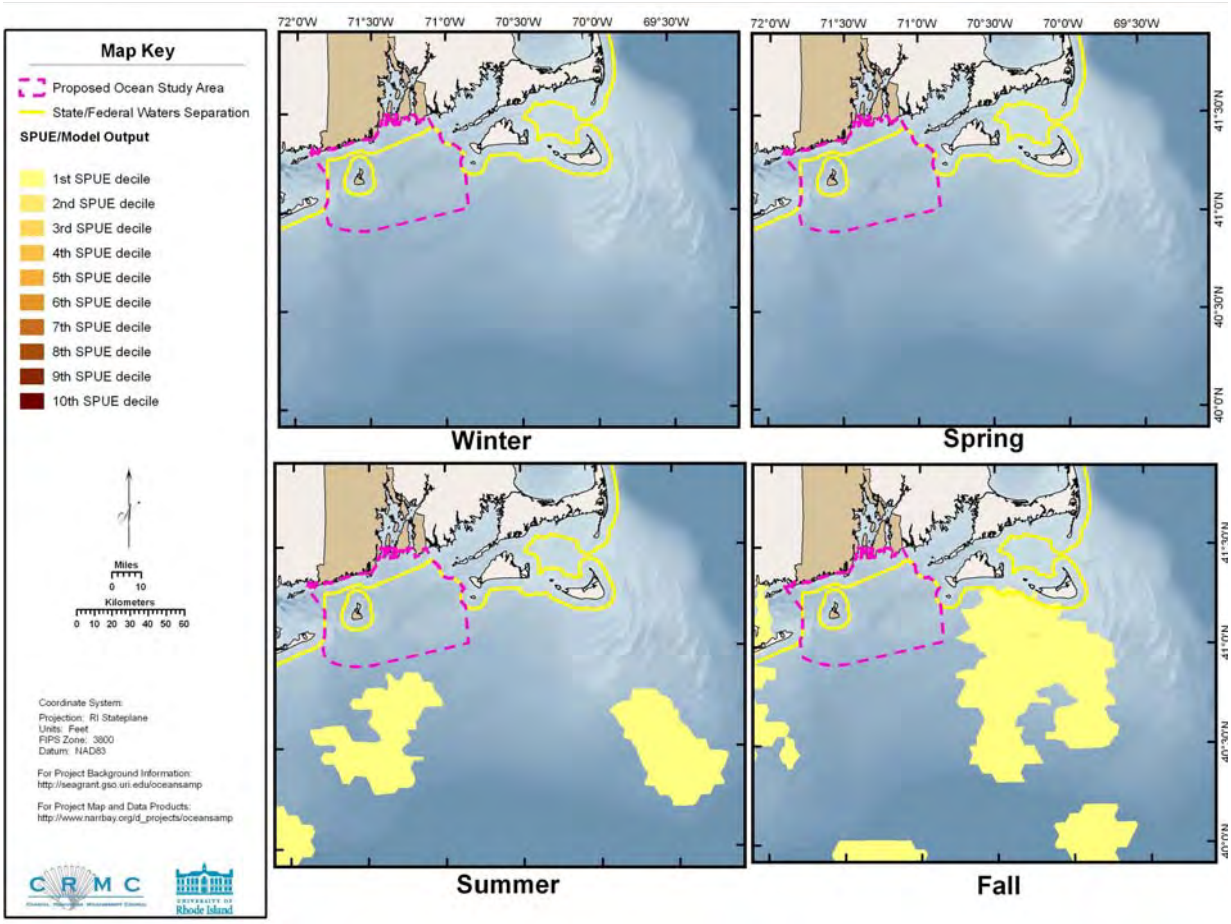


Figure 2.35. Modeled seasonal relative abundance patterns of leatherback sea turtles in the Ocean SAMP area, corrected for uneven survey effort (from Kenney and Vigness-Raposa 2009).

250.6. Avifauna

1. Birds are an element of the Ocean SAMP area ecology; they are attracted to the area because of temperate climate—many of these birds nest in the Arctic or Antarctic—and for feeding purposes, utilizing the seasonal abundance of fish and invertebrates as an important resource. The impact of avifauna on the overall ecology of the Ocean SAMP area is not well studied and so how bird use shapes benthic invertebrate ecology in shallow waters is not well known and is an area of further possible research.

2. Bird life throughout the Ocean SAMP area is dynamic, with substantial changes between seasons and years. During summer in some years (e.g., 2009), tens of thousands of pelagic seabirds migrate into the area for several months to feed, while in other years (e.g., 2010) seabirds inhabit more offshore area and are not observed in the Ocean SAMP area. In general, avifauna in the Ocean SAMP area is most abundant during fall and spring migration periods, and during winter. Water depth is an important factor in the spatial distribution of these birds. Gannets and loons for instance, which feed mainly on fish, frequent waters up 45 m in depth, while seaducks primarily forage in Ocean SAMP waters less than 20 m deep.

3. Reinert et al. (2002) found 109 species of songbirds on Block Island during the time of spring migration and 113 species during the fall migration, with 103 of the species found during both seasons. Table 2.11 shows the most common passerine birds utilizing the terrestrial portion of the Ocean SAMP area (e.g., Block Island), and season(s) they are typically found on the island. While many species utilize Block Island as a migratory stopover, Reinert et al. (2002) found that 38% of the spring-captured species, and 21% of the fall-captured species, were species that are known to breed on Block Island. Reinert et al. (2002) provide greater detail on specific island habitat use by passerine birds. Actual use of marine waters are expected to be minimal, though tree swallows appear to utilize nearshore air space over water on a regular basis (Paton et al. 2010), perhaps for feeding purposes.

Table 2.11. Common songbirds utilizing Block Island, and the season(s) in which they are found on the island, and the percent of total captures for each species (Reinert et al. 2002).

Species	Scientific Name	% of Total Capture (Spring/Fall)
Gray Catbird	*Dumetella carolinensis*	17.1 / 13.2
Common Yellowthroat	*Geothlypis trichas*	13.7 / 0
Yellow-Rumped Warbler	*Dendroica coronate*	10.7 / 35.1
White-Throated Sparrow	*Zonotrichia albicollis*	6.6 / 0
Golden-Crowned Kinglet	*Regulus satrapa*	0 / 4.5
Red-Eyed Vireo	*Vireo olivaceous*	0 / 4.1

4. Paton et al. (2010) have found approximately 25 waterbird species that commonly inhabit and/or use the waters of the Ocean SAMP area (Table 2.12). Use of the Ocean SAMP area by any given species of waterbird, except for various gulls, is seasonal. Figure 2.36 shows waterbird seasonality in a graphical fashion. Waterbirds either overwinter in the Ocean SAMP area (e.g., common eider) or use it as summer feeding grounds, perhaps after the nesting cycle is completed (e.g., loons, scoters).

Table 2.12. Avifauna of the Ocean SAMP area as described by Paton et al. (2010).

Common Name	Scientific Name	Seasonal Use
Cormorant, Double-crested	*Phalacrocorax auritus*	Mar–Nov
Eider, Common	*Somateria mollissima dresseri*	Oct–Apr
Gannet, Northern	*Morus bassanus*	Sep–Jun
Gull, Bonaparte's	*Chroicocephalus philadelphia*	
Gull, Great Black-backed	*Larus marinus*	All Year
Gull, Herring	*Larus argentatus*	All Year
Gull, Laughing	*Leucophaeus atricilla*	May–Nov
Gull, Ring-billed	*Larus delawarensis*	All Year
Loon, Common	*Gavia immer*	Oct–Jun
Loon, Red-throated	*Gavia stellata*	Oct–May
Scoter, Black	*Melanitta nigra americana*	Sep–may
Scoter, Surf	*Melanitta perspicillata*	Sep–may
Scoter, White-winged	*Melanitta deglandi*	Sep–May
Shearwater, Cory's	*Calonectris diomedea*	Jun–Aug
Shearwater, Greater	*Puffinus gravis*	Jun–Sep
Shearwater, Manx	*Puffinus puffinus*	May–Aug
Shearwater, Sooty	*Puffinus griseus*	May–Sep
Storm-Petrel, Wilson's	*Oceanites oceanicus*	Jun–Jul
Tern, Black	*Chlidonias niger*	
Tern, Common	*Sterna hirundo*	Apr–Sep
Tern, Forster's	*Sterna forsteri*	
Tern, Least	*Sternula antillarum*	May–Aug
Tern, Roseate	*Sterna dougallii*	Jul–Aug

5. Paton et al. (2010) have found that water depth is an important factor in the spatial distribution of birds in the Ocean SAMP area. Based on a review of the literature, most sea ducks typically forage in water of 5 to 20 m depth (Figure 2.37) where bivalves and other forage is available. Sea ducks will therefore be largely found in nearshore habitats where water depth allows efficient feeding. Gannets and loons are piscivorous specialists and tend to occur in areas where water depths 30–45 m deep, and <35 m deep, respectively (Paton et al., 2010). Razorbills were consistently found in shallower waters closer to the mainland, common murre primarily in the central regions of the Ocean SAMP area, and dovekies offshore over deeper depths out to the Continental Shelf (Paton et al., 2010). While bathymetry is known for the Ocean SAMP area, benthic community composition is not and therefore preferred/critical waterbird forage areas cannot be readily identified. For further information on the potential effects of offshore development on bird foraging habitat, see Chapter 8, Renewable Energy and Other Offshore Development.

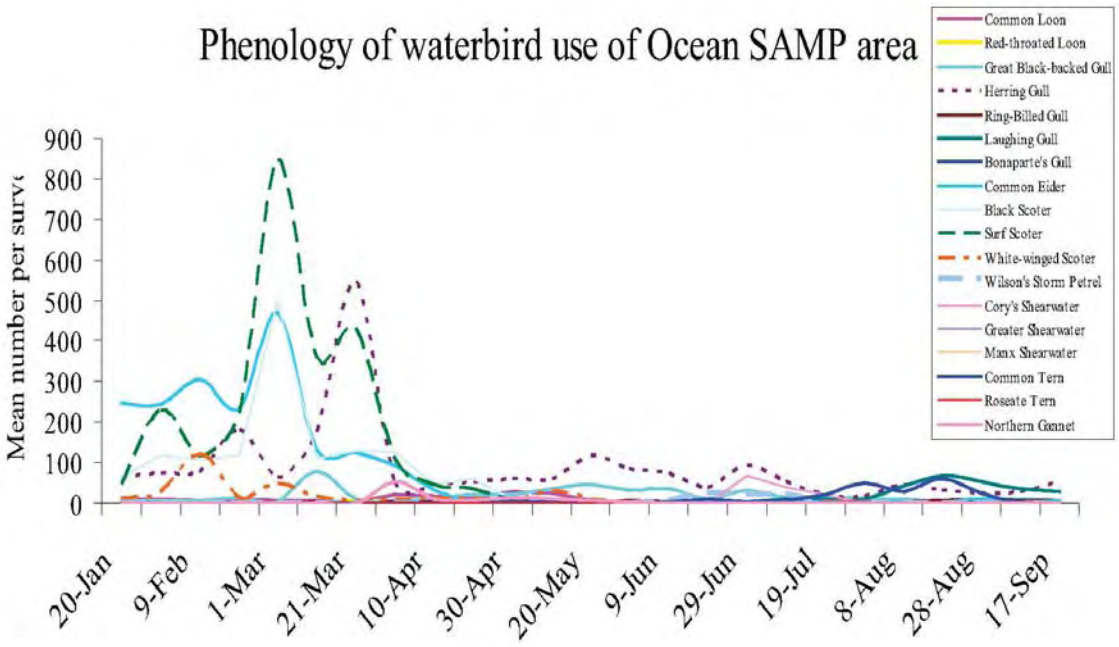


Figure 2.36. Seasonality of avifauna in the Ocean SAMP area (from Paton et al. 2010).

6. Figure 2.38 shows the seasonality of waterbird use in the Ocean SAMP area, according to bird type, and providing greater definition than could be shown in Figure 2.36, which is useful in showing, at the same scale, seasonality of bird use in the Ocean SAMP area. Gull use of the area is year round, while loons appear to use the Ocean SAMP area as overwintering grounds. Pelagic birds, such as shearwaters, inhabit the Ocean SAMP area only during the summer. In general, bird life is most diverse and abundant during fall and spring migration, and during winter (Paton et al., 2010).

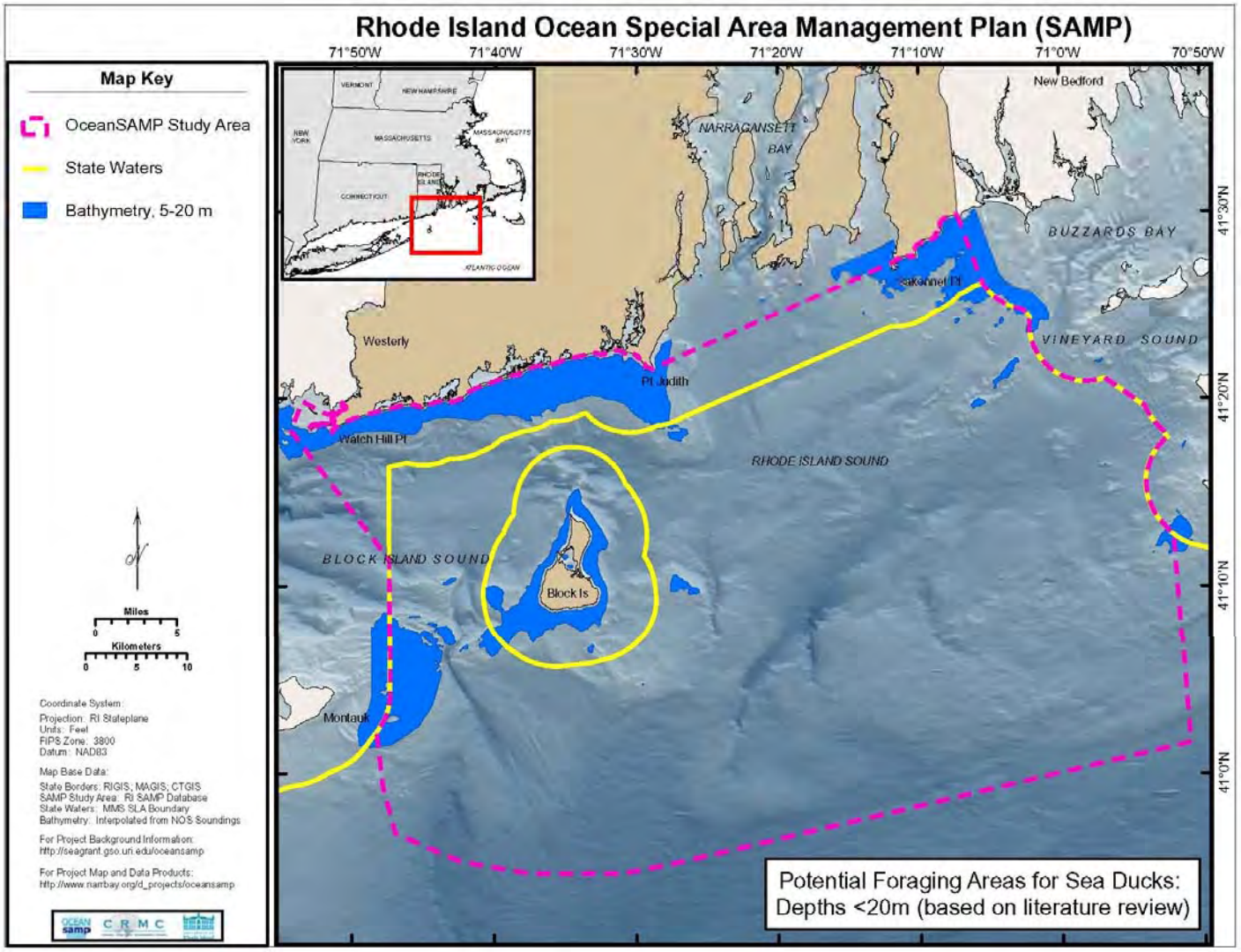
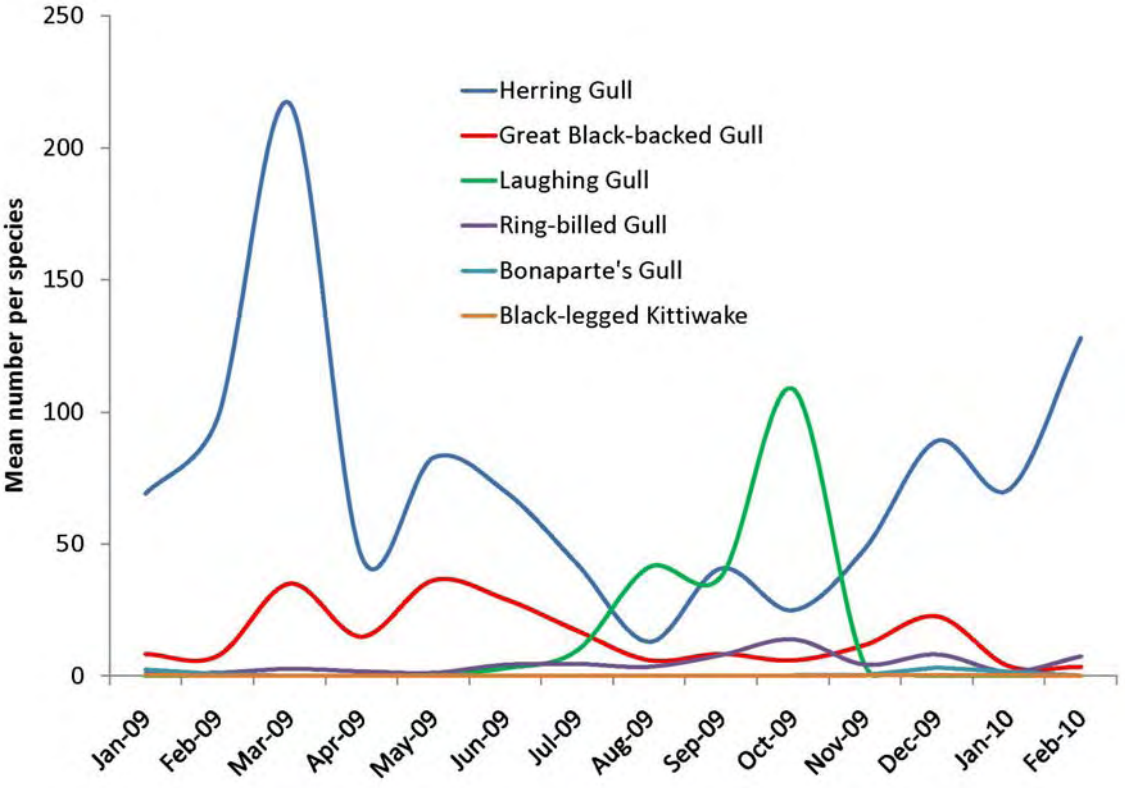
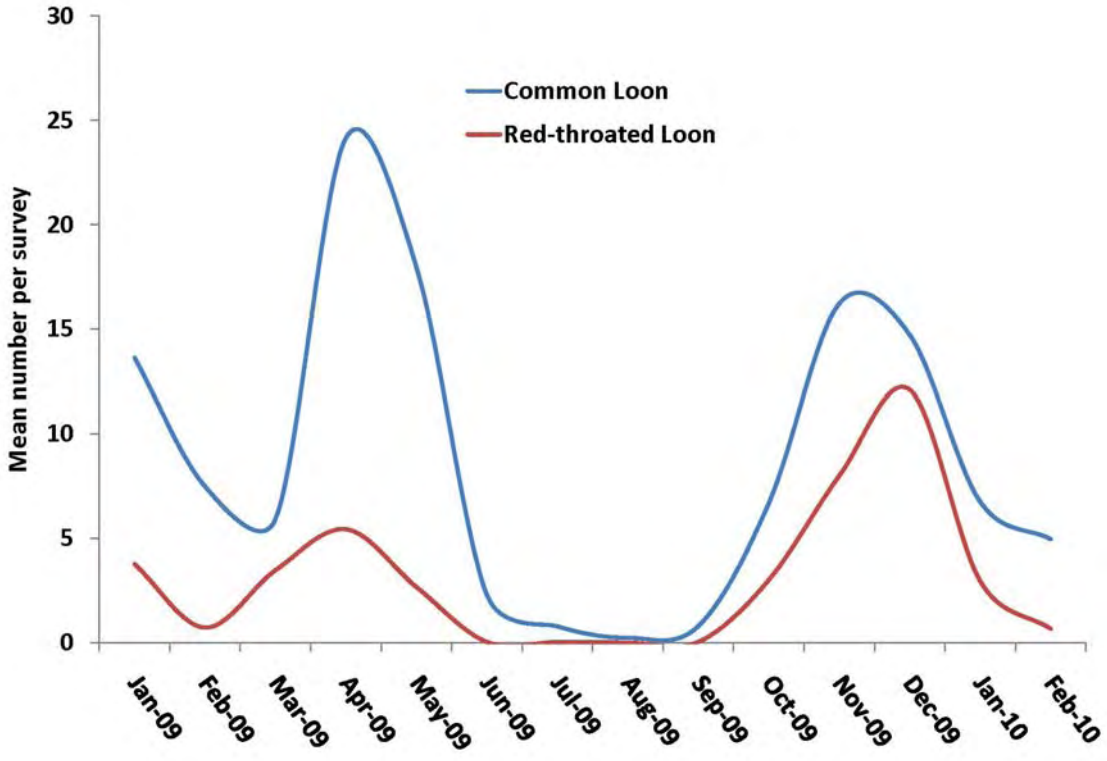


Figure 2.37. Potential use of the Ocean SAMP area by diving ducks, which suggests they forage in waters less than 20 feet deep. Since benthic community composition is not known, this map shows potential, not preferred, foraging sites.


Mean number per species
250
200
150
100
50
0
Herring Gull
Great Black-backed Gull
Laughing Gull
Ring-billed Gull
Bonaparte's Gull
Black-legged Kittiwake
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10


Mean number per survey
30
25
20
15
10
5
0
Common Loon
Red-throated Loon
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10

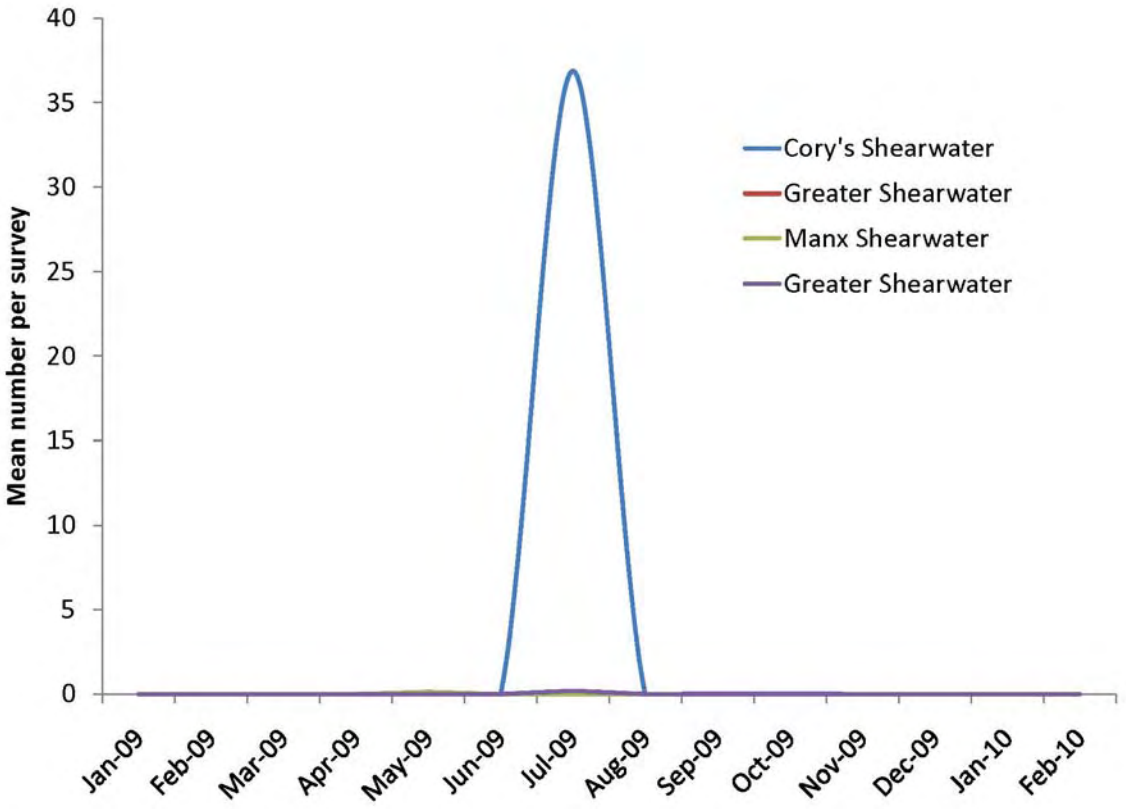


Figure 2.38. Seasonal use of the Ocean SAMP area by gulls, loons and shearwaters (from Paton et al. 2010).

7. Paton et al. (2010), based on both land-based and ship-based survey counts, have identified the most common bird species using Ocean SAMP waters (Figure 2.39). Common eider are the most abundant user of nearshore waters (≤ 3 km), followed by the herring gull and surf scoter. Offshore waters (> 3 km) are utilized most heavily by northern gannets, followed by Wilson's storm-petrels, and herring gulls. Gulls appear to be one of the major users of Ocean SAMP waters, both inshore and offshore, and throughout the seasons.

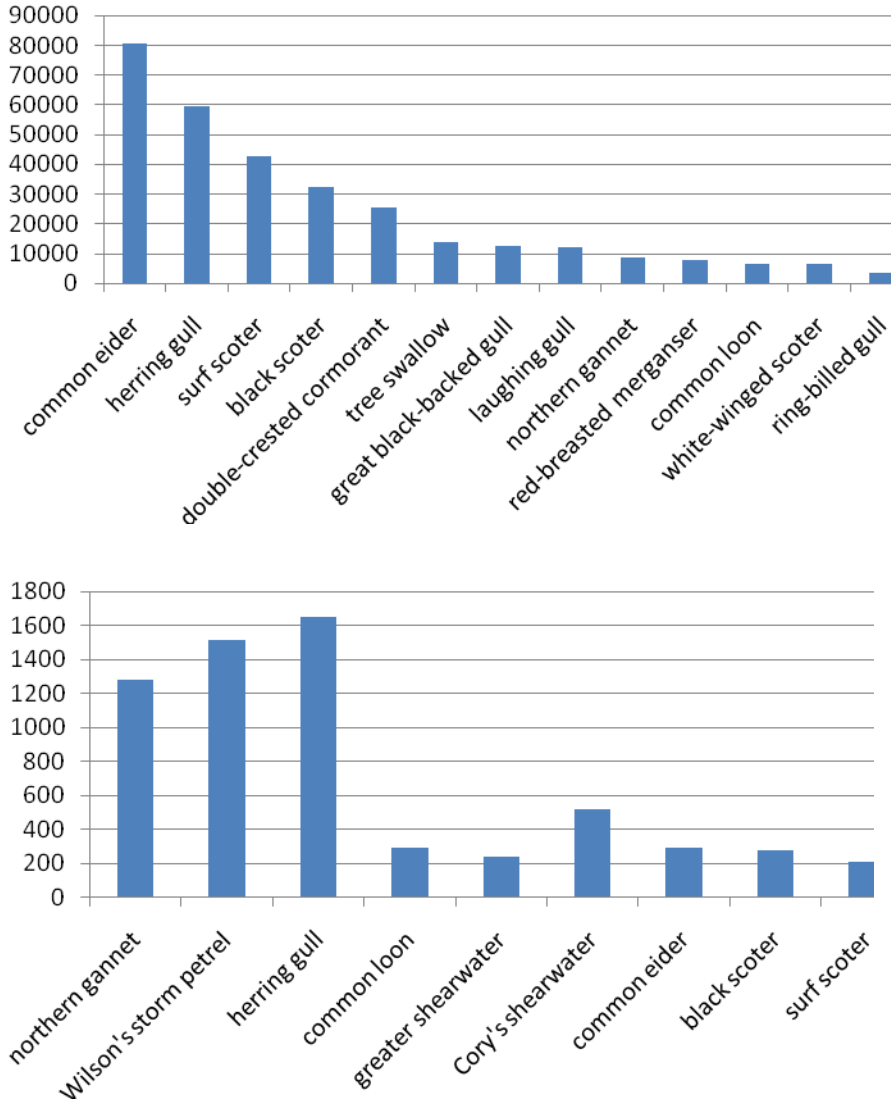


Figure 2.39. Most abundant waterbirds found nearshore (top panel) and offshore (bottom panel) in the Ocean SAMP area, based on land-based (Jan 2009–Jan 2010) and ship-based (Mar 2009–Jan 2010) survey counts (from Paton et al. 2010).

8. Various species of tern are found throughout the Ocean SAMP area during summer months (Paton et al. 2009; Paton et al. 2010), with more birds in the area during the post-breeding season. For endangered roseate terns, nearly all observations were over the waters north of Block Island, increasing with nearness to the Rhode Island coastline. Roseate terns do not appear to significantly utilize more open, deeper water areas of Block Island Sound, Rhode Island Sound or the Offshore Ocean SAMP area, although they have been detected roosting on Block Island (Paton et al., 2010). Impact of tern feeding on fish ecology of the Ocean SAMP area is not known.

9. Paton et al. (2010) report the following patterns of avian use of Ocean SAMP area waters for the period of late November 2009 through late February 2010:

a. Both common and red-throated loons are abundant species during winter months in the Ocean SAMP area, and population estimates suggest this area provides critical wintering habitat for a significant number of loons. Loons were found to be scattered throughout the area, though thinly throughout most of the central portion of Rhode Island Sound. Densest concentrations occurred along the Rhode Island south shore shoreline, around Block Island shoreline, and in the area west of Block Island bordering Montauk Point and the opening to Long Island Sound. Waters less than 35 m deep appear to be preferred, though some loons were documented in deeper offshore waters in Rhode Island Sound.

b. Scoters and common eider were among the most abundant birds observed using nearshore habitats during with months. They tended to concentrate around the west side of Block Island, along the Rhode Island south shore shoreline, and around the Sakonnet shoreline bordering Rhode Island Sound. Few were found over the open waters of Block Island Sound, Rhode Island Sound or the Offshore Ocean SAMP area. Scoter appeared to be most abundant during the November through January time span; eider appeared to use the area throughout the surveyed time span. While research suggests that seaduck primary foraging depth is less than 20 m of water depth, Paton et al. (2010) found seaducks to consistently forage in waters up to 25 m deep in the Ocean SAMP area.

c. Alcids (razorbills, dovekies, murres), winter migrants to the Ocean SAMP area, were found scattered throughout the area, though densest concentrations occurred in deeper waters south of Block Island and throughout the central portions of Rhode Island Sound and south onto the Offshore Ocean SAMP area. These species exhibited spatial segregation in the Ocean SAMP study area, with razorbills specializing in northern, shallow water sections closer to land, while common murres tend to use the central portions of the Ocean SAMP area. Dovekies were offshore specialists that reached peak densities in southern Ocean SAMP areas, out to the Continental Shelf.

d. Northern gannets are a common spring and fall migrant in the Ocean SAMP area. This piscivorous specialist tends to occur in areas where depths exceed 30 m in depth, and were observed scattered throughout the area, though their densities peaked approximately 3 miles offshore of Block Island and/or the Rhode Island mainland during fall and winter.

10. A large population of harlequin ducks (*Histrionicus histrionicus*) winters in Rhode Island coastal waters (January to March), which is the southern extent of their range. Harlequin ducks were generally not observed more than 50 m offshore (Caron and Paton 2007), where they dive underwater to forage on mollusks and crustaceans. It is possible for this species to be impacted regarding possible range constriction due to changing climate/warming temperatures.

11. During land-based surveys, Paton et al. (2010) detected 7 species of raptors and 27 other species of landbirds. However, with the exception of tree swallows, which are diurnal migrants along the coast, very few songbirds or other types of landbirds were detected. During ship-based line transect diurnal surveys only 8 species of landbirds were detected in

Rhode Island's offshore waters (Paton et al. 2010). This is not surprising as most landbirds, particularly songbirds, are nocturnal migrants, and are only effectively monitored by radar. Mizrahi et al. (2010), using a radar unit on Block Island throughout 2009, were not able to separate out landbirds from other species during radar investigations. Based on this radar study, peak flight altitudes of targets ranged between 200-400 m above sea level, with more birds passing over Block Island in the fall than spring. Peak migration appeared to take place from sunset to 5 hours after sunset.

Section 260. Emerging Issues

260.1. Native Species Explosions

1. Explosions of native, opportunistic species can be initiated by one or several conditions, such as changes in primary productivity, fishing pressure, habitat availability, competition, and/or predator-prey interactions. Changing climate can also be a main instigator of native species explosions by either tightening or loosening restrictions due to thermal tolerances, and allowing population levels to increase, perhaps dramatically (and see Chapter 3, Global Climate Change, Section 330.3). Although native species explosions are known to occur in the Ocean SAMP area, few are studied and/or well documented in the literature.

2. The ctenophore *Mnemiopsis leidyi* has been extensively studied in the region, where it is known to be a voracious, non-selective consumer of plankton. In Narragansett Bay, studies by Martin (1965, 1970) found that *Skeletonema* abundance declined coincident with an increase in the abundance of the ctenophore *Mnemioposis leidyi*, but he found the ctenophore in high abundance only during the later study. Increases of *M. leidyi* are being observed throughout the northeastern United States continental shelf area (Link and Ford 2006), with population increases correlated to warming waters as a primary causative factor (Kremer 1994; Costello et al. 2006). The occurrence of *M. leidyi* in the Ocean SAMP is not known, and further research needs to be conducted to determine presence and impact, if any, upon the ecology of the Ocean SAMP area.

260.2. Invasive species

1. The contemporary rate of invasive species introductions is mostly a result of human transportation systems working at global scales. Increased speed and movement of people and cargo due to the mechanization of travel has increased the opportunities for invasive organisms to be introduced at scales unimaginable naturally (CRMC et al. 2007). Ship ballast water is an obvious, though not the only, transport vector of marine invaders. Non-native species are readily transported via packing material used by the recreational bait and commercial shellfish industries, and via live-market fish for both aquarium use and as food items. Winds and currents also transport organisms, as do birds and other wildlife moving through the area.

2. Ascidians (sea squirts, tunicates) are a group of organisms that are seeing rapid human-mediated expansion of their ranges, and are becoming firmly established in many communities, often at the expense of displacing native species (Bullard et al. 2007). The colonial ascidians *Didemnum* spp. are particularly aggressive invasive tunicates, of unknown origin, that arrived in the New England region in the late 1980s and have become firmly situated in the aquatic community from Eastport, Maine to Shinnecock, New York (Bullard et al. 2007). These species have been found covering large areas of ocean bottom on Georges Bank, in portions of Fishers Island Sound, and in a few locations in Block Island and Rhode Island Sound (Bullard et al. 2007; Valentine et al. 2007). There are no known, consistent predators of these invasives, which grow rapidly on hard structure to depths of 80 m. These species have the potential to significantly alter benthic ecosystem ecology, and perhaps several fisheries as well if they become widespread in the Ocean SAMP area.

3. In response to invasive species threats, Rhode Island assembled a comprehensive plan that lays out management strategies intended to prevent the introduction and spread of invasive species (CRMC et al. 2007). The plan identifies a basic list of invasive and potentially invasive species (Table 2.13) as threats to Rhode Island waters; the occurrence or abundance of these species in the Ocean SAMP area is not well documented.

Table 2.13. Listing of invasive and potentially invasive marine species according to CRMC et al. (2007).

Species	Scientific Name	Type of Organism
European green crab	*Carcinus maenus*	crustacean
Codium	*Codium fragile* spp.	algae
Red algae	*Grateloupia turuturu*	algae
SSO	*Haplosporidian costalis*	shellfish pathogen
MSX	*Haplosporidian nelsoni*	shellfish pathogen
Asian shore crab	*Hemigrapsus sanguineus*	crustacean
Lace bryozoan	*Membranipora membranacea*	bryozoan
Derma	*Perkinsus marinus*	shellfish pathogen
Quahog Parasite Unknown QPX		shellfish pathogen
Caulerpa	*Caulerpa taxifolia*	algae
Pacific oyster	*Crassostrea gigas*	mollusk
Chinese mitten crab	*Eriocheir sinensis*	crustacean
Nori	*Porphyra yezoensis*	algae
Veined rapa whelk	*Rapana venosa*	mollusk

260.3. Marine Diseases

1. Marine diseases are not widely studied in the Ocean SAMP area. However, increasing water temperatures and changing water salinities due to changing climate are creating conditions that are often favorable to the spread of disease organisms (Kennedy et al. 2002; and see Chapter 3, Global Climate Change, Section 330.2).

2. Lobster shell disease was first described 80 years ago in lobster pounds, and was associated with the bacterium *Vibrio* (Hess 1937). Shell disease is now seen in wild populations, and the bacteria in the family Flavobacteriaceae are the dominant microbes found on the shell (Chistoserdov et al. 2005). The incidence of the disease in the wild is 20 to 30%, and the location of its emergence appears to be the area including eastern Long Island Sound, Block Island Sound, and Narragansett Bay (Castro and Angell 2000). Lobsters become infected with an epizootic shell disease caused by bacteria that invade the lobster's shell through its pores. Severity ranges from black spots that develop on the shell, to holes in the shell that cause the shell and membrane to fuse together, and which can result in death of the individual (Cobb and Castro 2006). The more frequently a lobster molts, the less likely it is to have the disease, therefore younger lobsters, which molt more frequently, are more likely to be disease free than are older lobsters. Lobster disease does not appear to be contagious, healthy lobsters held in close proximity to diseased lobsters do not appear to contract the disease, which suggests that the disease is environmentally mediated and/or depends upon genetic factors in the population (Duboise and Moulton 2005). A stressful environment may facilitate the disease by compromising the immune system, changing the pathogen

characteristics or bacterial community on the shell, or causing complications with the natural molting process. While the source of shell disease remains unknown, it is almost certain that one or more environmental stressors are driving the widespread appearance of shell disease, which is causing increased mortality in lobster populations.[1]

3. A rickettsia-like bacterium has been found to infect the gill area of the sea scallop, *Placopecten magellanicus*, in Block Island Sound (Gulka and Cheng 1985). Heavy infection inhibits the swimming response of the scallops, which may indirectly contribute to mortality by reducing mobility and predator avoidance (Gulka and Cheng 1985). It is not clear how this disease spreads or the impacts to the populations of scallops in Block Island Sound.

4. Striped bass along the Atlantic coast, and particularly in the Chesapeake Bay ecosystem, have exhibited a high prevalence—up to 75%—of mycobacteriosis, a chronic wasting disease caused by *mycobacterium* (Rhodes et al. 2004; Kaattari et al. 2005). Resulting symptoms of mycobacterios includes tumors, external lesions, swelling of the eyes, emaciation, and stunted growth. It is estimated that as many as 60 percent of striped bass within the Chesapeake Bay ecosystem have this disease. Striped bass mortality rates due to mycobacteriosis are not well known, though it does appear to play a role in making striped bass more susceptible to other sources of mortality. Furthermore, it appears that other species are also experiencing infection, with Chesapeake Bay menhaden experiencing up to 57% infection rates (Kane et al. 2007). Striped bass are a migratory species and regular visitors to the Ocean SAMP area, and it is therefore likely that *mycobacterium* have been introduced to the area, though its occurrence or impact on striped bass and/or the ecology of the Ocean SAMP area is unknown.

[1] Further details on lobster shell disease can be found at http://www.seagrant.gso.uri.edu/baird/2010_diseases.html.

Section 270. General Policies and Regulatory Standards

270.1 General Policies

1. The Council recognizes that the preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured. Proposed activities shall be designed to avoid impacts and, where unavoidable impacts may occur, those impacts shall be minimized and mitigated.

2. As the Ocean SAMP is an extension and refinement of CRMC's policies for Type 4 Multipurpose Waters as described in the RICRMP, CRMC will encourage a balance among the diverse activities, both traditional and future water dependent uses, while preserving and restoring the ecological systems.

3. The Council recognizes that while all fish habitat is important, spawning and nursery areas are especially critical in providing shelter for these species during the most vulnerable stages of their life cycles. The Council will ensure that proposed activities shall be designed to avoid impacts to these sensitive habitats, and where unavoidable impacts may occur, those impacts shall be minimized and mitigated. In addition, the Council will give consideration to habitat used by Species of Concern as defined by the NMFS Office of Protected Resources.

4. Because the Ocean SAMP is located at the convergence of two eco-regions and therefore more susceptible to change, the Council will work with partner federal and state agencies, research institutions, and environmental organizations to carefully manage this area, especially as it relates to the projected effects of global climate change on this rich ecosystem.

5. The Council shall appoint a standing Habitat Advisory Board (HAB) which shall provide advice to the Council on the ecological function, restoration and protection of the marine resources and habitats in the Ocean SAMP area and on the siting, construction, and operation of off shore development in the Ocean SAMP study area The HAB shall also provide advice on scientific research and its application to the Ocean SAMP. The HAB is an advisory body to the Council and does not supplant any authority of any federal or state agency responsible for the conservation and restoration of marine habitats. The HAB shall be comprised of nine members, five representing marine research institutions with experience in the Ocean SAMP study area and surrounding waters, and four representing environmental non-governmental organizations that maintain a focus on Rhode Island. HAB members shall serve four-year terms and shall serve no more than two consecutive terms. The Council shall provide to the HAB a semi-annual status report on Ocean SAMP area marine resources and habitat-related issues and adaptive management of projects in the Ocean SAMP planning area, including but not limited to: protection and restoration of marine resources and habitats, cumulative impacts, climate

change, environmental review criteria, siting and performance standards, and marine resources and habitat mitigation and monitoring. The Council shall notify the HAB in writing concerning any project in the Ocean SAMP area. The HAB shall meet not less than semi-annually with the Fishermen's Advisory Board and on an as-needed basis to provide the Council with advice on protection and restoration of marine resources and habitats in the Ocean SAMP areas and potential adverse impacts on marine resources and habitat posed by proposed projects reviewed by the Council. The HAB may also meet regularly to discuss issues related to the latest science of ecosystem-based management in the marine environment and new information relevant to the management of the Ocean SAMP planning area. In addition the HAB may aid the Council and its staff in developing and implementing a research agenda. As new information becomes available and the scientific understanding of the Ocean SAMP planning area evolves, the HAB may identify new areas with unique or fragile physical features, important natural habitats, or areas of high natural productivity for designation by the Council as Areas of Particular Concern or Areas Designated for Preservation.

270.2 Regulatory Standards

1. Ocean SAMP sea duck foraging habitats in water depths less than or equal to 20 meters [65.6 feet] (as shown in Figure 11.7) are designated as Areas Designated for Preservation due to their ecological value and the significant role these foraging habitats play to avian species, and existing evidence suggesting the potential for permanent habitat loss as a result of offshore wind energy development. The current research regarding sea duck foraging areas indicates that this habitat is depth limited and generally contained within the 20 meter depth contour. It is likely there are discreet areas within this region that are prime feeding areas; however at present there is no long-term data set that would allow this determination. Thus, the entire area within the 20 meter contour is being protected as an Area Designated for Preservation until further research allows the Council and other agencies to make a more refined determination. For further information on Areas Designated for Preservation, see Chapter 11, The Policies of the Ocean SAMP.

2. Glacial moraines are important habitat areas for a diversity of fish and other marine plants and animals because of their relative structural permanence and structural complexity. Glacial moraines create a unique bottom topography that allows for habitat diversity and complexity, which allows for species diversity in these areas and creates environments that exhibit some of the highest biodiversity within the entire Ocean SAMP area. The Council also recognizes that because glacial moraines contain valuable habitats for fish and other marine life they are also important to commercial and recreational fishermen. Accordingly, , the Council shall designate glacial moraines as identified in Chapter 11, Figures 11.3 and 11.4, as Areas of Particular Concern. For further information on Areas of Particular Concern, see Chapter 11, The Policies of the Ocean SAMP.

3. The Council shall require, for Large -Scale Projects, modeling of circulation and stratification to ensure that water flow patterns and velocities are not altered in ways that would lead to major ecosystem change. The current patterns that exist within the Ocean SAMP ecosystem play an important role in shaping ecosystem functions at all biological and ecological scales, and in shaping physical oceanographic process such as water column stratification.

4. Biological resource assessments shall be conducted according to the procedures outlined in Section 1160.5 of Chapter 11, The Policies of the Ocean SAMP, and detailed in the Site Assessment Plan and the Construction and Operation Plan sections.

5. The Council in coordination with the Joint Agency Working Group, as described in Chapter 11, The Policies of the Ocean SAMP, shall determine requirements for monitoring prior to, during and post-construction. Specific biological monitoring requirements shall be determined on a project by project basis and may include but are not limited to the monitoring of:
    i. Coastal processes and physical oceanography
    ii. Underwater noise
    iii. Benthic ecology
    iv. Avian species
    v. Marine mammals
    vi. Sea turtles
    vii. Fish and fish habitat

6. Any Large-Scale Offshore Development, as defined in Chapter 11 in section 1160.1.1, shall require a meeting between the HAB, the applicant, and the Council staff to discuss potential marine resource and habitat-related issues such as, but not limited to, impacts to marine resource and habitats during construction and operation, project location, construction schedules, alternative locations, project minimization, measures to mitigate the potential impacts of proposed projects on habitats and marine resources, and the identification of important marine resource and habitat areas. For any state permit process for a Large-Scale Offshore Development, this meeting shall occur prior to submission of the state permit application. The Council cannot require a pre-application meeting for federal permit applications, but the Council strongly encourages applicants for any Large-Scale Offshore Development, as defined in Section 1160.1.1, in federal waters to meet with the HAB and the Council staff prior to the submission of a federal application, lease, license, or authorization. However, for federal permit applicants, a meeting with the HAB shall be necessary data and information required for federal consistency reviews for purposes of starting the CZMA 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930, subpart E, pursuant to 15 C.F.R. § 930.58 (a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project.

Section 280. Literature Cited

Anderson, D.M., Kaefer, B.A., McGillicuddy, D.J., Jr., Mickelson, M.J., Keay, K.E., Libby, P.S., Manning, J.P., Mayo, C.A., Whittaker, D.K., Hickey, J.M., He, R., Lynch, D.R., and Smith, K.W. 2005. Initial observations of the 2005 *Alexandrium fundyense* bloom in southern New England: General patterns and mechanisms. *Deep-Sea Research II* 52:2856-2876.

Asher, T.G., Grilli, A., Grilli, S.T., and Spaulding, M.L. 2009. Analysis of extreme wave climates in Rhode Island waters. 10 August 2009. University of Rhode Island. Ocean SAMP document.

Ayers, J.C. 1950. The transparency (by white Secchi disk) of the waters in and about New York Harbor. Cornell University Status Report No. 7. (cited in Williams 1969; original not seen)

Battelle, Inc. 2002a. Fall 2001 Infauna Characterization Report, Rhode Island Region, Long-Term Dredge Material Disposal Site Evaluation Project, U.S. Army Corps of Engineers, New England District, Concord, MA. www.nae.usace.army.mil/projects.ri/riltds/ridredging.htm Accessed 25 January 2010.

Battelle, Inc. 2002b. Fall 2001 REMOTS® Characterization Report. Rhode Island Region, Long-Term Dredge Material Disposal Site Evaluation Project, U.S. Army Corps of Engineers, New England District, Concord, MA. www.nae.usace.army.mil/projects.ri/riltds/ridredging.htm Accessed 25 January 2010.

Battelle, Inc. 2003a. Benthic Infauna Data for Area E and Area W, July 2003. Long-Term Dredge Material Disposal Site Evaluation Project, U.S. Army Corps of Engineers, New England District, Concord, MA. www.nae.usace.army.mil/projects.ri/riltds/ridredging.htm Accessed 25 January 2010.

Battelle, Inc. 2003b. Sediment Profile Imaging of Area E and Area W, July 2003. Long-Term Dredge Material Disposal Site Evaluation Project, U.S. Army Corps of Engineers, New England District, Concord, MA. www.nae.usace.army.mil/projects.ri/riltds/ridredging.htm Accessed 25 January 2010.

Battelle, Inc. 2003c. Survey Report for the Rhode Island Region Side-Scan Sonar and Bathymetric Survey. Long-Term Dredge Material Disposal Site Evaluation Project, U.S. Army Corps of Engineers, New England District, Concord, MA. www.nae.usace.army.mil/projects.ri/riltds/ridredging.htm Accessed 25 January 2010.

Beardsley, R.C., and Boicourt, W.C. 1981. On estuarine and continental shelf circulation in the Middle Atlantic Bight. In: *Evolution of Physical Oceanography*, pp. 198–233. Warren, B.A., and Wunsch, C. (eds.) MIT Press, Cambridge, MA.

Beardsley, R.C., Chapman, D.C., Brinks, K.H., Ramp, S.R., and Shlitz, R. 1985. The Nantucket Shoals Flux Experiment (NSFE79), I, A basic description of the current and temperature variability. *Journal of Physical Oceanography* 15:713–748.

Beardsley, R.C., Boicourt, W.C., and Hansen, D.V. 1976. Physical oceanography of the Middle Atlantic Bight. In: Gross, M.G. (ed) *Proceedings of the symposium Middle Atlantic continental shelf and the New York Bight*. American Museum of Natural History, New York. pp. 3–5.

Beaugrand, G., Brander, K.M., Allistair Lindley, J., Souissi, S., and Reid, P.C. 2003. Plankton effect on cod recruitment in the North Sea. *Nature* 426:661-664.

Beaugrand, G., Reid, Philip C., Ibanez, F., Alistair Lindley, J., and Edwards, M. 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. *Science* 296:1692-1694.

Bohaboy, E., Malek, A., and Collie, J. 2010. Baseline characterization: data sources, methods and results. Appendix A to Chapter 5: Commercial and Recreational Fisheries. Ocean SAMP. Rhode Island Coastal Resources Management Council, Wakefield, RI.

Boicourt, W., and Hacker, P. 1976. Circulation on the Atlantic continental shelf off the United States, Cape May to Cape Hatteras. *Memoirs of the Royal Society of Science in Liege.* Set 6(10):187-200.

Boothroyd, J.C. 2009. Coarse-Grained Sediment Transport in Sounds, Bays, Estuaries, and Lagoons. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm

Boothroyd, J.C., and Sirkin, L. 2002. The Quaternary geology of Block Island and adjacent regions. In: *The Ecology of Block Island*, pp. 13–27. Paton, P., Gould, L., August, P., and Frost, A. (eds.) The Rhode Island Natural History Survey, Kingtson, RI.

Bowen, W.D., and Harrison, G.D. 1994. Offshore diet of grey seals *Halichoerus gyrpus* near Sable Island, Canada. *Marine Ecology Progress Series* 112:1–11.

Bowen, W.D., Lawson, J.W., and Beck, B. 1993. Seasonal and geographic variation in the species composition and size of prey consumed by grey seals (*Halichoerus grypus*) on the Scotian shelf. *Canadian Journal of Fisheries and Aquatic Science* 50:1768–1778.

Bricker, S.B., Longstaff, B., Dennison, W., Jones, A., Boicourt, K., Wicks, C., and Woerner, J. 2008. Effects of nutrient enrichment in the nation's estuaries: A decade of change. *Harmful Algae* 8:21–32.

Brown, R.W. 2009. Rhode Island Fisheries and the Ocean SAMP: Are we ready for the tradeoffs? In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm

Brussaard, C.P.D. 2004. Viral control of phytoplankton populations—a review. *Journal of Eukaryotic Microbiology* 51:125-138.

Bullard, S., Lambert, G., Carman, M., Byrnes, J., Whitlatch, R., Ruiz, G., Miller, R., Harris, L., Valentine, P., and Collie, J. 2007. The colonial ascidian *Didemnum sp*. A: Current distribution, basic biology and potential threat to marine communities of the northeast and west coasts of North America. *Journal of Experimental Marine Biology and Ecology* 342:99-108.

Byron, C.J, and Link, J.S. in press. Stability in the feeding ecology of four demersal fish predators in the US Northeast Shelf Large Marine Ecosystem. *Marine Ecology Progress Series*.

Caron, C.M., and Paton, P.W.C. 2007. Population trends and habitat use of Harlequin Ducks in Rhode Island. *The Journal of Field Ornithology* 78(3): 254-262.

Castro, K.M., and Angell, T.E. 2000. Prevalence and progression of shell disease in American lobster, *Homarus americanus*, from Rhode Island waters and the offshore canyons. *Journal of Shellfish Research* 19:691-700.

Chistoserdov, A.Y., Smolowitz, R., Mirasol, F., and Hsu, A. 2005. Culture dependent characterization of the microbial community associated with epizootic shell disease lesions in American lobster, *Homarus americanus*. *Journal of Shellfish Research* 24:741–747.

Clancy, M., and Cobb, J.S. 1997. Effect of wind and tidal advection on distribution patterns of rock crab Cancer irroratus megalopae in Block Island Sound, RI. *Marine Ecology Progress Series* 152: 217-225.

Coastal Carolina University College of Natural and Applied Sciences. N.d. Gulf Stream Rings. Available online at: http://kingfish.coastal.edu/gulfstream/p6.htm

Collie, J., Wood, A., and Jeffries, H. 2008. Long-term shifts in the species composition of a coastal fish community. *Canadian Journal of Fisheries and Aquatic Science* 65:1352-1365.

Cobb, J.S., and Castro, K.M. 2006. Shell disease in lobster: A synthesis. New England Lobster Research Initiative. University of Rhode Island.

Codiga, D.L. 2009. Circulation in Block Island Sound, Rhode Island Sound, and Adjacent Waters, with Emphasis on Subsurface Flows. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/Abstracts/codiga.pdf

Codiga, D.L. 2005. Interplay of wind forcing and buoyant discharge off Montauk Point: seasonal changes to velocity structure and a coastal front. *Journal of Physical Oceanography* 35: 1068–1085.

Codiga, D.L., and Aurin, D.A. 2007. Residual circulation in eastern Long Island Sound: observed transverse-vertical structure and exchange transport. *Continental Shelf Research* 27:103–116.

Codiga, D.L., and Rear, L.V. 2004. Observed tidal currents outside Block Island Sound: Offshore decay and effects of estuarine outflow. Journal of Geophysical Research doi:10.1029/2003JC001804

Codiga, D.L., and Ullman, D.S. 2010. Characterizing the physical oceanography of coastal waters off Rhode Island: Part 1: Literature review, available observations, and a representative model simulation. Final Report for Rhode Island Ocean Special Area Management Plan. Coastal Resources Management Council, Wakefield, RI.

Collie, J. 2009. Long-term data reveal climate forcing of the Rhode Island Sound fish community structure. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm

Collie, J., Wood, A., and Jeffries, H. 2008. Long-term shifts in the species composition of a coastal fish community. *Canadian Journal of Fisheries and Aquatic Science* 65:1352–1365.

Cook, G.S. 1966. Non-tidal circulation in Rhode Island Sound—drift bottle and sea bed drifter experiements (1962–1963). *TM No. 369*. Naval Underwater Weapons Research Engineering Station, Newport, RI.

Costello, J.H., Sullivan, B.K., Gifford, D.J., Van Keuren, D., and Sullivan, L.J. 2006. Seasonal refugia, shoreward thermal amplification, and metapopulation dynamics of the ctenophore *Mnemiopsis leidyi* in Narragansett Bay, RI. *Limnology and Oceanography* 51:1819-1831

Cowles, G.W., Lentz, S.J., Chen, C., Xu, Q., and Beardsley, R.C. 2008. Comparison of observed and model-computed low frequency circulation and hydrography on the New England shelf. Journal of Geophysical Research 113: C09015, doi:10.1029/2007JC004394.

CRMC, URI, RINHS. 2007. Rhode Island Aquatic Invasive Species Management Plan. Approved by the Aquatic Nuisance Species Task Force. November 7, 2007. www.anstaskforce.gov/State%20Plans/RI_SAMP_Approved.pdf. Accessed 25 January 2010.

DeAlteris, J.T., Skrobe, L.G., Castro, K .M. 2000. Effects of mobile bottom fishing gear on biodiversity and habitat in offshore New England waters. Northeastern Naturalist **7**(4): 379-394.

Deevey, G. B. 1952a. A survey of the zooplankton of Block Island Sound, 1943-1946. *Bulletin of the Bingham Oceanography Collection* 13: 66-119.

Deevey, G. B. 1952b. Quality and composition of the zooplankton of Block Island Sound, 1949. *Bulletin of the Bingham Oceanography Collection* 13: 120-164.

Drinkwater, K.F. 2005. The response of Atlantic cod (*Gadus morhua*) to future climate change. *ICES Journal of Marine Science* 62:1327-1337.

Driscoll, N. 1996. Scientists study large storm and human effects in Block Island Sound. *Oceanus* 22 March 1996. Woods Hole Oceanographic, Woods Hole, MA.

Duboise, S.M., and Moulton, K.D. 2005. Defining the etiology of epizootic shell disease: the importance of genetic investigations of the associated bacterial and viral ecology. In: *Lobster Shell Disease Workshop Forum Series 051,* pp. 26-35. Tlusty, M.F., Halvorson, H.O., Smolowitz, R., and Sharma, U. (eds.) New England Aquarium, Boston, MA.

Edwards, C.A., Fake, T.A., and Bogden, P.S. 2004. A numerical model investigation of spring-summer frontogenesis at the mouth Block Island Sound. *Journal of Geophysical Research* 109 C12021, doi: 12010.11029/12003JC002132.

Emanuel, K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* 436:686–688.

Enfield, D.B., Mestas-Nunez, A.M., and Trimble, P.J. 2001. The Atlantic Multidecadal Oscillation and its relationship to rainfall and river flows in the continental U.S. *Geophysical Research Letters* 28:2077–2080. doi:10.1029/2000GL012745.

Eriksson, B.K., Rubach, A., Hillebrand, H. 2006. Biotic Habitat Complexity Controls Species Diversity and Nutrient Effects on Net Biomass Production. *Ecology* 87(1):246-254.

Fahay, M.P. 1992. Development and distribution of cusk eel eggs and larvae in the Middle Atlantic Bight with a description of *Ophidion robinsi* n. sp. (Teleostei: Ophidiidae). *American Society of Ichthyologists and Herpetologists* 3:799–819.

First, M.W. 1972. Municipal waste disposal by shipborne incineration and sea disposal of residues. Harvard University School of Public Health, Boston MA.

Fogarty, M.J. 1979. Assessment of the ocean quahog, *Arctica islandica*, resource in Rhode Island Sound and south of Martha's Vineyard, MA. RIDEM, Division of Fisheries and Wildlife.

Frank, K.T., Perry, R.I., and Drinkwater, K.F. 1990. Predicted response of Northwest Atlantic invertebrates and fish stocks to CO2 induced climate change. *Transactions of the American Fisheries Society* 119:353–365.

French-McCay, D. and Grilli, A. 2010. Ecological Value Map (EVM) for the Rhode Island Ocean Special Area Management Plan. Technical Report.

Fuhrman, J.A. 1999. Marine viruses and their biogeochemical and ecological effects. *Nature* 339: 541-548.

Gay, P.S., O'Donnell, J., and Edwards, C.A. 2004. Exchange between Long Island Sound and adjacent waters. *Journal of Geophysical Research*. 109, C06017, doi: 10.1029/2004JC002319.

Griscom, C.A. 1978. Currents 0.25 meters above the bottom in 10 meters of water off Charlestown, RI during two severe winter storms—24 Jan–Feb 1978: An Environmental Study of a Nuclear Power Plant at Charlestown, Rhode Island, Part Two. Division of Marine Resources, Graduate School of Oceanography, University of Rhode Island.

Gulka, G., and Cheng, P. W.. 1985. Pathogenicity and infectivity of a rickettsia-like organisms in the sea scallop, *Placopecten magellanicus*. *Journal of Fish Diseases* 8:309–318.

Hale, S.S. 2002. Marine bottom vommunities of Block Island waters. In: *The Ecology of Block Island*, pp. 131-149. Paton, P., Gould, L., August, P., and Frost, A. (eds.) The Rhode Island Natural History Survey, Kingtson, RI.

Hargraves, P.E., Maranda, L. 2002. Potentially toxic or harmful microalgae from the northeast coast. *Northeastern Naturalist* 9(1):81-120.

Hays, G.C., Richardson, A.J., and Robinson, C. 2005. Climate change and marine plankton. *Trends in Ecology and Evolution* 20 (6):337-344

He, R., and Wilkin, J.L. 2006. Barotropic tides on the southeast New England shelf: A view from a hybrid data assimilative modeling approach. *Journal of Geophysical Research* 111, C08002, doi: 08010.01029/02005JC003254.

Hequette, A., and Hill, P.R. 1993. Storm-generated currents and offshore sediment transport on a sandy shoreface, Tibjak Beach, Canadian Beaufort Sea. *Marine Geology* 113:283–304.

Hess, E. 1937. A shell disease in lobsters (*Homarus americanus*) caused by chitinovorous bacteria. *Journal of the Fisheries Research Board of Canada* 3:358–362.

Hicks, S.D., and Campbell, R. 1952. Report on physical oceanographic cruises #3 and #4, Narragansett Bay and its approaches. *Narragansett Marine Laboratory Report 52-16*, University of Rhode Island, Narragansett, RI.

Ho, K. 1999. The chemistry and toxicity of sediment affected by oil from the North Cape spilled into Rhode Island Sound. *Marine Pollution Journal* Vol. 38, Issue 4:314.

Holland, G.J., and Webster, P.J. 2007. Heightened tropical cyclone activity in the North Atlantic: Natural variability or climate trend? *Philosophical Transactions of The Royal Society A* Vol. 365, No. 1860:2695-2716.

Hollman, . 1976. A histogram analysis of the annual variations of physical and chemical parameters: 1970–1973. *Environmental Atlas of Block Island and Long Island Sound Waters 1976*. New York Ocean Science Laboratory, Montauk, NY

Hulsizer, E.E. 1976. Zooplankton of Lower Narragansett Bay, 1972-1973. *Chesapeake Science* 17(4):260-270.

Hyde, K. 2009. Seasonal and interannual variability of phytoplankton production in Rhode Island and Block Island Sound. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm

Hyde, K.J.W., O'Reilly, J.E., and Oviatt, C.A.. 2008. Evaluation and application of satellite primary production models in Massachusetts Bay. Continental Shelf Research 28:1340-1351.

IPCC. 2007. Climate Change 2007: Synthesis Report. *Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Core writing team Pachauri, R.K., and Reisinger, A. (eds.) IPCC, Geneva, Switzerland.

Kaattari, I.M., Rhodes, M.W., Kator, H., and Kaattari, S.L. 2005. Comparative analysis of mycobaterial infections in wild striped bass *Morone saxatilis* from Chesapeake Bay. *Diseases of Aquatic Organisms* 67: 125–132.

Kane, A.S., Stine, C.B., Hungerford, L., Matsche, M., Driscoll, C., and Baya, A.M. 2007. Mycobacteria as environmental portent in Chesapeake Bay fish species. *Emerging Infectious Diseases* 13(2): 329–331.

Kane, J. 2007. Zooplankton abundance trends on Georges Bank, 1977–2004. ICES Journal of Marine Science. 64:909–919.

Kaputa, N.P. and Olsen, C.B. 2000. Summer hypoxia monitoring survey '91–'98 data review. Long Island Sound Water Quality Monitoring Program. Connecticut Dept. of Environmental Protection, Hartford, CT.

Katz, C.H., Cobb, J.S., and Spaulding, M. 1994. Larval behavior, hydrodynamic transport, and potential offshore-to-inshore recruitment in the American lobster, *Homarus americanus*. *Marine Ecology Progress Series* 103:265–273.

Keller, A.A., Taylor, C., Oviatt, C.A., Dorrington, T., Holcombe, G., and Reed, L.W. 2001. Phytoplankton production patterns in Massachusetts Bay and the absence of the 1998 winter-spring bloom. Marine Biology 138:1051-1062.

Kenefik, A.M. 1985. Barotropic M_2 tides and tidal currents in Long Island Sound: A numerical model. *Journal of Coastal Research* 1(2):117–128.

Kennedy, V.S., Twillley, R., Kleypas, J.A., Cowan, J.H., Jr., and Hare, S.R. 2002. Coastal and marine ecosystems and global climate change: Potential effects on U.S. resources. Pew Center on Global Climate Change. Arlington, VA.

Kenney, R.D. and Vigness-Raposa, K.J. 2009. Marine mammals and sea turtles of Narragansett Bay, Block Island Sound, Rhode Island Sound, and nearby waters: An analysis of existing data for the Rhode Island Ocean Special Area Management Plan. *DRAFT TECHNICAL REPORT* Version 2 of 31 May 2009.

Kincaid, C., Pockalny, R.A., and Huzzey, L.M. 2003. Spatial and temporal variability in flow at the mouth of Narragansett Bay. *Journal of Geophysical Research* 108(C7), 3218, doi:10.1029/2002JC001395.

King, J., and Collie, J. 2010. Geological, geophysical, benthic habitat, archaeological study in the Rhode Island Ocean SAMP study area. Appendix A: Technical reports for the Rhode Island Ocean Special Area Management Plan. RI Coastal Resources Management Council, Wakefield, RI.

Kirincich, A. and Hebert, D. 2005. The structure of the coastal density front at the outflow of Long Island Sound in spring 2002. *Continental Shelf Research* 25: 1097–1114.

Koppelman, L.E., Weyl, P.K., Gross, M.G., and Davies, D.S. 1976. *The Urban Sea: Long Island Sound.* Special Student Design/Environmental Planning Service. Praeger, NY.

Kremer, P. 1994. Patterns of abundance for *Mnemiopsis* in U.S. coastal waters - a comparative overview. *ICES Journal of Marine Science* 51:347-354.

LaFrance, M., Shumchenia, E., King, J., Pockalny, R., Oakley, B., Pratt, S., and Boothroyd, J. 2010. Benthic habitat distribution and subsurface geology of selected sites from the Rhode Island Ocean Special Area Management Study Area. Technical Report #4. Rhode Island Coastal Resources Management Council, Wakefield, RI.

Lillick, L. 1937. Seasonal studies of phytoplankton off Woods Hole, Massachusetts. *Biological Bulletin* 73(3):488-503.

Linder, C.A., and Gawarkiewicz, G. 1998. A climatology of the shelfbreak front in the Middle Atlantic Bight. *Journal of Geophysical Research* 103: 18405–18423.

Link, J., and Ford, M.D. 2006. Widespread and persistent increase of *Ctenophora* in the continental shelf ecosystem off NE USA. *Marine Ecology Progress Series* 320:153-159

Loder, J.W.B., Petrie, G., and Gawarkeiwicz, G. 1998. The coastal ocean off northeastern North America: a large-scale view. *The Sea* 11 (Robinson, A.R., & Brink, K.H. eds.), Wiley and Sons, NY, pp. 105-133.

Malek, A., Collie, J., LaFrance, M., and King, J. 2010. Fisheries ecology and benthic habitat in Rhode Island and Block Island Sounds. Technical Report #14 of the Ocean Special Area Management Plan. Rhode Island Coastal Resources Management Council, Wakefield, RI.

Malone, T.C., and Chervin, M.B. 1979. The production and fate of phytoplankton size fractions in the plume of the Hudson River, New York Bight. Limnology and Oceanography 24:683-696.

Mann, K.H. 2000. Ecology of Coastal Waters with Implications for Management. 2nd Ed. Blackwell Science.

Mann, K.H., and Lazier, J.R.N. 2006. Dynamics of Marine Ecosystems. 3rd Ed. Blackwell. Massachusetts, USA.

Mann, M.E., and Emanuel, K.A. 2006. Atlantic hurricane trends linked to climate change. *Eos, Transactions, American Geophysical Union* 87:233.

Mann, K.H., and Lazier, J.R.N. 1996. *Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans.* 2nd Edition. Blackwell Science, Inc., Cambridge MA. 394 pp.

Marston, M.F. 2008. Natural viral communities in the Narragansett Bay ecosystem. In: *Science for ecosystem-based management: Narragansett Bay in the 21st century.* Desbonnet, A. and Costa-Pierce, B.A. Springer**:** 419-430.

Martin, J.H. 1970. Phytoplankton–zooplankton relationships in Narragansett Bay. IV. The seasonal importance of grazing. *Limnology and Oceanography* 15:413–418.

Martin, J. 1965. Phytoplankton-zooplankton relationships in Narragansett Bay. *Limnology and Oceanography* 10(2):185-191.

Mau, J.-C., Wang, D.-P., Ullman, D.S., and Codiga, D.L. 2007. Comparison of observed (HF radar, ADCP) and model barotropic tidal currents in the New York Bight and Block Island Sound. *Estuarine and Coastal Shelf Science* 72:129–137.

McMullen, K.Y., Poppe, L.J., Twomey, E.R., Danforth, W.W., Haupt, T.A., and Crocker, J.M. 2007. Sidescan sonar imagery, multibeam bathymetry, and surficial geologic interpretations of the sea floor in Rhode Island Sound, off Sakonnet Point, Rhode Island. U.S. Geological Survey Open File Report 2007-1150. http://pubs.usgs.gov/of/2007/1150/

McMullen, K.Y., Poppe, L.J., Denny, J.F., Haupt, T.A., and Crocker, J.M. 2008. Sidescan sonar imagery and surficial geologic interpretations of the sea floor in Central Rhode Island Sound. U.S. Geological Survey Open-File Report 2007-1366. http://pubs.usgs.gov/of/2007/1366/.

Merriman, D., and Sclar, R.C. 1952. The pelagic fish eggs and larvae of Block Island Sound. *Bulletin of the Bingham Oceanography Collection* 13: 165-219.

Mizrahi, D., Fogg, R., Mararian, T., Elia, V., and La Puma,. D. 2010. Radar monitoring of bird and bat movement patterns on Block Island and its coastal waters. Draft interim report. Rhode Island Ocean Special Area Management Plan. University of Rhode Island, Narragansett, RI.

Mouw, C.B., and Yoder, J.A. 2005. Primary production calculations in the Mid-Atlantic Bight, including effects of phytoplankton community size structure. Limnology and Oceanography 50:1232-1243.

Munk, P., Larsson, P.O., Danielson, D., and Mokness, E. 1995. Larval and small juvenile cod *Gadus morhua* concentrated in the highly productive areas of a shelf break front. *Marine Ecology Progress Series* 125: 21–30.

NOAA Coastal Services Center. N.d. Historical Hurricane Tracks. Available online at: http://www.csc.noaa.gov/beta/hurricanes/#

NOAA National Marine Fisheries Service, Marine Ecosystems Division. N.d. Zooplankton monitoring: Northeast continental shelf. Available online at: http://www.st.nmfs.noaa.gov/plankton/time-series/site__nmfs-sne/index.html

NOAA Tides and Currents. N.d. Center for Operational Oceanographic Products and Services. Available online at: http://tidesandcurrents.noaa.gov/.

Nixon, S., Granger, S., Oviatt, C., Fields, L., and Mercer, J. 2010. Spatial and temporal variability of surface chlorophyll, primary production, and benthic metabolism in Rhode Island and Block Island Sounds. Technical Report #9 for the Ocean Special Area Management Plan. Rhode Island Coastal Resources Management Council, Wakefield, RI.

Northeast Fisheries Science Center. 2010. Media Advisory: "Record Number of North Atlantic Right Whales Sighted off Rhode Island", April 23, 2010. Available online from: http://www.nefsc.noaa.gov/press_release/2010/MediaAdv/MA1004/index.html

Nye, J.A., Link, J.S., Hare, A.J., and Overholtz, W.J. 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. *Marine Ecology Progress Series* 393:111–129.

O'Donnell, J., and Houk, A.E. 2009. The Structure and Variability of the Hydrography of the Block Island Sound. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm.

Olesiuk, P.F., Bigg, M.A., Ellis, G.M., Crockford, S.J., and Wigen, R.J. 1990. An assessment of the feeding habits of harbor seals (Phoca vitulina) in the Strait of Georgia, British Columbia, based on scat analysis. Canadian Technical Report on Fisheries and Aquatic Sciences 1730.

O'Reilly, J.E., Evans-Zetlin, C., and Busch, D.A. 1987. Primary Production, p. 220-233. *In* R. H. Backus [ed.], Georges Bank. MIT Press.

Oviatt, C., and Pastore, R. 1980. Some aspects of water quality in and pollution sources to the Providence River. Report for Region I EPA. Contract #68-04-1002. Boston, MA.

Oviatt, C.A., Hyde, K.J.W., Keller, A.A., and Turner, J.T. 2007. Production patterns in Massachusetts Bay with outfall relocation. Estuaries and Coasts 30: 35-46.

Oviatt, C.A., Keller, A.A., and Reed, L.W. 2002. Annual primary production in Narragansett Bay with no bay-wide winter-spring phytoplankton. Estuarine and Coastal Shelf Science 54**:** 1013-1026.

Paerl, H.W., Dennis, R.L., Whitall, D.R. 2002. Atmospheric deposition of nitrogen: implicatons for nutrient over-enrichment of coastal waters. *Estuaries* 25(4b):677-693.

Paton, P., Winiarski, K., Trocki, C., and McWilliams, S. 2010. Spatial distribution, abundance and flight ecology of birds in nearshore and offshore waters of Rhode Island. Interim

Technical Report for the Rhode Island Ocean Special Area Management Plan. University of Rhode Island, Narragansett, RI.

Payne, P.M., and Selzer, L.A. 1989. The distribution, abundance and selected prey of the harbor seal, *Phoca vitulina concolor*, in Southern New England. *Marine Mammal Science* 5(2):173–192.

Perry, A.L., Low, P.J., Ellis, J.R., and Reynolds, J.D. 2005. Climate change and distribution shifts in marine fishes. *Science* 308:1912–1915.

Pfeiffer-Herbert, A. 2009. Summary of Larval Transport in Block Island and Rhode Island Sounds. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm

Pilson, M.E.Q. 2008. Narragansett Bay amidst a globally changing climate. In: *Science for Ecosystem-based Management: Narragansett Bay in the 21st Century*. Desbonnet, A., and Costa-Pierce, B.A. (eds.) Springer. pp. 35–46.

Poppe, L., DiGiacomo-Cohen, M., Smith, S., Stewart, H., and Forfinski, N. 2006. Seafloor character and sedimentary processes in Eastern Long Island Sound and Western Block Island Sound. *Geo-Marine Letters* 26:59-68.

Pratt, S.D. 1973. Benthic fauna. Pages 5-1–5-70 In: *Coastal and Offshore Environmental Inventory: Cape Hatteras to Nantucket Shoal*, pp. 5-1 – 5-70. Saila, S.B. (ed.) Marine Publication Series No. 2., University of Rhode Island, Kingston, RI.

Ramp, S.R., Brown, W.S., and Beardsley, R.C. 1988. The Nantucket Shoals Flux Experiment 3. The alongshelf transport of volume, heat, salt and nitrogen. *Journal of Geophysical Research* 93:14,039–14, 054.

Reinert, S.E., Lapham, E., and Gaffett, K. 2002. Landbird migration on Block Island: community composition and conservation implications for an island stopover habitat. In: Paton, P.W., Gould, L.L., August, P.V., and Frost, A.O. (eds), *The Ecology of Block Island. Proceedings of the Rhode Island Natural History Survey Conference, October 28, 2000*. The Rhode Island Natural History Survey, Kingston, RI. pp. 151–168.

Rhoads, D., McCall, P., and Yingst, J. 1978. Disturbance and production on the estuarine seafloor. *American Scientist* 66:577-586.

Rhoads, D.C., and Germano, J.D. 1986. Interpreting long-term changes in benthic community structure: a new protocol. *Hydrobiologia* 142:291-308.

Rhodes, M.W., Kator, H., Kaattari, I., Gauthier, D., Vogelbein, W., and Ottinger, C.A. 2004. Isolation and characterization of mycobacteria from striped bass *Morone saxatisis* from the Chesapeake Bay. *Diseases of Aquatic Organisms*. 61: 41–51.

Richards, S.W., Mann, J.M., and Walker, J.A. 1979. Comparison of spawning seasons, age, growth rates, and food of two sympatric species of searobins, *Prionotus carolinus* and *Prionotus evolans*, from Long Island Sound. *Estuaries* 2(4):255–268.

Richardson, A.J., and Schoeman, D.S. 2004. Climate impact on plankton ecosystems in the northeast Atlantic. *Science* 305:1609-1612.

Richardson, D.E., Hare, J.A., Overholtz, W.J. and Johnson, D.L. in press. Development of long-term larval indices for Atlantic herring (Clupea harengus) on the northeast U.S. Continental Shelf. ICES Journal of Marine Science.

Ridoux, V., Spitz, J., Vincent, C., and Walton, M.J. 2007. Grey seal diet at the southern limit of its European distribution: combining dietary analyses and fatty acid profiles. *Journal of the Marine Biological Association United Kingdom* 87:225–264.

Riley, G. 1952. Phytoplankton of Block Island Sound, 1949. *Bulletin of the Bingham Oceanography Collection* 13:40-64.

Riley, G.A., and Conover, S.M. 1967. Phytoplankton of Long Island. Sound 1954-1955. *Bulletin of the Bingham Oceanographic Collection*. 19:5-34.

Roff, J.C., and Evans, M.J.S. 2002. Frameworks for marine conservation—non-hierarchical approaches and distinctive habitats. *Aquatic Conservation: Marine and Freshwater Ecosystems* 12:635-648

Rose, G.A. 2005. On distributional response of North Atlantic fish to climate change. *ICES Journal of Marine Science* 62:1360–1374.

Saila, S.B., Pratt, S.D., and Polgar, T.T. 1972. Dredge Spoil Disposal in Rhode Island Sound. Marine Experiment Station. Sea Grant. National Sea Grant. Marine Technical Report No 2.

Sanders, H.L. 1952. The herring (*Clupea harengus*) of Block Island Sound. *Bulletin of the Bingham Oceanographic Collection* 13:220–237.

Savard, W.L. 1966. *The sediments of Block Island Sound*. Master of Science Thesis, University of Rhode Island.

Schroeder, C.L. 2000. Population status and distribution of the harbor seal in Rhode Island waters. Master of Science Thesis, University of Rhode Island Graduate School of Oceanography.

Shcherbina, A.Y., and Gawarkiewicz, G.G. 2008. A coastal current in winter: Autonomous underwater vehicle observations of the coastal current east of Cape Cod. *Journal of Geophysical Research* 113, C07030, doi:10.1029/2007JC004306.

Shonting, D.H. 1969. Rhode Island Sound square kilometer study 1967: flow patterns and kinetic energy distribution. *Journal of Geophysical Research* 74:3386–3395.

Shonting, D.H., and Cook, G.S. 1970. On the seasonal distribution of temperature and salinity in Rhode Island Sound. *Limnology and Oceanography* 15:100–112.

Signell, R.P. 1987. Tide and wind-forced currents in Buzzards Bay, Massachusetts. M.S. Thesis. Massachusetts Institute of Technology.

Smayda, T.J. 2008. Complexity in the eutrophication-harmful algal bloom relationship, with comment on the importance of grazing. *Harmful Algae* 8:140-151.

Smayda, T.J. 1973. A survey of phytoplankton dynamics in coastal waters from Cape Hatteras to Nantucket. In: *Coastal and Offshore Environmental Inventory: Cape Hatteras to Nantucket Shoals.* Occasional Publication No. 5. Graduate School of Oceanography, University of Rhode Island, Narragansett, RI.

Smayda, T.J. 1957. Phytoplankton studies in Lower Narragansett Bay. *Limnology and Oceanography* 2(4): 342-359.

Smith, F.E. 1950. *The benthos of Block Island Sound. I. The invertebrates, their quantities and their relations to the fishes*. Ph.D. Thesis. Yale University, New Haven, CT.

Spaulding, M. 2007. http://www.crmc.ri.gov/samp_ocean/Wind_Energy_RI_EBC.pdf; accessed 11 February 2010.

Staker, R.D., and Bruno, S.F. 1977. Phytoplankton in coastal waters off Eastern Long Island (Block Island Sound) Montauk, N.Y. New York Ocean Science Laboratory.

Staroscik, A.M., and Smith, D.C. 2004. Seasonal patterns in bacterioplankton abundance and production in Narragansett Bay, Rhode Island, USA. *Aquatic Microbial Ecology* 35: 275-282.

Steimle, F.W., Jr. 1982. The benthic invertebrates of Block Island Sound. *Estuarine, Coastal and Shelf Science* 15:1–16.

Steimle, F.W., Jr. 1990. Benthic macrofauna and habitat monitoring on the Continental Shelf of the Northeastern United States. I. Biomass. *NOAA Technical Report NMFS 86*. U.S. Department of Commerce, Washington, DC.

Stone, B.D., and Borns, H.W., Jr. 1986. Pleistocene glacial and interglacial stratigraphy of New England, Long Island, and adjacent Georges Bank and Gulf of Maine. In: *Quaternary*

Glaciations in the Northern Hemisphere, pp. 39–52. Sibrava, V., Bowen, D.Q., and Richmond, G.M. (eds.) Pergamon Press, Oxford, UK.

Sullivan, B.K., Gifford, D.J., Costello, J.H., and Graff, J.R. 2008. Narragansett Bay ctenophore-zooplankton-phytoplankton dynamics in a changing climate. In: *Science for ecosystem-based management Narragansett Bay in the 21st century.* pp. 485–498. Desbonnet, A., and Costa-Pierce, B.A. (eds.) Springer, NY.

Suttle, C.A. 2005. Viruses at sea. *Nature* 437: 356-361.

Taylor, M.H., Holzwarth-Davis, T., Bascunan, C. and Manning, J.F. 2009. Description of the 2008 oceanographic conditions on the Northeast U.S. Continental Shelf. U.S. Department of Commerce, Northeast Fisheries Science Center, Reference Document 09-12.

Theroux, R.B., and Wigley, R.L. 1998. Quantitative composition and distribution of the macrobenthic invertebrate fauna of the Continental Shelf ecosystems of the Northeastern United States. *NOAA Technical Report NMFS 140*. U.S. Department of Commerce, Seattle, WA.

Uchupi, E., Driscoll, N., Ballard, R.D., and Bolmer, S.T. 2001. Drainage of late Wisconsin lakes and the morphology of later Quaternary stratigraphy of the New Jersey-southern New England continental shelf and slope. *Marine Geology* 172:117–145.

Ullman, D.S. and Codiga, D.L. 2010. Characterizing the physical oceanography of coastal waters off Rhode Island: Part 2: New observations of water properties, currents and waves. Final Report for Rhode Island Ocean Special Area Management Plan. Coastal Resources Management Council, Wakefield, RI.

Ullman, D.S., and Codiga, D.L. 2004. Seasonal variation of a coastal jet in the Long Island Sound outflow region based on HF radar and Doppler current observations. *Journal of Geophysical Research* 109, C07S06, doi: 10.1029/2002JC001660.

Ullman, D.S., and Cornillon, P.C. 2001. Continental shelf surface thermal fronts in winter off the northeast U.S. coast. *Continental Shelf Research* 21:1139–1156.

Ullman, D. 2009. Surface Current Patterns in Block Island Sound and Adjacent Waters. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm

U.S. Army Corps of Engineers. 2002. Final Report. Fall 2001 Water Column Characterization Report. Rhode Island Region Long-Term Dredged Material Disposal Site Evaluation Project. U.S. Army Corps of Engineers New England District, Concord, MA.

Valentine, P., Collie, J., Reid, R., Asch, R., Guida, V., and Blackwood, D. 2007. The occurrence of the colonial ascidian *Didemnum sp.* on Georges Bank gravel habitat—Ecological

observations and potential effects on groundfish and scallop fisheries. *Journal of Experimental Marine Biology and Ecology* 342:179-181.

Webster, P.J., Holland, G.J., Curry, J.A., and Chang, H.-R. 2005. Changes in tropical cyclone number, duration and intensity in a warming environment. *Science* 309:1844–1846.

Weinbaur, M.G., Rassoulzadegan, F. 2004. Are viruses driving microbial diversification and diversity? *Environmental Microbiology* 6: 1-11.

Williams, A.S. 1969. Prey selection by harbor seals in relation to fish taken by the Gulf of Maine sink gillnet fishery. *Master of Science Thesis*. University of Maine.

Williams, R.G. 1967. The physical oceanography of Block Island Sound. A review report. *Technical Memorandum No. 2213–3367.* U.S. Navy Underwater Sound Laboratory, New London, CT.

Wilson, S.J.K, Fredette, T.J., Germano, J.D., Blake, J.A., Neubert, P.L.A., and Carey, D.A. 2009. Plan-view photos, benthic grabs, and sediment-profile images: Using complementary techniques to assess response to seafloor disturbance. *Marine Pollution Bulletin* 59:26-37.

Wommack, K.E., and Colwell, R.R. 2000. Virioplankton: viruses in aquatic ecosystems. *Microbiology and Molecular Biology Reviews* 64: 69-114.

Wood, S.A. 2000. Summary of harbor seal (*Phoca vitulina concolor*) food habits in Mid-coast Maine: Summer 2000. *Report to the Marine Environmental Research Institute* 1–11.

Worm, B., Sandow, M., Oschlies, A., Lotze, H.K., and Myers, R.A. 2005. Global patterns of predator diversity in the open oceans. *Science* 309:1365–1369.

Yin, J.H. 2005. A consistent poleward shift of the storm tracks in simulations of 21st century climate. *Geophysical Research Letters* 32: L18701, DOI:10.1029/2005GL023684.

Zajac, R.N. 2009. The ecology and dynamics of benthic communities in Block Island Sound and Rhode Island Sound: A short review and prospectus. In: *Sound Connections: The Science of Rhode Island & Block Island Sounds. Proceedings of the 7th Annual Ronald C. Baird Sea Grant Science Symposium.* Rhode Island Sea Grant, Narragansett, RI. October 2008. http://seagrantadm.gso.uri.edu/Baird_08/default.htm

Appendix I. Siting Analysis- Ecological Value Map

1. A second tool developed to help identify areas most suitable for offshore renewable energy development is the Ecological Value Map (EVM) created by French-McCay and Grilli (2010). As part of the EVM framework, French-McCay and Grilli (2010) modeled the ecological value of the Ocean SAMP area by inputting geospatial data describing the geophysical environment, fish and wildlife species distribution, ecosystem and habitat characteristics, as well as human uses, such as fishing activity collected by Ocean SAMP researchers. For this analysis, French-McCay and Grilli (2010) defined 'ecological value' to include both the intrinsic value of biodiversity and the socioeconomic value associated with the goods and services provided by the marine ecosystem (e.g. fishing activity). See French-McCay and Grilli (2010) for more information on the development and application of EVM.

2. The process used by French-McCay and Grilli (2010) is illustrated in Figure 2.40. First, separate EVMs were generated for individual species based on aggregation data collected and modeled over a 100 meter grid across the Ocean SAMP area (the same grid used by the TDI analysis described in Section 830.2).[2] The species specific EVMs were then combined to create group EVMs, resulting in EVMs for the following categories: benthic ecosystems, pelagic ecosystems, fish, birds, sea turtles, marine mammals, bats and fisheries. This grid is the same grid used by the TDI analysis described in Section 830.2. French-McCay and Grilli (2010) used alternative weighing schemes when combining species maps into group maps to reflect relative intrinsic and service values, as well as uncertainties in the underlying data. The researchers then combined all category EVMs, across all resources, to create a composite EVM for the entire Ocean SAMP area. In the end, the EVM framework provides a tool to help identify portions of the Ocean SAMP area that have greater ecological value. Understanding where these zones of greatest ecological value exist in the Ocean SAMP area may help in determining appropriate sites suitable for an offshore renewable energy development.

3. To complement the EVM framework, French-McCay and Grilli (2010) also performed a principal component and cluster analysis on the maps of species distribution to identify homogeneous areas within the Ocean SAMP boundary and generate an Ecological Topology Map of the Ocean SAMP area. To accomplish this, French-McCay and Grilli (2010) used principal component analysis to identify what factors best explain species distribution (e.g. bathymetry, water temperature, fishing activity). The researchers then use cluster analysis to identify similar zones within the Ocean SAMP area, in terms of biodiversity and ecological structure, and generate an ecological topology map. This type of analysis may also provide a useful tool when siting offshore renewable energy facilities, as it provides information on what factors are influencing biological distributions in the Ocean SAMP area. For more information on the principal component and cluster analysis used please see French-McCay and Grilli (2010).

[2] To quantify distributions and relative densities of specific species, French-McCay and Grilli (2010) applied the wildlife movement (migration and behavior) model (WILDMAP™). This model is based on life history information, nesting/breeding and foraging locations, and available observational data for the species evaluated. The model predictions are then ground-truthed by presence/absence, abundance, frequency and spatial observational data. For more information on the WILDMAP model used to predict usage by marine life see (ASA 2010).

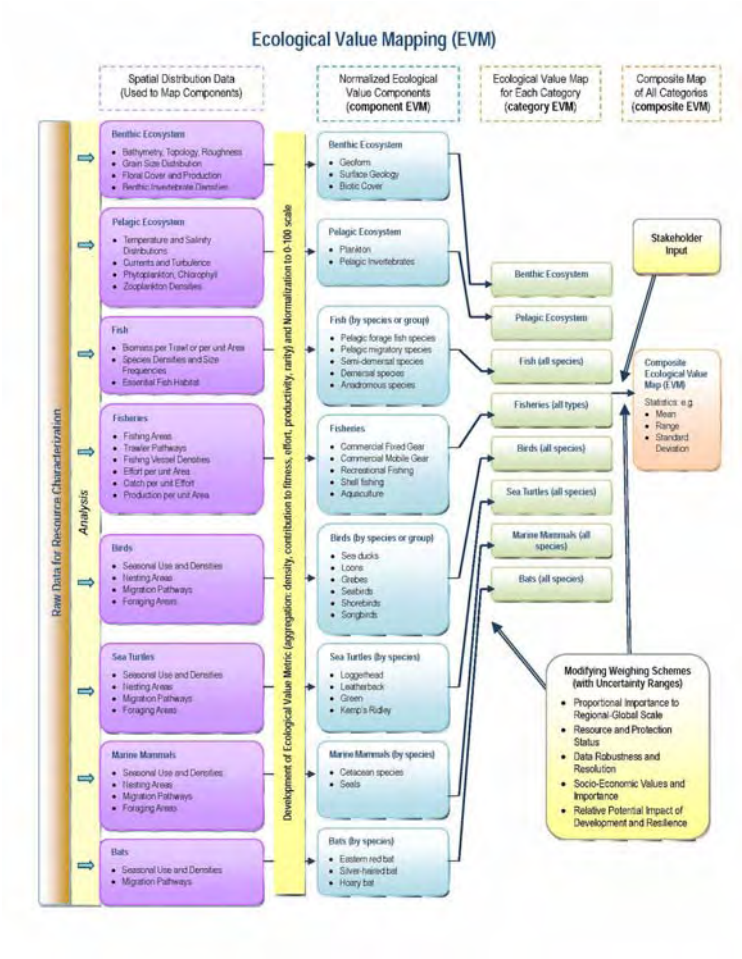


Figure 2.40. Framework for Ecological Valuation Mapping as applied to the Ocean SAMP (French-McCay and Grilli 2010).

Chapter 3: Global Climate Change

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Section 300. The Ocean SAMP Area in a Climate Changed World

1. Ecologically, economically, and culturally, Rhode Island is inexorably linked to the ocean and therefore faces a number of challenges from climate change that are specific to the coastal and marine landscape.

2. The climate of the Ocean Special Area Management Plan (Ocean SAMP) area has changed over the past century. Overall, both air and sea temperature in the region have been getting warmer, sea level has been rising, it has become wetter, the severity of storms is increasing, and the acidity of the sea has increased.[1]

3. Human activities since the start of the Industrial Age have caused a significant increase in greenhouse gases in the atmosphere. The most prevalent greenhouse gas in the atmosphere in terms of anthropogenic emissions, carbon dioxide, has risen from a pre-industrial level of 280 parts per million (ppm) to 385 ppm in 2008, the highest it has been in 650,000 years. There is strong scientific consensus that carbon dioxide in the atmosphere warms the air and sea surface, accelerates sea level rise, makes the ocean more acidic, causes shifts in precipitation and weather patterns, and leads to more extreme weather events, among other effects (Anderegg et al. 2010; Sills 2010). These effects are already being witnessed globally and in Rhode Island and are projected to intensify in years to come.

4. Future projections of climate change include sea water warming and possible changes to offshore ocean circulation patterns, stratification, nutrient distribution, and plankton productivity. Alteration of these variables is expected to affect the ecological functioning of the Ocean SAMP region, create stress on marine plants and animals, shift geographic ranges of commercially important fish species northward, and change the timing of biological events. Other implications, such as accelerated sea level rise, more intense storms, sea surge, accelerated rates of coastal erosion and beach migration, more rain, salinity changes, and runoff and salt water intrusion into fresh water aquifers, all have consequences for coastal infrastructure and recreation associated with the Ocean SAMP, marine navigation and transportation, and the offshore marine ecology.

5. Concern over the effects of current and future impacts upon humans and the natural environment is being expressed at local and international levels. In Rhode Island, concern over climate change is one of the driving considerations behind the policy goal of 16 percent renewable energy in the state's electrical supply by 2019, and efforts to promote renewable energy (e.g. offshore wind energy) and energy efficiency.

6. Reducing greenhouse gas emissions, or "mitigation," is one of two proactive choices society can make to address climate change. Climate change mitigation is a human intervention to actively reduce the production of greenhouse gas emissions (e.g., through replacement of fossil fuels with renewable energy) or to remove the gases from the atmosphere (e.g., through planting additional vegetation on land and in water such as eel grass planting).

7. The other proactive choice that Rhode Island can make is "adaptation." Adaptation is an adjustment in human or natural systems to reduce harm from climate change impacts or

[1] This section is a summary, references and support will come later in the text.

exploit beneficial opportunities. Beyond these two choices, the only other option is to wait for climate changes to occur and react to them. Reactive adaptation is likely to be less efficient and result in lost opportunities.

8. The Ocean SAMP is a tool for adaptive management, suited to address long-term and evolving phenomena such as climate change. Among some of the notable potential impacts of current and future climate change are an accelerated rate of erosion and deterioration of the state's recreational beaches, flooding damage and loss of coastal infrastructure associated with Ocean SAMP uses, fatigue (weakening) and more severe damage to offshore installations and marine vessels, and the introduction of invasive species to the Ocean SAMP marine ecology. With advanced planning, the harm and costs associated with these potential impacts can be reduced and may be avoided.

9. This chapter looks at observed past climate-related trends across global and local scales, and at climate change projections as suggested by existing peer-reviewed studies and models. The chapter examines what these climate change trends mean for the marine ecosystem of the Ocean SAMP area and human activities related to the Ocean SAMP. That there will be changes is unequivocal in the scientific community, which relies upon proven data from the past. Making projections inherently includes uncertainty. However, it provides information for planning, backed by the best available science, which gives managers and citizens a tool to be proactive.

10. In other words, current assessment and informed analysis begins to "mainstream" climate change into the Ocean SAMP, recognizing that conditions will change and management must be adaptive in response. Mainstreaming means that climate concerns and adaptation responses are integrated into relevant policies and plans. This chapter only begins to overlay climate change on the Ocean SAMP. Assessing climate change vulnerabilities and defining adaptation goals and actions require an inclusive process over time.

Section 310.Climate Change Observed Trends: Global, U.S. Northeast, Rhode Island

1. Overall, both air and sea temperature in the state, region, and globally have been increasing, sea level has been rising, it has become wetter, the severity of storms is increasing, and the acidity of the sea has increased. A summary of observed and documented climate change trends described in this section at the global, regional, and state levels is given in Table 3.1. Since there are little or no data for the Ocean SAMP area, this is generally for the state of Rhode Island and its offshore waters.

Table 3.1. Summary of observed climate changes.

Climate Change Variable	Geographic Scale	Observations of Recent Change
Air Temperature	Global	• Global mean temperature has increased 0.74°C (1.33°F) over the last 100 years.
	U.S. Northeast	• Since 1900 the annual mean temperature has risen 0.83°C (1.5°F).
	Rhode Island	• Average annual temperature rose 0.94°C (1.7°F) from 1905 to 2006.
Ocean Temperature	Global	• The ocean has been warming consistently over the past 50 years, with 2007 as the warmest year on record.
	U.S. Northeast	• Annual average temperatures in the waters off the southern New England coast have increased by about 1.2°C (2.2°F) since the 1970s.
	Rhode Island	• In Narragansett Bay, sea surfaces temperatures have risen 2.2°C (4°F) since the 1960s.
Sea Level Rise	Global	• Globally, sea levels rose in the 20th century at an average rate of 1.8 mm (0.07 in) per year, a rate greater than that of the preceding eight centuries. • Between 1993 and 2003 this rate almost doubled to 3.4 mm (0.13 in) per year.
	Rhode Island	• In Newport, sea level has risen an average of 2.6 mm (0.1 in) per year since 1930.
Storminess	Global	• The severity of tropical cyclones has increased since the 1970s.
	U.S. Northeast	• The severity of tropical cyclones in the North Atlantic has increased.
Precipitation and Weather	Global	• Rainfall has decreased in the Northern Hemisphere subtropics and increased in mid-latitudes over the last 50 years.
	U.S. Northeast	• Studies have found a 5-17 percent increase in regional precipitation during roughly the last 100 years.
	Rhode Island	• Over the past 100 years, Rhode Island precipitation (rain and snow) has increased by 3 mm (0.12 in) per year. • Wind speed at T.F. Green Airport has significantly declined since at least the 1960s.
Ocean Acidification	Global	• Current pH on the surface of the ocean is 0.1 units lower than pre-industrial levels.

Note: Citations are provided in the text below.

310.1. Air Temperature is Increasing

1. Evidence shows that temperatures have been increasing locally and globally. The most recent report issued by the Intergovernmental Panel on Climate Change (IPCC 2007) states that the global average temperature has increased 0.74°C (1.33°F) over the last 100 years, with most of this increase during the last 50 years, and with the last decade (2000–2009) the warmest since instrumental records began in the mid 1800s (Allison et al. 2009).

2. Annual average temperature has increased similarly in the Northeastern U.S. and Rhode Island. Since 1900, the annual average temperature in the Northeastern U.S. has risen 0.83°C (1.5°F), with the majority of warming occurring in the past few decades (Frumhoff et al. 2007). Winter temperatures have risen even faster with a total increase of 2.22°C (4°F) between 1970 and 2000 (Frumhoff et al. 2007). In Rhode Island, National Weather Service data in Providence shows that the annual mean temperature has increased 10.41°C (18.74°F) from 1905 to 2006. The average temperature has risen 0.094°C (1.7°F) per decade from 1905 to 2006, and 0.31°C (0.56°F) between 1961 and 2005 (Figure 3.1) (Pilson 2008). It should be noted that the temperature recording station was moved several times in the early 1900s within the Providence city limits, until it was located to the T.F. Green Airport in Warwick in 1953 where it has remained since. Although lower temperatures might be expected outside of an urban area and near water, the trend line beginning around 1960 suggests a more rapid increase than that for the entire time series (1905–2006).

3. Increased air temperature increases sea surface temperature with numerous effects on marine ecology (see below). It also alters the timing of seasonal conditions, lengthening the amount of time with warmer temperatures and shortening the amount of time with freezing air temperatures. In the long run, warming may also produce other global changes that will affect the Ocean SAMP area, positively and negatively. These include, among others, the melting of the Greenland ice sheet and Arctic sea ice, and collapse of Atlantic currents that would result in serious societal costs of coastal land and infrastructure loss and major changes to the marine environment. However, the probability and timing of these large-scale occurrences is uncertain. This impact of climate change may have some benefits for tourism and recreation, fishing, and other Ocean SAMP uses that are more easily conducted in warmer weather. Shorter, warmer winters and reduced icing on vessels' gear and structures could be beneficial to winter navigation and shipping.

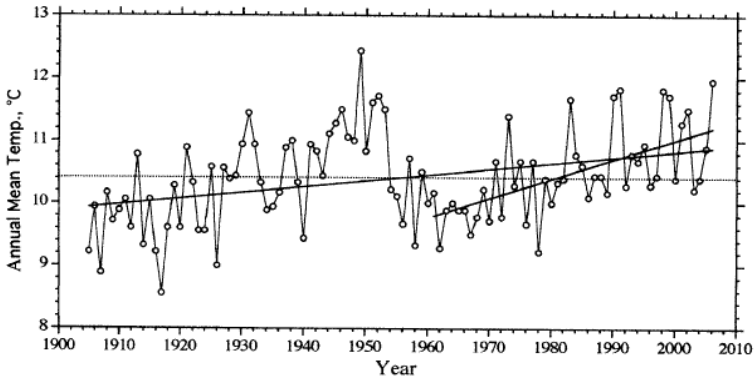


Figure 3.1. Annual mean temperature at the official weather service stations for Providence, R.I., from 1905 to 2006 (Pilson 2008).

310.2. Ocean Temperature is Increasing

1. Globally, the ocean has been warming consistently over the past 50 years, with 2007 as the warmest year on record, and June, July, and August 2009 the warmest months recorded (Allison et al. 2009). The increase in oceanic heat content from 1963 to 2003 in the upper ocean (top 700 m/2300 ft) has been found to be 50 percent higher than previously estimated (IPCC 2007; Domingues et al. 2008; Allison et al. 2009).

2. For nearby waters of the New England coast (Woods Hole, Massachusetts and Narragansett Bay), Oviatt (2004) found that since the 1970s annual average temperatures have increased by about 1.2°C (2.2°F). Nixon et al. (2004) estimated that coastal temperatures in Woods Hole have increased at an average rate of 0.04°C (0.07°F) per year from 1960 to 2002, amounting to a total increase of 1.7°C (3°F) during that time. Nixon et al. (2009) found significant variability in annual sea surface temperature in Narragansett Bay, but estimated that sea surface temperatures have risen 2.2°C (4°F) since the 1960s (Figure 3.2).

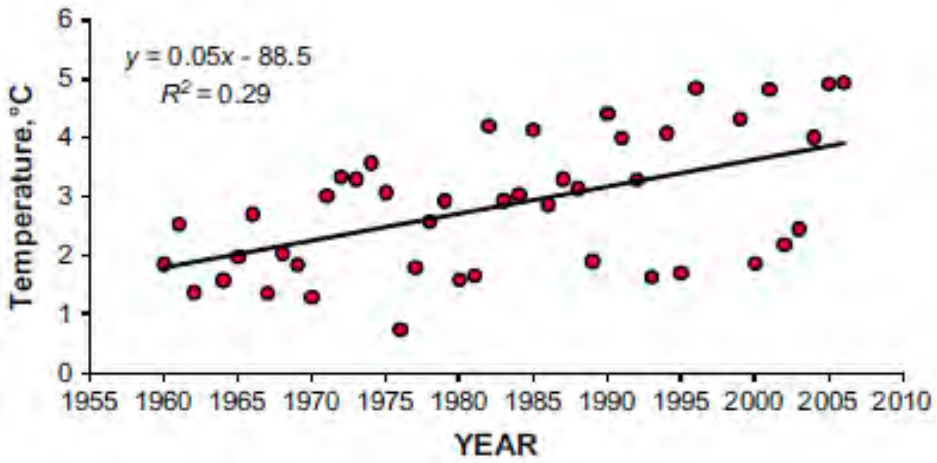


Figure 3.2. Mean surface water temperatures during December, January, and February in the middle of the West Passage of Narragansett Bay, R.I., near Fox Island (Nixon et al. 2009).

3. The marine environment, including the Ocean SAMP marine environment, is very sensitive to changes in sea surface temperature. Increasing sea surface temperature affects the distribution and reproductive success of plankton, fish, and marine invertebrates, marine mammals, sea turtles, and seabirds. It is also partially responsible for harmful algal blooms, marine diseases, and the spread of invasive species. The relationship of sea surface temperature with marine ecology is discussed in Section 330 of this chapter.

310.3. Sea Level is Rising at an Accelerated Rate

1. Sea level rise is caused by two effects. The first is the global warming effect, which is a combination of thermal expansion of seawater and increased volume of water from melting mountain glaciers and polar ice sheets. There is a lag in thermal response of the oceans. Therefore, thermal expansion can be expected to increase for hundreds of years due to current observations of increased temperature. The second effect is caused by land subsidence, or downward movement relative to sea level, due to the response of the earth's lithosphere (the outer, rigid shell of the earth) from ice or sediment loading, or the extraction

of water or oil. The contribution of land subsidence to sea level rise varies spatially at regional and local scales (NAS 2008).

2. There is evidence that the coastline from Cape Cod to New Jersey is subsiding (Frumhoff et al. 2007; Yin et al. 2009). The precise rate of subsidence is uncertain. When subsidence is taken into account, Rhode Island's historic rate of relative sea level rise as observed at Newport is thought to be greater than the global average (CRMC 2007).

3. Since changes in global temperature directly influence sea level, global warming brings with it increased sea level with rates accelerating as well. Globally, sea levels have risen at an average 17 cm (6.7 in) over the past century, a rate greater than that of the preceding eight centuries (IPCC 2007). Between 1961 and 2003, global sea level rose at an average rate of 1.8 mm (0.07 in) per year (IPCC 2007). Between 1993 and 2003 this rate almost doubled to 3.4 mm (0.13 in) per year (Allison et al. 2009). These rates are equivalent to sea level rise of 18 cm (7 in) and 34 cm (13 in) per century, respectively.

4. The accelerated rate is likely due to loss of polar ice in Greenland and Antarctica and the addition of melt water in the sea (IPCC 2007; Cazenave et al. 2009) with Greenland polar melt water the primary cause of accelerated sea level rise. The current rate of sea level rise is 80 percent faster than what was projected for this time period by the IPCC Third Assessment Report (2001) (Allison et al. 2009).

5. Newport, R.I., tide gauge data is available for 1930–2008. During this time, sea level has risen 2.58 mm (0.10 in) per year. If this rate of sea level rise is extrapolated for a century (1908–2008), then sea level has risen 25.8 cm (10.2 in) in the last century (Figure 3.3).

6. The primary concern with sea level rise in the Ocean SAMP area is erosion, flooding, and loss of coastal habitat, beaches, and private and public land and infrastructure utility with offshore uses. Sea level rise will reduce the effectiveness and decrease the life of existing coastal structures such as seawalls and revetments, docks, roads, and bridges. The adverse effects of sea level rise on infrastructure, recreation, and tourism are discussed in more detail in section 340 of this chapter.

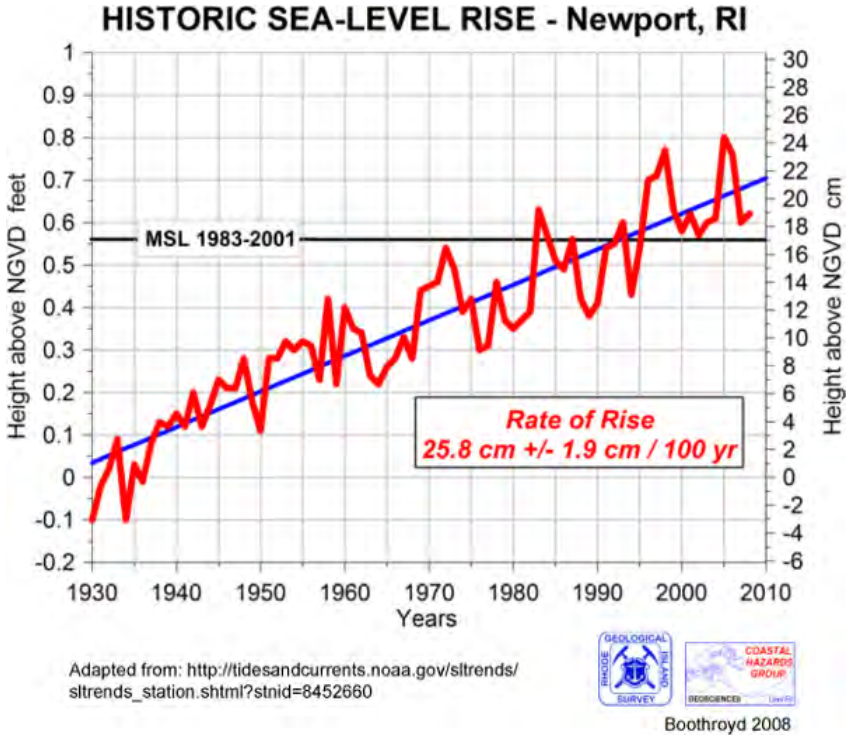


Figure 3.3. Observed sea level in Newport, R.I., from 1930 to 2008.[2] (Figure courtesy of J. Boothroyd, the University of Rhode Island).

310.4. Storminess is Increasing

1. The IPCC Fourth Assessment Report found a substantial increase in the severity of global tropical cyclones (hurricanes and typhoons) since the 1970s, with a strong link to the observed increase in ocean surface temperatures (IPCC 2007). There is evidence that storm intensity has increased in the North Atlantic in the last 30 years (Emanuel 2005; Webster et al. 2005; Emanuel et al. 2008; Holland 2009; Mann et al. 2009) and this correlates well with variations in tropical Atlantic sea surface temperature (Mann and Emanuel 2006; Holland and Webster 2007). Yin (2005) found that major storm tracks have been moving northward and attributed this to changing climate. Some studies have reported an increase in the number of tropical cyclones in certain areas, including, the North Atlantic (e.g. Hoyos et al. 2006; Mann and Emanuel 2006; Emanuel et al. 2008; Holland 2009; Mann et al. 2009).

2. Whether the characteristics of tropical cyclones have changed has been the subject of considerable investigation, often with conflicting results (Allison et al. 2009). Large amplitude fluctuations in the frequency and intensity of tropical cyclones greatly complicate both the detection of long-term trends and their attribution to rising levels of atmospheric greenhouse gases. Trend detection is further impeded by substantial limitations in the availability and quality of global historical records of tropical cyclones. Therefore, it remains

[2] Sea level data (collected by the National Oceanic and Atmospheric Administration from the Newport, R.I., tide gauge) are measured relative to the National Geodetic Vertical Datum of 1929 (NGVD 29) for mean sea level (MSL). NGVD 29 is a vertical control point historically used for measuring elevations, including the absolute change in sea level (incorporating both global and local dynamics) at the site. These data are available on line and continuously updated at: http://co-ops.nos.noaa.gov/sltrends/sltrends_station.shtml?stnid=8452660%20Newport,%20RI (NOAA/NOS 2008).

still uncertain whether past changes in tropical cyclone activity have exceeded the variability expected from natural causes.

3. Rhode Island has been impacted by a number of major storms, and they represent a major coastal and marine hazard. In terms of wave height and storm surge, the Hurricane of 1938 was of the magnitude of the 100-year storm of record for Rhode Island (Pogue 2005). This means that there is a 1 percent probability of this size storm occurring in any single year. However, with more intense storms, the probability increases that any one storm will be greater than that currently defined as a 100-year storm.

4. Storms and associated storm surge cause damage to ports, seawalls and revetments, docks, roads, bridges, wastewater treatment plants and stormwater infrastructure. Storms can also damage wind turbines and other offshore infrastructure and affect sediment movement, altering beaches and coastal habitats as well as needs for dredging for marine transportation and port operations. Potential damage from increasing storm intensity and past damage to the ports of Providence and East Providence are described in more detail in section 340 of this chapter.

310.5. Precipitation and Weather Patterns are Changing

1. Globally, rainfall has decreased in the Northern Hemisphere subtropics and increased in mid-latitudes over the last 50 years (Zhang et al. 2007). Rainfall and wind patterns have also been changing over time in the U.S. Northeast and coastal New England. Frumhoff et al. (2007) reported that since 1900, precipitation has increased 5 to 10 percent in the northeastern U.S., with most of the increase historically occurring during fall, spring, and summer. In the last few decades, however, increases have also occurred in winter. However, more of this precipitation is falling as rain than snow. The New England Regional Assessment estimated a greater—16.8 percent—increase in precipitation between 1905 and 2006 in coastal New England (NERAG 2001).

2. Between 1905 and 2006 there has been a 32 percent increase in precipitation (rain and snow) in Rhode Island when all years, even extremely dry and wet years, are included (Figure 3.4) (Pilson 2008). The rate of increase (slope of the simple linear regression) is 3.05 mm (0.12 in) per year (Pilson 2008). This estimate is comparable to the New England Regional Assessment data if extremely dry and wet years are excluded (Pilson 2008). The increase in precipitation, as well as warmer winter temperatures, is related to the observed increase in cloudiness, which results in a decreasing amount of sunlight reaching Rhode Island (Nixon et al. 2009).

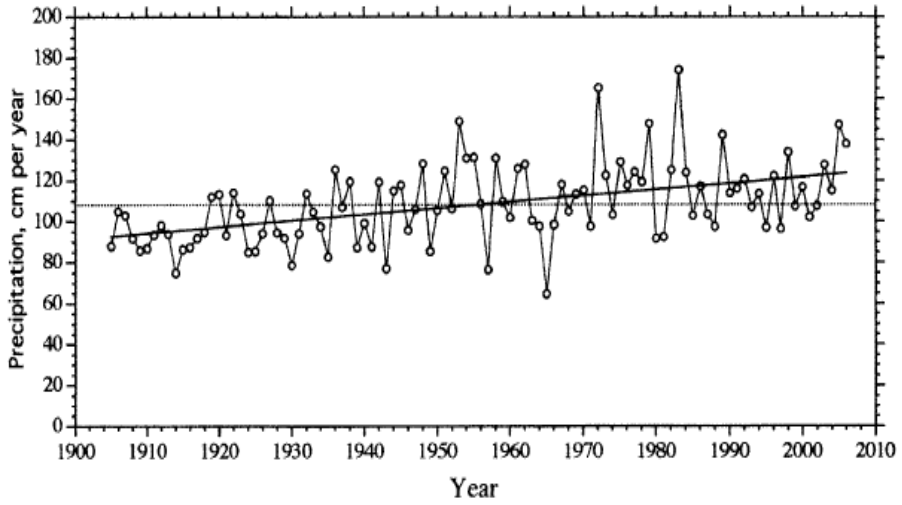


Figure 3.4. Total annual precipitation (rain and snow) at the weather stations in Providence, R.I., from 1905 to 2006. (Pilson 2008).

3. In contrast to precipitation, data show a decline in annual mean wind speed in the northeastern U.S. (Pryor et al. 2009). For example, Figure 3.5 shows that wind speed recorded at T.F. Green Airport has significantly declined from 1964 to 2004 (Pilson 2008).

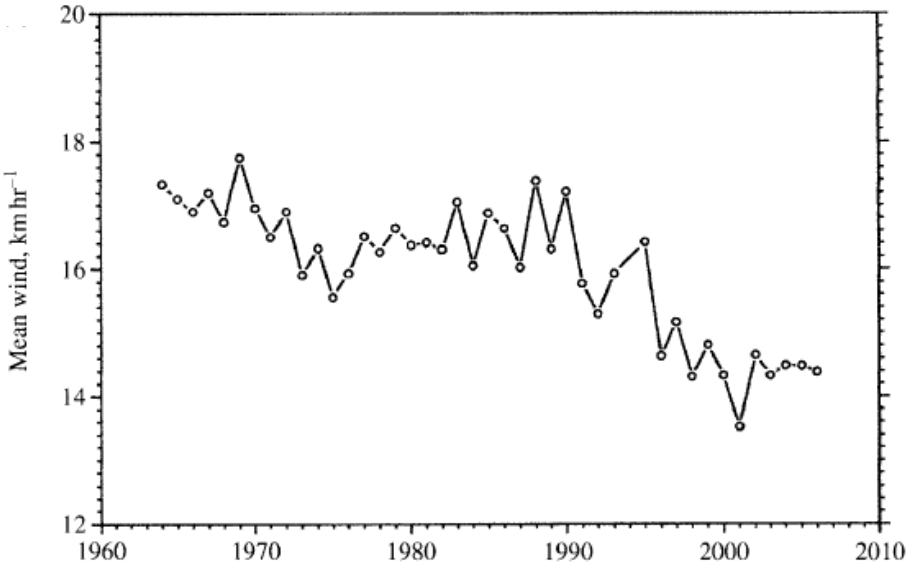


Figure 3.5. Annual average wind speed at T.F. Green Airport, R.I., from 1964 to 2006 (Pilson 2008).

4. Increased precipitation matters to the Ocean SAMP because it increases river flow and transports pollutants and nutrients to coastal waters, which adversely affects ecology, coastal habitat, wildlife, and recreation and tourism associated uses of the Ocean SAMP area. Some of the river flow to the marine environment enters Block Island Sound and Rhode Island Sound, altering salinity (critical to marine productivity) and transporting contaminants and nutrients. Decreasing wind speeds are of concern to the Ocean SAMP with respect to impacts on mixing and stratification.

5. The North Atlantic Oscillation (NAO) influences regional climate patterns of temperature, precipitation, and winds in the North Atlantic due to the interaction of the Icelandic low and Azores high pressure atmospheric cells. The principal winter weather effect of the NAO is on the jet stream, which determines primary seasonal storm tracks. In positive years, storms track straighter west-to-east and in negative years, storm tracks are deeply meandering. The NAO has a known effect on sea surface temperature through atmospheric wind-stress changes, which are associated with differences in water densities from different sources and can therefore affect ocean circulation (Delworth and Dixon 2000).

6. In addition, the Atlantic Multidecadal Oscillation (AMO) is an ocean fluctuation that also significantly influences weather patterns in the North Atlantic through an ocean heat flux and involves ocean-atmosphere interaction as well as variability in the strength of circulation (Knight et al. 2005; Delworth and Mann 2000). Hubeny et al. (2006) found evidence of a coupling between the atmosphere and ocean at multidecadal time scales based on photosynthetic estuarine pigments over the last millennium adjacent to Narragansett Bay, which suggests that the AMO could be attributed to changes in the atmosphere and the NAO is affected by solar variability.

7. Since 1972, the NAO has been primarily positive, with notable short-term negative periods (Delworth and Dixon 2000; Hurrell 1995). Based on climate reconstructions using historic data, the current trend appears to be unprecedented in recorded time (Hurrell 1995; Watanabe and Nitta 1998). The positive NAO index causes the Icelandic low pressure system to draw a stronger southwesterly circulation over the North American continent in the east, preventing Arctic air from meandering southward and resulting in less severe winters over eastern Canada and the northwest Atlantic (Thompson and Wallace 1998).

310.6. Ocean Acidification is Occurring

1. As concentrations of carbon dioxide increase in the atmosphere, more carbon dioxide is absorbed by the oceans, resulting in the lowering of seawater pH levels (reduced alkalinity). The increased acidity is due to the formation of carbonic acid as CO_2 dissolves in seawater.

2. Roughly half of the carbon emitted from human activities between 1800 and 1994 has been absorbed by the ocean (Sabine et al. 2004), and one-third of modern emissions is being absorbed (Feely et al. 2004; Canadell et al. 2007 in UNEP 2009; Cooley and Doney 2009; U.S.GCRP 2009). As a result, globally averaged marine surface atmospheric CO_2 has increased 13.2 percent since 1981 (NEFSC 2009). This has resulted in a reduction of surface ocean seawater pH levels by 0.1 pH units (U.S.GCRP 2009). Because pH units are expressed on a logarithmic scale, a change from one unit (e.g., from 8.0 to 7.0) represents a 10-fold change, and two units (e.g., 8.0 to 6.0) is a 100-fold change.

3. Broad-scale time series of ocean pH measurements are not currently available to assess the effects of ocean acidification in the Northeast continental shelf region (NEFSC 2009). However, correlation between atmospheric CO_2 and dissolved CO_2 in ocean waters is evident in regions where estimates of both are available (NEFSC 2009).

4. Acidification is a concern for marine animals, many of whom are valuable to the food chain, that have shells or skeletons made of calcium carbonate (such as quahogs, foraminifera, slippershell snails, sea stars, and coral). It is also a concern for corrosion of metals on vessels

and infrastructure associated with marine transportation, navigation, ports and harbors. Increased acidification may also cause more rapid deterioration of historic and cultural assets on the seafloor (such as wrecks). The potential impacts of acidification are discussed in more detail in Sections 330 and 340 in this chapter.

Section 320. Future Climate Change Projections

1. Human activities have caused a significant increase in greenhouse gases in the atmosphere. The most prevalent greenhouse gas in the atmosphere, carbon dioxide, has risen from a pre-industrial level of 280 ppm to 385 ppm in 2005, the highest it has been in 650,000 years (IPCC 2007; Allison et al. 2009). The IPCC in its last report (IPCC 2007) and peer-reviewed science updates since then (Allison et al. 2009; UNEP 2009; U.S.GCRP 2009) conclude that this increase in carbon dioxide and other greenhouse gases is unprecedented, is driving climate change today, and will continue to do so long into the future.

2. Since climate change and associated impacts are long term and not necessarily linear phenomena, and since positive feedback loops can increase impact, modeling is essential for projecting into the future based on assumptions of future greenhouse gas emissions and atmospheric concentrations of greenhouse gases. Since the climate change landscape will continue to change, adaptive planning and management for climate change in the Ocean SAMP region needs to be cognizant now of projected future change.[3]

3. This section describes possible future changes as "projections" rather than "predictions." As defined by the IPCC, "climate predictions are the result of an attempt to produce an estimate of the actual evolution of the climate in the future. Since the future evolution of the climate system may be highly sensitive to initial conditions, such predictions are usually probabilistic in nature" (Baede 2007). In contrast, climate projections are not based on an estimate of the actual evolution of climate, but rather are based on emissions scenarios (lower, intermediate and higher emissions scenarios). As defined by the IPCC, "climate projection is a projection of the response of the climate system to emission or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based upon simulations by climate models" (Baede 2007). Scenarios help move dialogue from a debate about exactly how the climate will change to the implications of the different scenarios of low to high degrees of change.

4. In the late 1990s, carbon dioxide emissions scenarios were developed by the IPCC, as outlined in the Special Report on Emissions Scenarios (SRES) in the IPCC Third Assessment Report (Nakicenovic et al. 2000). The SRES scenarios assumed varying degrees of reductions in CO_2 emissions and are based on five global models. The low emissions scenario (B1) assumes that reductions in CO_2 emissions would occur with resource efficient technologies. CO_2 concentrations in the atmosphere would reach 550 ppm by 2100 (about twice the pre-industrial level). The high emissions scenario (A1FI) assumes an increase in CO_2 emissions due to fossil fuel-intensive economic growth. CO_2 concentrations in the atmosphere would reach 940 ppm by 2100 (about three times the pre-industrial level). Since the scenarios were developed a decade ago, actual experience has shown that the rate of emissions has exceeded the high emissions scenario as a result of growing populations, per capita gross domestic product, and reliance on fossil fuels (Figure 3.6) (Raupach et al. 2007; Allison et al. 2009; UNEP 2009). To date there are no regions that are substantially decreasing carbon in their energy supply (Raupach et al. 2007; UNEP 2009). In light of this, projections of climate change impacts under a low emissions scenario are becoming less

[3] Note that even if greenhouse gases were capped today, air and sea temperatures will continue to rise as a result of past emissions—as greenhouse gases in the atmosphere have a lifetime of between 10 and several thousand years (Solomon et al. 2009; UNEP 2009).

likely as high rates of CO_2 emissions continue. It is important that decision-makers seriously consider and plan for impacts under a high emissions scenario.

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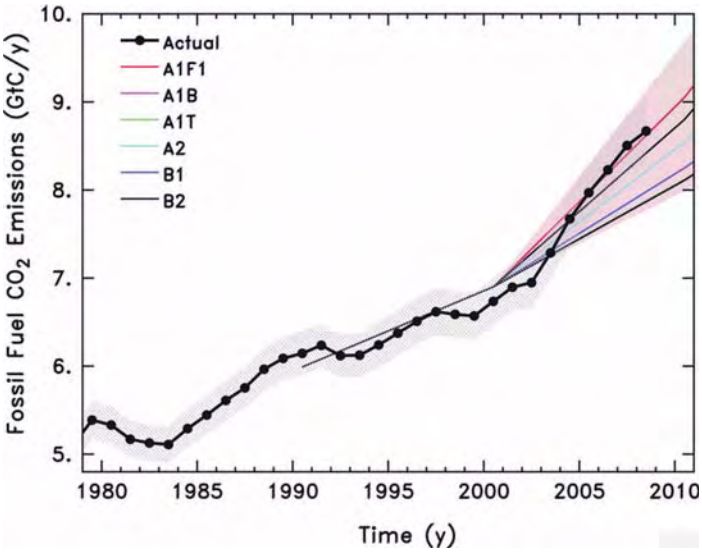


Figure 3.6. Observed global CO_2 emissions from fossil fuel burning and cement production compared with IPCC emissions scenarios (Le Quéré et al. 2009).[4]

5. Where available, this section presents projections for the low and high emissions scenarios with the widely used temporal benchmarks of mid-century and late-century (21st century). In some cases, only end-of-century projections are found in the literature. The projections are global or regional. The grid scale of climate change models is approximately 2 degrees longitude-latitude, too coarse for Ocean SAMP scale projections.

6. With accelerating greenhouse gas emissions, changes in global climate trends have occurred faster than predicted, with no indication of a slow-down or pause, and future changes could be more severe and arise more quickly than predicted (Allison et al. 2009). An example of such a positive feedback loop affecting climate change is the release of methane, a greenhouse gas, from the melting of permafrost areas leading to further warming. Scientists warn that current and continuing climate change may lead to permanent and irreversible changes in natural systems. These are referred to as "tipping points" in which a critical threshold is reached where the state of a system is altered (Lenton et al. 2008; Schellnhuber 2009). There are a number of tipping points predicted to occur in the climate system, based on its current non-linear dynamics, and as revealed by past abrupt climate changes and climate models (Schellnhuber 2009). Among the tipping points are the complete disappearance of Arctic sea ice in summer, leading to drastic changes in ocean circulation and climate patterns across the whole Northern Hemisphere; acceleration of ice loss from the Greenland and Antarctic ice sheets, driving rates of sea level rise to 6 feet or more per century; collapse of the Atlantic thermohaline circulation; and, ocean acidification from carbon dioxide absorption, causing massive disruption in ocean food webs (NRC 2002; Lenton et al. 2008; Overpeck and Weiss 2009).

[4] The shaded area covers all scenarios used to project climate change by the IPCC. Actual emissions began following the high emissions scenario in 2006 A1FI is high emissions scenario; B1 is low emissions scenario. (Source: Allison et al. 2009)

320.1. Air Temperature Projections

1. Projections of greenhouse gas emission under low and high scenarios estimate global mean temperatures warming 2°C to 7°C (3.6°F to 12.6°F) by the end of the century (Figure 3.7) (Allison et al. 2009; Richardson et al. 2009). This range surpasses the estimated threshold range of 1°C to 3°C (1.8°F to 5.4°F) increases for dangerous climate tipping points, such as the melting of summer Arctic sea ice, Himalayan glaciers, and the Greenland ice sheet (Ramanathan and Feng 2008 in UNEP 2009). An increase above 2°C (3.6°F) is cited as being a threshold beyond which the consequences from global warming will cause severe environmental and societal disruptions worldwide (Richardson et al. 2009).

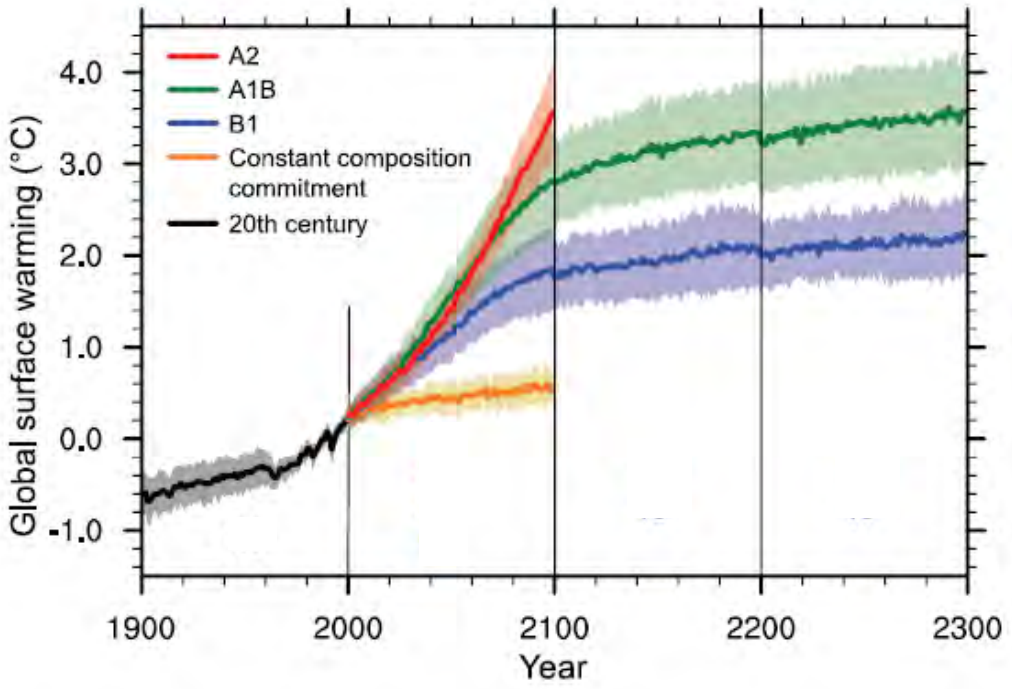


Figure 3.7. Mean values of projected surface warming (compared to the 1980–1999 base period) for several scenarios of the Special Report on Emissions Scenarios (IPCC 2007).[5]

2. Temperature changes are also projected regionally. The late century projections for the U.S. Northeast are similar to global projections, but have a wider range when one looks at summer vs. winter change (See Table 3.2). The range for low to high emissions scenarios is from 2°F to 14°F (1.1°C to 7.8°C) (Frumhoff et al. 2007).

[5] Scenarios A2 (red – higher emissions), A1B (green – intermediate emissions) and B1 (blue – lower emissions) are from the Special Report on Emissions Scenarios (SRES). Projections when emissions are kept constant from 2000 levels are shown (orange). Lines show the multi-model means, shading denotes the ±1 standard deviation range (Source: IPCC 2007).

Table 3.2. Air temperature projection increases for U.S. Northeast (Frumhoff et al. 2007).

Season	Low emissions scenario (B1)	High emissions scenario (A1FI)
2050 Projection		
Summer	1.1°C to 2.8°C (2°F to 5°F)	2.2°C to 4.4°C (4°F to 8°F)
Winter	2.2°C to 2.8°C (4°F to 5°F)	2.2°C to 3.9°C (4°F to 7°F)
2100 Projection		
Summer	1.5°C to 3.9°C (3°F to 7°F)	3.3°C to 7.8°C (6°F to 14°F)
Winter	2.8°C to 4.4°C (5°F to 8°F)	4.4°C to 6.7°C (8°F to 12°F)

320.2. Ocean Temperature Projections

1. By late century, sea surface temperatures in the U.S. Northeast are expected to increase by 2.2°C to 2.8°C (4°F to 5°F) or 3.3°C to 4.4°C (6°F to 8°F) under the low or high emissions scenario, respectively, though these increases vary for the different portions of the Northeast continental shelf (Table 3.3) (Frumhoff et al. 2007).

2. By late century, regional bottom temperatures in the northern Mid-Atlantic Bight are expected to increase 1.1°C (2°F) or 2.8°C to 3.9°C (5°F to 7°F) from the historic average (1970–2000), under the low or high emissions scenario, respectively. On Georges Bank, increases of 1.1°C (2°F) or 3.3°C (6°F) are expected, depending on the emissions scenario (Frumhoff et al. 2007).

Table 3.3. Ocean temperature change projections for U.S. Northeast, 2100 (Frumhoff et al. 2007).

Ocean Depth	Lower emissions scenario (B1)	Higher emissions scenario (A1FI)
Sea surface	2.2°C to 2.8°C (4-5°F)	3.3-4.4°C (6-8°F)
Bottom temperatures	1.1°C (2°F)	2.8-3.9°C (5-7°F)

320.3. Sea Level Rise and Flooding Projections

1. Great variability in sea level rise projections exists because of uncertainty of the contribution of melting sheet ice. Many analyses, including those in the Fourth Assessment by the IPCC do not account for the unexpected rates of rapid sheet ice breakup and melting that have occurred in recent years (Frumhoff et al. 2007; Allison et al. 2009). The contribution of the ice sheets to sea level rise was not included in the IPCC report because no IPCC consensus on ice sheet dynamics could be reached based on published literature at that time (Solomon et al. 2009; UNEP 2009). Increasingly, evidence is being presented in peer-reviewed literature indicating that this is a concern.

2. There is an unknown threshold beyond which a collapse of the polar ice sheets, especially Greenland's, will be inevitable and irreversible, which would add an additional several meters of sea level rise within the next millennium. This risk is growing, particularly under a high emissions scenario (Frumhoff et al. 2007; Solomon et al. 2009). This is one of the "tipping points" described earlier.

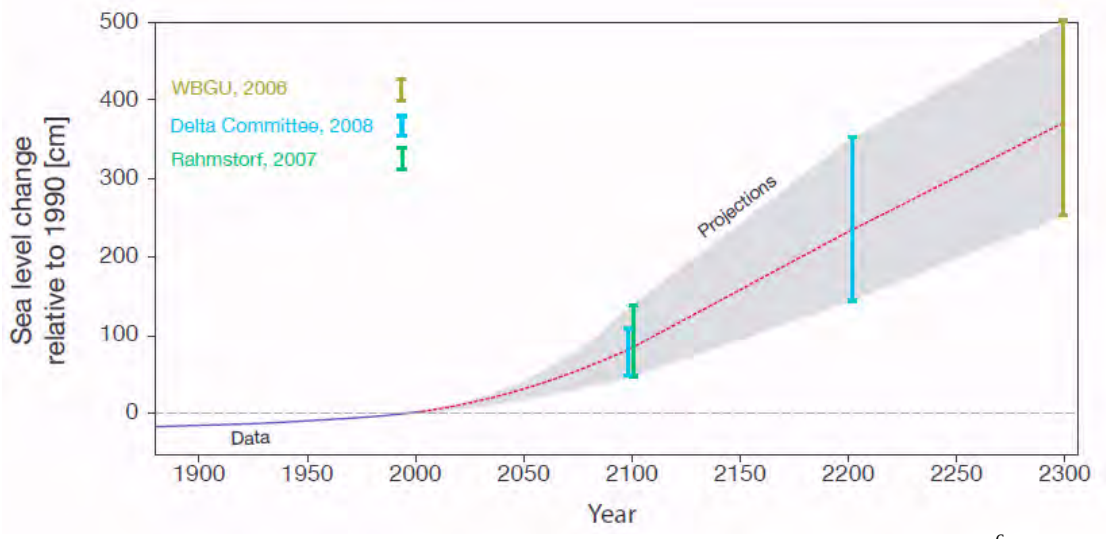


Figure 3.8. Projections of future global sea level rise to 2300 (Allison et al. 2009).[6]

3. Updated estimates of future global mean sea level rise are twice as large as the IPCC 2007 projections of 18 cm to 59 cm (0.6 ft–1.9 ft) for end of the century. New estimates of the increase in global sea level by the end of the century range from 0.5 m to 2 m (1.6 ft–6.6 ft) (Rahmstorf et al. 2007; Horton et al. 2008; Pfeffer et al. 2008; Allison et al. 2009; Richardson et al. 2009). These updated projections incorporate new observations of accelerated loss of mass from glaciers, ice caps, and the Greenland and Antarctic ice sheets.

4. Changes in the salinity and temperature of the ocean in the Arctic and North Atlantic will likely (90 percent probability) cause a slowdown of ocean circulation in the North Atlantic by the year 2100, which, among other effects, will lead to a more rapid rise in sea level along the northeastern U.S. coastline compared to other parts of the world (Figure 3.9) (IPCC 2007; Yin et al. 2009).

[6] Historical data from Church and White (2006). Future projections are from Schubert et al. (2006) (represented as 'WGBU'), Rahmstorf (2007), and Vellinga et al. (2008) (represented as 'Delta Committee'), (Source: Allison et al. 2009).

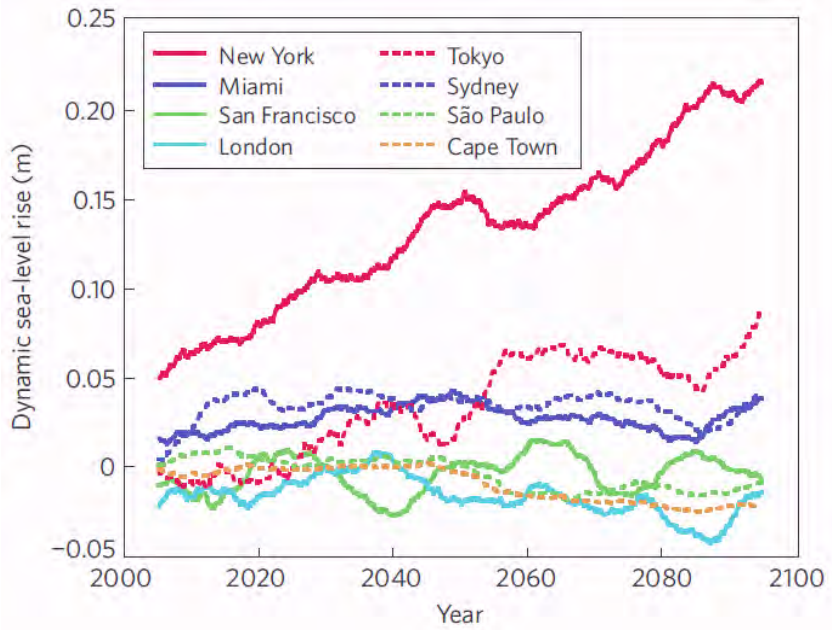


Figure 3.9. Projected dynamic sea level rise (10 year running mean) at coastal cities worldwide under the intermediate emissions scenario (Yin et al. 2009).[7]

5. The Northeast Climate Impacts Assessment in 2006 projected increases in sea level of 6 cm to 33 cm (2.5 in to 13 in) by mid-century (under either emissions scenario), and 10 cm to 53 cm (4 in to 21 in) under the lower-emissions scenario and 20 cm to 84 cm (8 in to 33 in) under the higher-emissions scenario by late-century (Figure 3.10) (NECIA 2006). Observations illustrate that sea level is rising at a rate slightly above the highest IPCC scenario (A1FI) from 2001 (Rhamstorf et al. 2007). The assessment report indicates that these projections do not incorporate the recently observed high rates of continental ice melt, and should be considered to be at the lower range of possible future sea level rise.

[7] These projections account for the amount of sea level rise caused by changes in large scale ocean currents alone and not other factors such as thermal expansion and ice sheet melting (Yin et al. 2009).

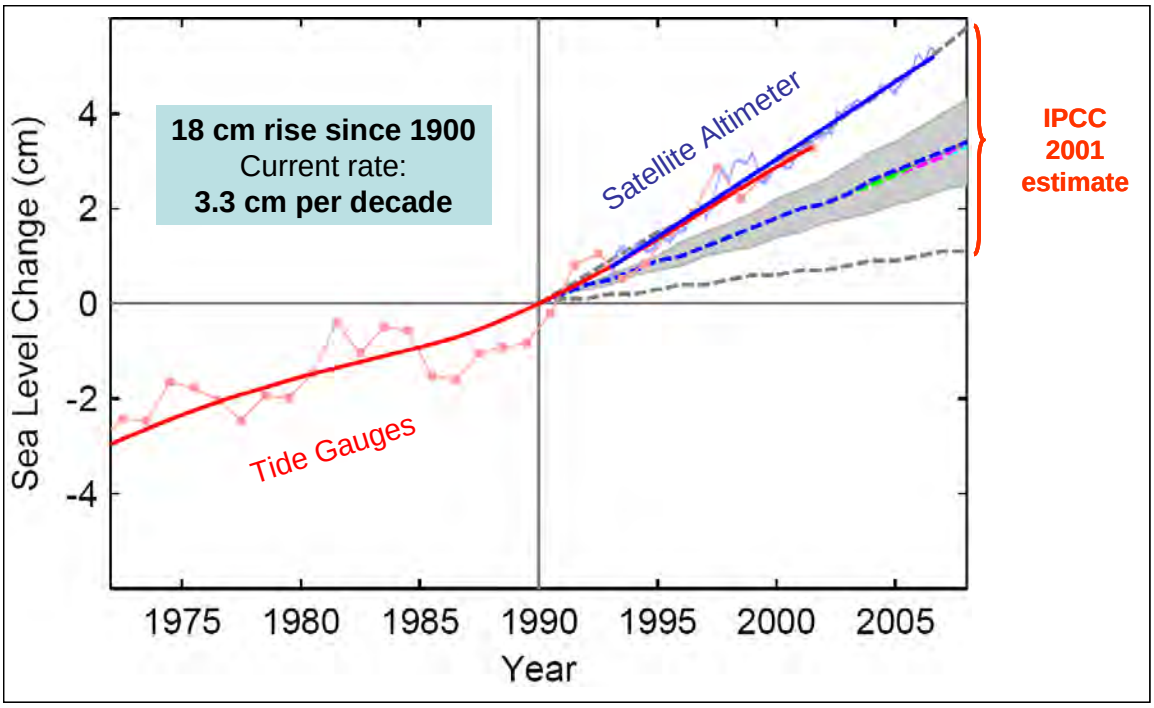


Figure 3.10. Observed and IPCC 2001 estimated global sea level rise. This figure illustrates the range of IPCC scenarios as of 2001 projections (Figure from Rhamstorf et al. 2007).

320.4. Storminess Projections

1. An observed increase in the strength of tropical cyclones and North Atlantic storms during the past few decades is linked to rising ocean temperatures. Future projections based on theory and high-resolution dynamic models consistently indicate that greenhouse warming will cause the globally averaged intensity of tropical cyclones to shift towards stronger storms, with intensity increases of 2 to 11 percent by 2100 (Knutson et al. 2010). Existing modeling studies also consistently project decreases in the globally averaged frequency of hurricanes by 6 to 34 percent. Balanced against this, higher-resolution modeling studies typically project substantial increases in the frequency of the most intense cyclones, and increases of the order of 20 percent in the precipitation rate within 100 km of the storm center.

2. Most climate models are incapable of reproducing the strongest hurricanes (Category 3 or higher). In a recent study, Bender et al. (2010) used a downscaling approach to model tropical cyclone activity through the end of the 21st century. They began by creating an average climate change projection based on 18 global climate models, and then fed this projection into a regional model with much higher resolution to simulate entire hurricane seasons. Finally, they used NOAA's operational hurricane prediction model to re-simulate each storm generated by the regional model—but at a still higher resolution—so that the very intense (Category 4 and 5) hurricanes could be simulated. These results are based on projections of a substantial warming of the tropical Atlantic hurricane regions over the 21st century due to an increase in greenhouse gases. The projections used a standard future emission scenario from the IPCC. The models showed a decrease in the total number of hurricanes by the end of this century, yet still produced nearly a doubling of Category 4 and 5

hurricanes. The largest increase in intense hurricanes was seen in the Western Atlantic region (between 20°N and 40°N). Category 4 and 5 hurricanes making landfall account for approximately 48 percent of all hurricane damage in the U.S., despite accounting for only 6 percent of the total number of hurricanes that make landfall. Bender et al. (2010) estimate about a 30 percent increase in potential damage from the combined effect of fewer hurricanes overall and more very intense hurricanes.

3. According to the National Weather Service, high hurricane activity occurs during periods of warmer tropical Atlantic sea surface temperature. Given current and historical trends of sea surface temperature, it is likely that there will be above-normal Atlantic hurricane activity over the next several years.

4. A small increase in frequency of nor'easters is projected for the U.S. Northeast (Frumhoff et al. 2007). Currently approximately 12 to 15 nor'easters (extra-tropical storms) hit the U.S. Northeast from November to March (Frumhoff et al. 2007). It is estimated that under a high-emissions scenario, one additional nor'easter could affect the Northeast coast each winter by late century (Frumoff et al. 2007). Nor'easters drive destructive waves and currents, and transport sediment along the coastlines resulting in beach and bluff erosion and sediment re-suspension offshore. Movement of sediment could have adverse impacts on planktonic organisms and navigation.

320.5. Precipitation and Weather Pattern Projections

1. Climate change is projected to change the intensity and timing of annual precipitation in rain and snow in the U.S. Northeast, and the timing and length of seasons. By the end of the century, under either the low or high emissions scenario, annual precipitation is projected to increase approximately 10 percent (4 in/10 cm per year). Winter precipitation could increase an average of 20 to 30 percent, depending on the emission scenario, with a greater proportion falling as rain rather than snow (Figure 3.11) (NECIA 2006). Little change is expected for summer rainfall, but projections are variable (Frumhoff et al. 2007).

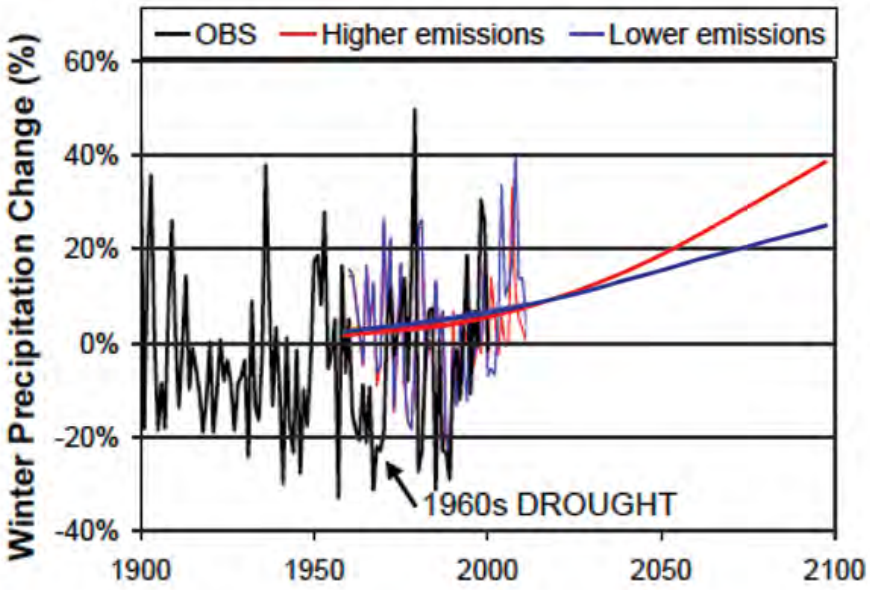


Figure 3.11. Observed and model-based winter precipitation as a percentage of change in the U.S. Northeast (NECIA 2006).[8]

2. In the Northeast, precipitation intensity (the amount of rain that falls on rain days) is projected to increase 8 to 9 percent by mid-century and 10 to 15 percent by late-century. In other words, wet days will become wetter (Table 3.4). The frequency of heavy-precipitation events is projected to increase by 8 percent by mid-century and 12 to 13 percent by late-century. Extreme precipitation events are defined as those with a larger precipitation total for one day than the smallest maximum annual precipitation event for each of the previous 59 years, the length of record assessed for this study (Madsen and Figdor 2007). These projections suggest that more of the annual rainfall total will come in heavy rainfall events. During the wettest five-day period of the year, 10 percent and 20 percent more rain will fall by mid- and late-century, respectively (Frumhoff et al. 2007).

3. Short and medium-term droughts (1 to 3 months and 3 to 6 months, respectively) are projected to increase slightly under the lower emissions scenario and dramatically under the higher emissions scenario by late century. Short-term droughts are projected to occur as frequently as once each summer under the higher emissions scenario in the New England states by late-century (Frumhoff et al. 2007; U.S.GCRP 2009).

4. By mid-century, summer-like conditions are projected to persist 16 or 27 days longer under the low and high emissions scenarios, respectively. Summer-like conditions are expected to be 21 or 42 days longer by late century under the two different emissions scenarios (Frumhoff et al. 2007; U.S.GCRP 2009).

5. Under a high emissions scenario, the length of the winter snow season is expected to be reduced to a week or two in Rhode Island and other southern Northeast states by late century (U.S.GCRP 2009).

[8] The black line depicts average historical precipitation patterns from 1900–2000. The red line represents the predicted change in precipitation under the higher emissions scenario. The blue line represents precipitation changes under the low emissions scenario. The largest increase in precipitation is expected after 2050, particularly in the high emissions scenario. (Source: NECIA 2006).

Table 3.4. Precipitation and weather projections for U.S. Northeast (Frumhoff et al. 2007).

Variable	Low emissions scenario (B1)	High emissions scenario (A1FI)
2050 Projection		
Precipitation intensity (amount of rain that falls on rain days)	8 to 9 percent increase	
Number of heavy precipitation events	8 percent increase	
Length of summer	16 days longer	27 days longer
Variable	Low emissions scenario (B1)	High emissions scenario (A1FI)
2100 Projection		
Annual precipitation	~10 percent increase (4 in/year)	
Winter precipitation	~20 percent increase, with a greater percent falling as rain than snow	~30 percent increase, with a greater percent falling as rain than snow
Summer precipitation	Little change	Little change
Precipitation intensity (amount of rain that falls on rain days)	10-15 percent increase	
Number of heavy precipitation events	12-13 percent increase	
Droughts	Slight increase	Dramatic increase. Short term drought (1-3 months) once each summer
Length of summer-like conditions	21 days longer	42 days longer
Winter snow season		Reduced to a week or two in Rhode Island

320.6. River Flow Projections

1. Most freshwater enters marine systems through rivers, rather than through direct precipitation or runoff (NEFSC 2009). The major freshwater influences for the Ocean SAMP area (as described further in the Chapter 2, Ecology of the SAMP Region, Section 250.3) are from Long Island Sound and the Connecticut and Thames Rivers. The Providence and Taunton Rivers are tidal bodies of water with the next most important influence upon the Ocean SAMP area. In the U.S. Northeast, river flow will likely increase from snow melting earlier and faster due to rising winter temperatures. Peak spring flow is projected to occur five days earlier during the next several decades, and 7 to 9 days earlier by mid-century (Frumhoff et al. 2007). By late century, peak flow is projected to occur 10 to 14 days earlier, depending on the emissions scenario (Frumhoff et al. 2007).

2. Under the high-emissions scenario, high-flow events are projected to be more frequent, especially in northern New England, as a consequence of snow melting faster and increases in winter precipitation. This will increase the risk of flooding (Frumhoff et al. 2007). High-flow events transport pollutants and nutrients to coastal waters, some of which may enter Block Island Sound and Rhode Island Sound.

3. By late-century under the high emissions scenario, low-flow periods are expected to arrive more than a week earlier in summer and extend several weeks later in the fall, with the

lowest flow dropping 10 percent or more. Little change is expected under the low emissions scenario (Frumhoff et al. 2007).

320.7. Ocean Acidification Projections

1. The most recent IPCC report projects that by late century, globally, pH will drop 0.3 to 0.4 units from current levels (IPCC 2007). With the exception of rare events, a change of this magnitude has not occurred in the last 300 million years (Caldeira and Wickett 2003). Such ocean acidification is essentially irreversible over a time scale of centuries with physical and biological impacts upon marine organisms, especially shellfish, and marine infrastructure (U.S.GCRP 2009).

Section 330. Ecological Impacts of Climate Change

1. The Ocean SAMP area is an ecologically unique and complex region in that the Rhode Island Sound and Block Island Sound ecosystems are located at the boundary of two biogeographic provinces, the Acadian to the north and the Virginian to the south. This unique positioning is the source of interesting biodiversity comprised of a mix of northern, cold-water species and more southern, warm-water species. It makes the ecosystems of the Ocean SAMP area highly vulnerable to impacts from warming due to climate change (see Chapter 2, Ecology of the SAMP Region, Section 200 for more detailed discussion).

330.1. Pelagic and Benthic Ecosystems

330.1.1. Plankton Blooms

1. Climate changes such as warmer waters, increased cloudiness caused by an increase in storminess, and altered circulation patterns at both vertical and horizontal scales affect plankton (Frumhoff et al. 2007; IPCC 2007; Allison et al. 2009; Yin et al. 2009). Warmer waters allow for higher rates of grazing of phytoplankton by zooplankton (Keller et al. 1999). Phytoplankton form the foundation of marine food webs, and therefore changes in phytoplankton dynamics can have significant impacts on higher trophic levels.

2. According to the Ecosystem Status Report for the Northeast Continental Shelf Large Marine Ecosystem (NEFSC 2009), the northeast U.S. shelf ecosystem is affected significantly by climate change. However, the specific processes that result in changes in zooplankton community structure remain unresolved and the implications for the remainder of the ecosystem are unclear (NEFSC 2009).

3. There is no data on climate change and plankton blooms for the Ocean SAMP area. There is research and data on Narragansett Bay. The Bay may or may not be an analog to the Ocean SAMP area, but findings from research in the Bay are presented below to illustrate the types of marine ecosystem changes that can occur, partially due to warming waters.

4. Narragansett Bay has experienced a decline in the consistency of the winter-spring bloom of phytoplankton. The timing of the annual-cycle of phytoplankton has shifted from a prolonged, bay-wide, large winter-spring bloom to a less consistent, less intense, shorter winter bloom with short intense blooms in the spring, summer, or fall. Data show that at least since the 1970s, the biomass of phytoplankton has decreased significantly in Narragansett Bay (Li and Smayda 1998; Smayda 1998; Nixon et al. 2009). It has been hypothesized that these changes have been induced by climate change, specifically warming waters (Keller et al. 1999; Oviatt et al. 2003) and an increase in cloudy days (Nixon et al. 2009). Increased cloudiness limits phytoplankton growth because photosynthesis is light-dependant.

5. Because the bloom now occurs later in the year, warmer waters allow for higher rates of grazing by zooplankton (Keller et al. 1999). The increased grazing depletes the supply of phytoplankton that sinks to the bottom and provides food to the benthos. It has also been shown that sinking phytoplankton blooms in warmer weather have less nutritional value than cold weather blooms, which would further diminish the food supply of the bottom community (Smetacek 1984). In addition, it has been shown that this decrease in organic matter reaching the bottom (resulting from the diminished phytoplankton bloom) can

drastically alter fluxes of nutrients between the sediment and water column. This has important implications for the ecological functioning of Narragansett Bay (Fulweiler et al. 2007).

6. The above factors are projected to decrease food availability to juvenile bottom-dwelling fish due to declines in the bottom filter- and deposit-feeders that readily consume dead phytoplankton (Nixon et al. 2009). A significant decline (75 percent from 1980 to 2000) in winter populations of bottom-dwelling fish species has been observed in Narragansett Bay while species that dominate the water column have increased (though less dramatically), which could be attributed to the effects of warming waters (Oviatt et al. 2003; Collie et al. 2008).

7. Similar climate-induced changes affecting bottom-dwelling communities have been observed in areas like the Bering Sea and North Sea (Grebmeier et al. 2006; Kirby et al. 2007).

330.1.2. Stratification and Mixing

1. Codiga and Ullman (2010) described the "typical" annual cycle of density stratification and how it varies geographically across the Ocean SAMP area, including the importance of temperature and salinity in driving stratification (See Chapter 2, Ecology of the SAMP Region, Section 230.3, for more detailed discussion). However, the impacts of changes in river flow, solar heating, wind strength, and storminess due to climate change upon stratification patterns cannot yet be predicted.

2. Warming waters due to changing climate have been reported as at least partially responsible for the increasing occurrence of harmful algal blooms (Bricker et al. 2008). Harmful algal blooms are a rapid rise of phytoplankton to levels that pose threats to ecosystem and/or human health (see Chapter 2, Ecology of the SAMP Region, Section 250.1.6, for a more detailed discussion). Harmful effects upon ecosystems can result from a massive die-off of phytoplankton and can lead to depleted oxygen in the water column, caused by microbes associated with the harmful algal bloom, and create hypoxic (very little oxygen) or anoxic (no oxygen) conditions that can stress or kill aquatic organisms. Harmful algal blooms are now frequently occurring along the coast of Maine and are becoming more common in Massachusetts waters; however, harmful algal blooms have not been documented in the Ocean SAMP area to date.

3. Stratification of the water column means that oxygen rich water at the surface does not mix down to the oxygen-poor bottom layer, causing an environment for hypoxic conditions. Beardsley et al. (1985) and Codiga and Ullman (2010) each found seasonal stratification in the waters of the outer shelf and continental slope with strong stratification of the water column during the spring and summer and weakly stratified or mixed waters during the fall and winter. Wind power increases vertical mixing. If wind speed declines in the Ocean SAMP area, as historical evidence suggests from the Rhode Island mainland, this would reduce the wind mixing potential of the water column (Nixon et al. 2009). Stronger storms, as projected, would increase the wind mixing potential of the Ocean SAMP area water column.

4. A decrease in water column mixing could also be a result of warmer surface water temperatures and increased inputs of freshwater from rivers (Pilson 2008). Higher water

temperatures decrease the solubility of oxygen (the amount of oxygen that the water can hold) and increase stratification, which could contribute to the occurrence and/or severity of hypoxia (NBEP 2009, Pilson 1998). Also, as water temperatures rise, the respiration rates of organisms in the water increase, thus increasing the demand on oxygen supply.

330.1.3. Marine Fish and Invertebrates

1. There has been mounting evidence that over extended periods of time, even small increases in water temperature can significantly affect species composition, distribution, and abundances of fish communities (Murawski 1993, Genner et al. 2004, Perry et al. 2005, Frumhoff et al. 2007). Temperature influences the geographical distribution of marine communities, and has a direct effect on the location and timing of spawning, which in turn affects the subsequent growth and survival of commercially important species, such as flounder, lobsters, and cod (see also Chapter 2, Ecology of the SAMP Region, Section 250.3). It is possible that warming waters, in addition to other stresses, may be a significant cause for the decline of ecologically and commercial important species (see also Section 340.5 of this chapter). Nye et al. (2009) found that 24 of 36 fish stocks assessed in the northwest Atlantic had a statistically significant response to warming water temperatures.

2. It has been projected that with warming, the general distribution of species will shift northward and there will be a vertical shift in species distribution to deeper water (e.g., cold-water species), causing a reduction of cold-water species while expanding the ranges of warm-water species (Nye et al. 2009). This projection is based on findings from analysis of a continuous, 40-year trawl survey (1968–2007) in the northwest Atlantic. As noted in Chapter 2, Ecology of the SAMP Region, Section 250.3, Perry et al. (2005) have documented similar shifts in both commercially and non-commercially valuable species, with an average latitudinal shift in distance of 175 km (range from 48 km to 403 km). Other studies in the northwest Atlantic have documented geographical shifts of northern species moving northward and being replaced by warmer-water species (EAP 2009, Hare and Able 2007, Rose 2005, Drinkwater 2005, Nye et al. 2009, Frumhoff et al. 2007). Cold-water species that are at the southern extent of their range will be most impacted and may decline in abundance (Drinkwater 2005; Nye et al. 2009). There is evidence that along the northeastern coast of the U.S., shallow-water sedentary species such as yellowtail flounder, winter flounder, summer flounder, windowpane, and longhorn sculpin have already shifted their center of biomass north toward the pole (Nye et al. 2009). Other species, including American shad, fourspot flounder, goosefish, halibut, cod, alewife, cusk, red hake, and silver hake, have shown some of the largest northward distributional shifts, concomitant with a warming trend (Nye et al. 2009).

3. Observational data has also shown that as southern species shifted their range northward, favorable conditions for growth and recruitment resulted in increases in abundance and range expansion. Hare et al. (2010) modeled both exploitation and climate change projections on Atlantic croaker (*Micropogonias undulatus*) and predicted a 60 to 100 percent increase of spawning biomass and a 50 km to 100 km northward shift of the center of the population by 2100. Northern species were found to shift northward slightly, contracting their range, or had shifted to deeper depths (Nye et al. 2009). It has also been hypothesized that the pelagic (water-column) fish communities will have higher rates of this northward distributional shift compared to demersal (bottom-dwelling) fish (Cheung et al. 2009).

4. A study in the North Sea found that species with faster life histories were able to respond to temperature changes by shifting their geographical distribution (Perry et al. 2005). Species with slower life histories are already more vulnerable to overexploitation by commercial fishing and will likely not be able to compensate for warming via a rapid demographic response. The differences in responses between fish of varying life histories may alter spatial overlap and disrupt species interactions (Perry et al. 2005). For example, previous work off the northeastern coast of the U.S. found that species with the largest responses in distributional shifts are key prey for non-shifting predator species (Murawski 1993). It has also been hypothesized that local extinctions of fish species will be most common in polar, subpolar, and tropical areas of the world (Cheung et al. 2009). Local extinctions in the North Atlantic along the U.S. and Canadian coasts were also projected to be higher than in other areas (Cheung et al. 2009)

5. In Narragansett Bay and Rhode Island Sound at the mouth of Narragansett Bay, dramatic shifts during the last half century in local fish populations associated with warming winter sea surface temperatures and fishing pressure have been observed (Oviatt 2004, Collie et al. 2008). Fish communities in the Ocean SAMP area may be especially vulnerable because of the area's location on the border of two biogeographic provinces: many species found at the edge of their geographical boundaries are more stressed, and as environmental conditions change their distribution shifts congruently (Sorte and Hoffman 2004, Harley et al. 2006). The increase in winter sea surface temperature is correlated with the decline of various species that reside in Rhode Island waters during the cold winter months (e.g., winter flounder, silver hake and red hake). These cold-water species may be in the process of being replaced by seasonal, southern migrants (e.g., butterfish and scup) that are increasingly abundant during summer months (Jeffries and Terceiro 1985, Jeffries 2001, Collie et al. 2008).

6. As noted in Chapter 2, Ecology of the SAMP Region, Section 250.3, a further major shift in the Rhode Island Sound coastal fish community is from demersal (bottom-dwelling) fish species to smaller pelagic (water-column) southern fish species and large invertebrates (e.g., squid, crabs, lobster) (Oviatt 2004, Collie, in prep.). The shift from benthic to pelagic species began abruptly around 1980 and is consistent with similar benthic-to-pelagic shifts in other estuaries, such as Chesapeake Bay (Jackson et al. 2001, Attrill and Power 2002, Genner et al. 2004).

7. This shift has been attributed primarily to increasing sea surface temperatures and secondarily to fishing (Collie et al. 2008), with changes in food availability as another potential factor. An increase of the winter North Atlantic Oscillation (NAO) (resulting in warmer ocean temperatures) and the decrease of phytoplankton, are associated with the rapid shift from benthic to pelagic species since the 1980s, and are strongly correlated to changes in the pelagic food web (Collie et al. 2008). During the NAO positive phase, ocean water and climate is warmer in the eastern U.S, south of Cape Cod, and Europe. It is projected that a positive NAO will dominate or have a strong presence during the next 50 to 100 years, especially in winter and under the high emissions scenario (Frumhoff et al. 2007), suggesting that the trends being observed will likely continue at regional scales, and could impact the Ocean SAMP area.

8. It is possible that warming waters may be a significant cause for the decline of commercially important winter flounder by changing the spring timing of when the sand shrimp, which preys on juvenile flounder, becomes active during the year (Jeffries 2001, Taylor 2003).

9. It has been observed that in recent years populations of the ctenophore *Mnemiopsis leidyi*, a comb jelly, have grown in size, and the timing of their annual arrival in local waters has shifted from late summer to early summer due to warming waters. This has caused a significant decline of *Acartia tonsa*, a once abundant copepod (a common type of zooplankton) in Narragansett Bay (Sullivan et al. 2001, Costello et al. 2006, Sullivan et al. 2007). *Cancer* crab, lobster, and some fish populations could also be affected by their larvae being consumed in larger quantities (Sullivan et al. 2001, Oviatt 2004).

10. Although Collie et al. (2008) found increased lobster populations from 1960's to 2000's, rising sea water temperature is expected to adversely affect lobster populations in the Ocean SAMP region due to distributional shifts northward and potential stresses such as increased incidence of disease (see Chapter 2, Ecology of the SAMP Region, Section 260.3, and this chapter, Section 330.3.1). Temperature affects lobster physiology and behavior at all life stages, including molting, the settlement of post-larval lobsters, growth rates, and movement and seasonal migration (Frumhoff et al. 2007). Currently the southern limit of lobster along the Northeast coast is located near Long Island and northern New Jersey. As waters warm, this southern limit will move northward, possibly north of Rhode Island waters, causing a severe decline in the local fishery and an increase in the northern Gulf of Maine fishery (Frumhoff et al. 2007). According to a comparison of lobster distribution between the relatively colder period from 1965 to 1969 and the warmer period from 2000 to 2004, the center of lobster geographical density has already shifted north (Frumhoff et al. 2007).

330.1.4. Marine Mammals

1. Thirty-six species of marine mammals are known to occur in the Ocean SAMP area (Kenney and Vigness-Raposa 2009); they use the water for seasonal feeding or migrating to feeding and calving grounds (See Chapter 2, Ecology of the SAMP Region, Section 250.4 for further discussion). No research showing direct impact to adult marine mammal populations as a result of climate in the Ocean SAMP area is known; however, studies showing indirect impacts are noted below.

2. Most of the marine mammals that occur in the Ocean SAMP area are wide-ranging and not resident in the area. However, some species may pass through and feed in the Ocean SAMP area, staying a few days, and others stay for weeks to several months. Therefore, changes to the marine ecosystem in Ocean SAMP waters due to climate change are less important than the effects of climate change impacts to a wider region. Although some of climate change impacts in this case are outside the domain of the Ocean SAMP, it is still important to be aware of how climate change affects these marine mammals. Of the 29 large marine mammals that use the Ocean SAMP area, seven are listed as endangered under the Endangered Species Act, and therefore demand an extra level of attention. In addition, all marine mammals are provided protection from harassment under the Marine Mammal Protection Act.

3. The IPCC (2001) concluded that marine mammals (and seabirds) are highly sensitive to climate changes (IPCC 2001). Sea surface temperature and distribution of preferred prey, for

example, are important determinants in the range of marine mammals (Learmonth et al. 2006, Kaschner et al. 2006). The range of some marine mammals that occur in the Ocean SAMP and require polar and cold temperature waters are expected to experience a loss in range as they move northward. Some of the marine mammals whose range is warm water (such as the West Indian manatee) will be more likely to enter the Ocean SAMP as their range is extended northward (Learmonth et al. 2006).

4. Species that rely on sea ice or the environment close to the ice edge as part of their habitat will be more vulnerable to climate change (e.g., ice-breeding seals). Climate change models predict reductions in sea ice concentrations. Among the 36 marine mammals identified in the Ocean SAMP range, ringed seal, gray seal, harp seal, and hooded seal are dependent on sea ice (Learmonth et al. 2006).

5. In general, species that are more adaptable to changing prey conditions will be less vulnerable to climate change. However, species such as the right whale that have a relatively narrow range of acceptable prey characteristics and feeding grounds closely linked to specific physical phenomena such as water structure, currents, and temperature, will be more likely to experience negative impacts of climate change (Learmonth et al. 2006; Simmonds and Isaac 2007).

6. Changes in prey distribution, abundance, and composition resulting from climate change are recognized by the IPCC (2001) as primary impacts of a changing climate on the marine mammals that feed from the top of the food chain. Marine mammals in general and baleen whales in particular (right whale, humpback whale, minke whale, Bryde's whale, sei whale, fin whale, and blue whale), require dense patches of prey such as copepods and other forms of plankton (Learmonth et al. 2006). Therefore, the distribution, abundance, and migration of these whales reflect the distribution, abundance, and movements of these dense prey patches (Learmonth et al. 2006). Changes in dominant copepod assemblages have been noted on both sides of the North Atlantic Ocean with increasing water temperatures (Beaugrand et al. 2002).

7. Changing water temperature and prey availability can also impact the reproductive success of marine mammals (IPCC 2007; Whitehead 1997). For example, a decrease in North Atlantic right whale calving has been related to abundance of the principal prey species of copepod, *Calanus finmarchicus*, and oceanographic changes influenced by the NAO (See Section 310.5 for further discussion about NAO; Greene and Pershing 2004). Intervals between right whale calves lengthened from 3 to 4 years between 1987 and 1992 to 5 to 6 years between 1993 and 1998 (Kraus et al. 2007). Kenney (2007) compared North Atlantic right whale calving rates with three atmospheric indices including the NOA, and found each of these atmospheric cycles may be correlated with calving. Additionally, Learmonth et al. (2006) suggest a close correlation between food abundance, body fat condition, and fecundity in female fin whales that in years of food abundance at the summer feeding grounds might produce a calf in consecutive years, whereas in poor years the cycle can be extended to three years.

8. Research has linked the NAO, prey abundance, and right whale calving rates. Positive NAO conditions in the 1980s corresponded with favorable calving rates and negative conditions in the 1990s were linked with very low rates. The NAO atmospheric phenomenon has a dramatic effect on the amount of cool, fresh water moving downstream from the Labrador

Sea to the Northeast (Pershing et al. 2001). In the winter of 1996, the NAO index exhibited its largest drop of the century. Resulting changes in the water in the Gulf of Maine determine zooplankton ecology. Green et al. (2003) found that major multi-year declines in calving rates have tracked those in *Calanus finmarchicus*, a copepod species that dominates the spring and summertime zooplankton biomass in the Gulf of Maine. The second multi-year decline corresponded with a precipitous drop in *C. finmarchicus* abundance with a record low three years in a row: six in 1998, four in 1999 and only one in 2000 (Kraus et al. 2007).

9. The IPCC (2007) concludes that there will be an increase in climate variability, which could lead to further variations in climate and impacts on the NAO. Since right whales require at least three years between births, increasing climate variability and corresponding NAO impacts may affect calving rates negatively (Green et al. 2003).

10. Finally, warmer sea temperature has been linked to increased susceptibility to disease, contaminants, and other potential causes of marine mammal death (Learmonth et al. 2006). Climate change has the potential to increase pathogen development and affect survival rates, disease transmission, and host susceptibility (Harvell et al. 2002).

330.1.5. Seabirds

1. How seabirds would be affected by climate change is an active area of research. The Third Assessment Report of the IPCC and many scientists since then found evidence of the sensitivity of seabirds to climate-ocean changes and concluded that survival and distribution impacts will occur as climates shift (IPCC 2001; U.S.FWS 2010; Wanless et al. 2007; Durant et al. 2004; Jenouvrier et al. 2009). It is known that changes in climate affect seabird behavior and populations in terms of food availability, nesting and feeding habitat, the ability to carry out courtship behavior, breeding, survival of young, and migration patterns. Seabirds that frequent the Ocean SAMP area may be affected by these impacts occurring both in and outside the Ocean SAMP. Each type of seabird (e.g., pelagics, sea ducks, gulls and relatives, and shorebirds) has a slightly different seasonal use of the area and, therefore, the impacts of climate change may affect them differently.

330.1.5.1. Nesting and Feeding Habitat

1. All 67 oceanic bird species (such as shearwaters and petrels found in the Ocean SAMP area) are among the most vulnerable birds on Earth to climate change because they don't raise many young each year, they face challenges from a rapidly changing marine ecosystem, and they nest on islands that may be flooded as sea level rises (U.S.FWS 2010).

2. Those species that are found in the Ocean SAMP area that nest in coastal habitats are also vulnerable to sea level rise from climate change (U.S.FWS 2010). For example, piping plovers (federally threatened) and least terns (state threatened) could lose critical beach nesting habitat (Paton pers. comm.). Vulnerable species that nest in salt marsh habitats in the Northeast include saltmarsh sharp-tailed sparrows (this species is only found nesting in Northeastern salt marshes), seaside sparrows, and willet (Paton pers. comm.). Finally, species that nest on the ground on low offshore islands (e.g., roseate terns, federally listed as endangered, and common tern) would be extremely vulnerable to sea level rise and loss of critical nesting habitat, for example, that of Great Salt Pond on Block Island, which is a regionally important migratory shorebird stopover site (Paton pers. comm.).

3. Coastal wetlands provide critical stopover habitat for migratory shorebirds that pass through the Ocean SAMP area. Most shorebird species forage on beaches and mudflats, or in low salt marshes (Koch and Paton 2009). Rhode Island provides valuable stopover habitat for a wide array of migratory species, particularly in the fall for species that breed throughout the tundra of Canada/Alaska and stop in Rhode Island and coastal New England to refuel before heading farther south to the southern U.S., Caribbean, and South America (Paton pers. comm.). Beaches (e.g., Napatree Spit) and coastal ponds (Trustom Pond, Goosewing, and Ninigret) provide useful foraging habitat for these long- and short-distance migrants. Loss of this foraging habitat to sea level rise could have major impacts on shorebird populations. (Paton pers. comm.).

330.1.5.2. Food Availability

1. Many of the seabirds that prey on fish and plankton are likely to have their food supply reduced or relocated if the predicted effects of climate change on lower trophic levels occur (Daunt et al. 2006; Frederiksen et al. 2006). There is no data on seabird impacts in the Ocean SAMP as a result of changes in food supply, but there is evidence elsewhere. The natural climate variability of El Niño Southern Oscillation (ENSO) events has provided insight into how sea surface temperature variation can result in significant change in the marine ecosystem. The population of sooty shearwaters and common murres off the west coast of North America greatly declined due to starvation during the 1997–1998 ENSO event (Mathews-Amos and Berntson 1999). Cormorants and pelicans experienced mass mortalities during the 1982–1983 ENSO event that were attributed to reduced nutrients in surface waters leading to decreased primary and secondary production (Glynn 1988). The common murre is a frequent winter visitor to the Ocean SAMP region. Double-crested cormorants are a common breeding species in Rhode Island (nesting in Narragansett Bay), and great cormorants are common in winter months in coastal Rhode Island.

330.1.5.3. Breeding

1. Time series data analysis of over 100 species of seabirds in the North Atlantic suggests a strong relationship between seabird breeding success and climate variables related to the NAO, which influences sea surface, air temperatures, precipitation and other aspects of regional climate (Sandvik et al. 2008). The results suggest that sea surface temperature was the single most relevant parameter to breeding success of seabirds. Sea surface temperature affects the marine ecosystem and seabird food abundance, distribution and seasonality. A lack of food affects the reproductive success of seabirds with a reduction in numbers of eggs produced, those successfully hatching, and the number of breeding pairs (Wanless et al. 2005).

330.1.5.4. Migration Patterns

1. Climate change also affects the timing of arrival and departure of migratory seabirds, and average laying dates (Frederiksen et al. 2004; Crick 2004). Time series data of long-term arrival and passage of migrants are not available for the Ocean SAMP area. However, reported observations of some bird species in the United Kingdom have been increasingly later in the fall, implying a longer stay on breeding grounds (Sparks and Mason 2001). Also, warmer springs are associated with earlier arrivals and earlier breeding (Sparks et al. 2001).

Depending upon prey resources utilized, climate-related alterations of the marine ecosystem could cause mismatches between migratory time and cycles in abundance of major prey species in the Ocean SAMP area (i.e., altered phenology).

330.1.6. Sea Turtles

1. Six species of sea turtles are known from the North Atlantic, with four—green, loggerhead, Kemp's ridley, and leatherback sea turtles—occurring rarely or occasionally in the Ocean SAMP area (Kenney and Vigness-Raposa 2009). All four are on the U.S. endangered species list. Warmer seawater temperatures may increase sightings of these sea turtles in Ocean SAMP boundaries, but this possibility has not yet been considered in models or other attempts to project climate change impacts to the Ocean SAMP area.

2. The major impact of global climate change on sea turtles that occur in the Ocean SAMP area is on their nesting and feeding grounds farther south outside the domain of the Ocean SAMP. This section summarizes these impacts outside the Ocean SAMP, recognizing that they are protected under the Endangered Species Act and therefore demand an extra level of attention.

3. Sea level rise will affect nesting areas on low-level sand beaches. All female turtles come ashore at nesting beaches, dig nests in the sand, lay their eggs, and then return to the sea. These areas of low-lying, sandy, coastal beaches, often key habitat for nesting sea turtles, are also areas that are most vulnerable to the impacts of sea level rise (Fuentes et al. 2009a). Erosion and inundation of beaches caused by rising sea level and more intense storms adds the potential for further dangers to nesting sites that are already threatened by people and animals. Coastal flooding can increase rates of egg mortality and decrease reproductive success as sea level rises closer to sea turtle nesting sites. The Outer Banks of North Carolina is especially prone to this because most beaches are backed by coastal development (e.g., seawalls, roads, etc.) or salt marsh, and increased storm surge and coastal land loss will threaten these beaches, which have nowhere to retreat (Hawkes et al. 2007).

4. Rising temperatures will affect incubating sea turtle eggs. The optimal temperature range for incubation is 25°C to 35°C (77°F to 95°F), with reduced hatchling success outside that range (Fuentes et al. 2009b). In addition, temperature during the middle third of incubation determines the sex of the hatchling. Hatchling sex ratio is 50:50 at 29°C (84°F), with more males at cooler temperatures and more females at warmer (Fuentes et al. 2009a). Vegetation (shading), beach slope, humidity, rainfall, and egg position in the nest can all influence incubation temperature and sex ratio (Hawkes et al. 2007).

5. Loggerhead turtles nest in North America from southern Florida to southern Virginia, and it is theorized that more males are born in the northern sites due to cooler temperatures (Mrosovsky and Provancha 1989). Loggerhead turtle nests in Florida are already producing 90 percent females owing to high temperatures, and if warming raises temperatures by an additional 1ºC (1.8°F) or more, no males will be produced there (Mrosovsky and Provancha 1989).

6. One study of loggerhead sea turtles at Bald Head Island in North Carolina found that increased sea surface temperature is associated with earlier nesting and longer nesting seasons. Modeling-predicted air and sea surface temperature increases indicate that nesting would need to be altered only a few days with a 1°C (1.8°F) increase and up to a week with a

3°C (5.4°F) increase (Hawkes et al. 2007). These results suggest that there is hope for sea turtle adaptation, especially along their northern nesting range, and that protecting these male-producing sites should be a priority for future management.

7. Adult sea turtle feeding patterns are also affected by climate change. Sea grass beds are declining for several reasons including pollution and increased sea temperatures from climate change, and water temperature is higher on inter-tidal sea grass flats, typically feeding grounds for green turtles (Short et al. 2006).

8. Leatherbacks may also shift their northern distribution due to increasing air and sea temperatures. McMahon and Hays (2006) investigated movements of one leatherback species, *Dermochelys coriacea*, using satellite telemetry, which revealed that habitat utilization remains within the 15°C isotherm (area with the same temperature) and has moved north along with the isotherm by 330 km in the summer position in the North Atlantic over the last 17 years.

9. Sea turtles have existed for more than 100 million years and have survived ice ages, massive sea level fluctuations, and major changes to the continents and the seas (Fuentes et al. 2009a). As a result, they may be able to respond to unfavorable nesting temperatures or inundation of beaches as they have in the past, by seeking out new nesting sites or modifying the seasonality of nesting. However, what is different today is the limited availability of new habitat due to steadily encroaching human development of coastal areas and the rapid rate of climate change.

330.2. Chemical Oceanography

330.2.1. Ocean Acidification

1. Marine animals that have shells or skeletons made of calcium carbonate (such as corals, quahogs, foraminifera, slippershell snails, and sea stars) may be impacted by further reductions in pH levels (increased acidity) (Cooley and Doney 2009). As ocean alkalinity decreases, the dissolution rate of calcium carbonate increases and less dissolved carbonate ions are available for animals to take up and use to form shells and skeletons (USGCRP 2009). Reduced alkalinity could also depress the metabolism of marine organisms with high metabolic rates, such as pelagic fishes and squid, which could lead to a decreased capacity to take up oxygen in the gills and cause asphyxiation in some fish, squid, and shrimp (TRS 2005, Fabry et al. 2008). Although the impacts to larval temperate fish are unknown, it has been observed in reef fish that decreases in pH can disrupt the olfactory cues used by larval fish to find suitable habitat for settlement, which could result in the reduction of population sustainability (Munday et al. 2009). Impacts to reproduction and larval development have already been shown in a lab setting, but additional possible impacts could include effects on immunity and on development at other life stages (Holman et al. 2004; Burgents et al. 2005; Fabry et al. 2008).

2. Recent laboratory research has shown that many organisms with calcium carbonate shells, such as periwinkles, oysters, urchins, and calcareous green algae, formed less calcium carbonate when the pH dropped below 8.2 (Ries et al. 2009). The same study also documented seven species whose rates of calcium carbonate formation increased and one

species that had no response when exposed to lower pH levels (Ries et al. 2009). The impacts of ocean acidification may be highly varied among species.

330.3. Emerging Issues

330.3.1. Disease

1. Marine diseases are not widely studied in the Ocean SAMP area. However, increasing water temperatures and salinities due to changing climate are creating conditions that are favorable to the spread of disease organisms (Kennedy et al. 2002). Temperature change in general makes marine species more vulnerable to stress and disease, particularly if it occurs during critical periods of the species' life cycle.

2. Diseases in southern waters could extend northward and negatively impact local communities of marine plants and animals. For example, the American oyster, which had repopulated Narragansett Bay and the south shore salt ponds in the 1990s after being absent from commercial fisheries for nearly four decades, was severely afflicted by a southern oyster parasite causing the *Dermo* disease (Ford 1996, Cook et al. 1998). A 1998 disease survey found this parasite, which was rarely seen north of the Chesapeake Bay until the 1990s, in over half of the dead oysters (Cook et al. 1998). The spread of *Dermo* is attributed to warming waters that have extended the northern limit of the parasite's geographical range (Ford 1996, Cook et al. 1998, Oviatt 2004, Frumhoff et al. 2007).

3. Lobster shell disease is described in Chapter 2, Ecology of the SAMP Region, Section 270.3. Though the cause of the spread of this disease is unknown, it has been speculated that anthropogenic forces are responsible, including warmer water temperatures (Cobb 2006, Castro et al. 2006). Currently, the southern extent of the commercial lobster harvest appears to be limited by this temperature-sensitive disease, and these effects are expected to increase as near-shore water temperatures rise (Frumhoff et al. 2007). The disease was found in less than 1 percent of lobsters sampled in 1996 and by 2004 the percentage of diseased lobsters sampled grew to 20 to 40 percent (Cobb 2006). Though the disease is not always fatal, it has had negative consequences for lobster marketability. The persistence and increase in prevalence of the disease in recent years has serious implications for the sustainability of the lobster fishery, especially as marine waters continue to warm.

330.3.2. Invasive Species

1. An invasive species is an introduced, non-native species that survives when introduced to a new ecosystem and does, or is likely to, cause harm to the ecosystem. Introduced species are recognized as one of the main anthropogenic threats to biological systems (Sala et al. 2000). As local and regional waters warm, additional warm-water species that once found the colder temperature inhospitable will be able to reproduce and spread (Frumhoff et al. 2007). Sorte et al. (2010) conducted a meta-analysis of marine species experiencing range shifts and found that 75 percent of the range shifts were in the northward direction, consistent with climate change scenarios. The expansion of the northward shift of warm water species may introduce new species into the Ocean SAMP area, and warmer temperature could prolong the stay of current seasonal migrants (Oviatt et al. 2003, U.S. EPA 2008a).

2. Invasive species that can breed in warmer winter waters may have an advantage over native species that breed in colder water (Stachowicz et al. 2002a). Additionally, as environmental changes affect native species composition and abundance, and potentially diversity, resistance to the establishment and spread of invasive species could decline (Stachowicz et al. 2002b). Resistance to invasive species may also be impeded by compound stressors such as anthropogenic disturbance (McCarty 2001) or the spread of new diseases (Harvell et al. 2002), in addition to the stress of temperature increases (Stachowicz et al. 2002b). It is also possible that certain non-native species could have minimal impacts to local marine ecosystems, and perhaps become acceptable or even desirable in future years (Walther et al. 2009).

3. There are no published data on invasive and introduced species in the Ocean SAMP area, but there is evidence of marine species coming from the south that have moved or are moving into New England, in some cases thought due to climate change (Carlton 2010) (see Table 3.5).

Table 3.5. Marine invasions coming from the south.

Species	Geographic Origin	Habitat	Notes
Lionfish (*Pterois miles* and *P. volitans*)	Indo-Pacific		An invasive warm-water species that feeds on juvenile fish. It is now found as far north as Rhode Island (Morris and Whitfield 2009).
Bryozoan *Zoobotryon verticillatum*	Unknown	Fouling	Ephemeral colonists detected in the Mystic River Estuary, Connecticut (Carlton 2010).
Sea squirt *Styela plicata*	Northwest Pacific	Fouling	Ephemeral colonists detected in the Mystic River Estuary, Connecticut and Long Island Sound (Carlton 2010).
Rapa whelk *Rapana venosa*	Japan	Benthos	Established in Chesapeake Bay (Carlton 2010).
Wedge clam *Rangia cuneata*	South Atlantic Bight/Gulf of Mexico	Benthos	Established in Hudson River (Carlton 2010).
Barnacle *Amphibalanus amphitrite*	South Pacific	Fouling	Colonizes New England in warm summers (Carlton 2010).
Barnacle *Amphibalamus subalbidus*	Chesapeake Bay and south	Fouling	Recorded in Charles River, Boston (Carlton 2010).
Isopod *Synidotea laevidorsalis*	Japan	Fouling	Detected in New York (Carlton 2010).

Section 340. Implications of Climate Change for Human Uses

1. Climate change affects all dimensions of human activity in multiple direct and indirect ways. This section reviews the ramifications—both potentially negative and positive—of climate change for the human uses expressed in other chapters. The Ocean SAMP's jurisdiction for management and regulation is offshore; however there are links between offshore and shore-side uses. Therefore, this chapter looks at the potential impacts of climate changes to both offshore uses and to selected shore-side uses as these would affect Ocean SAMP uses. The Rhode Island CRMP manages the shore-side uses more comprehensively.

2. There is little or no data and modeling of specific climate change impacts to human uses in the Ocean SAMP area. However, the direction and magnitude of the effects of climate change are becoming increasingly well understood. While it is possible to take these climate changes and overlay them on human uses to anticipate their general consequences, the complexity and uncertainty must be acknowledged and understood. As Figure 3.12 illustrates, the greater the number of climate change variables and direct and indirect interactions, the greater the uncertainty and complexity of climate change impacts. Added to the complexity is the fact that a number of these variables interact in a variety of ways, making the net impact of climate change drivers upon human uses unpredictable given the amount of research available at this time.

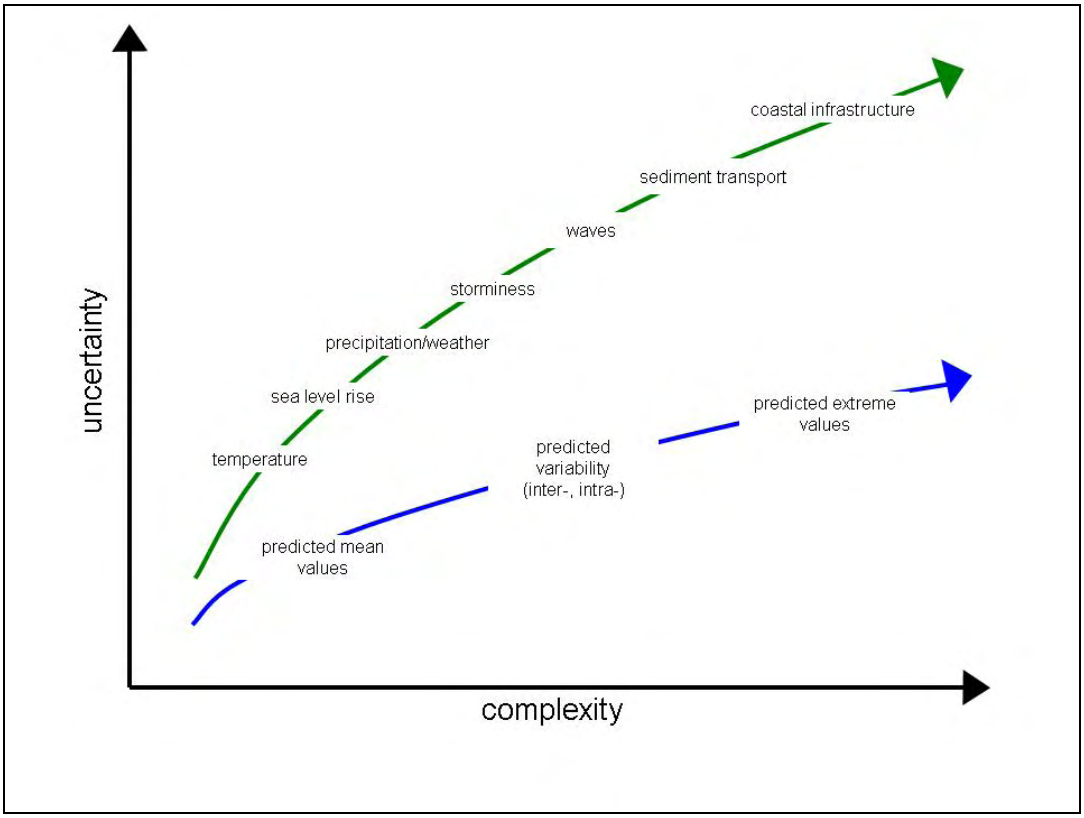


Figure 3.12. Complexity and uncertainty of linked climate change impacts (Adapted from PIANC 2009).

340.1. Marine Transportation, Navigation, and Related Infrastructure

340.1.1. Introduction

1. Marine transportation, navigation, and related infrastructure, as described in Chapter 7, Marine Transportation, Navigation, and Infrastructure, include transport by sea of various types of goods and services as well as people, and involve related issues including navigational routes and ports and harbors. Chapter 7 describes the importance of transportation and navigation through the Ocean SAMP area for cargo ships, such as tankers, bulk carriers, tugs and barges; passenger ferries; naval vessels; government research, enforcement, and search-and-rescue vessels; and pilot boats. In addition, marine transportation is supported by a network of navigation features—including shipping lanes, traffic separation schemes, navigational aids, and other features that facilitate safe navigation—and adjacent land-based infrastructure, such as cargo handling facilities and storage areas in nearby ports.

2. Climate change may influence numerous aspects of the way marine transportation and navigation occurs in the Ocean SAMP area as well as the infrastructure that supports it. Table 3.6 presents a summary of the primary drivers of climate change with direct potential impacts to the user groups associated with marine transportation, navigation, and infrastructure.

3. There are many potential impacts. Among the most critical is an extended shipping season. A longer shipping season has positive implications for the shipping industry. Although it is projected that increasing air temperatures will reduce concern of icing in waterways and on vessels and infrastructure, it is not clear, given the potential for negative impacts to infrastructure and ports, what net impact this will have on shipping through the Ocean SAMP area.

4. Increased vulnerability of infrastructure will also be of significant concern to shipping and navigation. Coastal and offshore infrastructure may be subject to greater damage from more intense storms and increased decay from increasingly acidic seas (PIANC 2009). In addition, coastal infrastructure is more likely to be flooded by higher sea levels, and more coastal infrastructure will be exposed to higher wave loads and tidal fluxes, increasing fatigue and corrosion.

Table 3.6. Climate change impacts on marine transportation, navigation, and infrastructure affecting the Ocean SAMP area.

Climate Change Variable	Potential Impact	Marine Transportation	Navigation	Infrastructure
Increasing air temperatures	Extended shipping season and use of infrastructure (Neumann and Price 2009)	+	n/a	+
	Degradation and shortened lifespan of ships and infrastructure	–	–	–
	Reduced icing in waterways and on vessels and infrastructure (PIANC 2009)	+	+	+
Increasing sea level	Increased exposure to infrastructure (corrosion)	–	n/a	–
	Increased likelihood of flooding/inundation of coastal infrastructure (Neumann and Price 2009)	–	n/a	–
	Need for higher passing height for bridges (PIANC 2009)	–	–	–
	May increase navigability of waterways (TRB 2008)	+	+	+
Increase in storm intensity	Changing movements of sediment (erosion/accretion) (U.S.EPA 2008b)	–	–	–
	Increased degradation and vulnerability of infrastructure (coastal and offshore) (PIANC 2009)	–	n/a	–
	Loss/retreat of land (for associated infrastructure) (PIANC 2009)	–	n/a	–
	Increase in unsafe condition and poor visibility for navigation/transferring cargo (TRB 2008)	–	–	–
	More need for emergency planning and rescue (Neumann and Price 2009)	–	n/a	–
Increasing precipitation and decreasing wind speed	May result in changing currents (PIANC 2009)	?	?	n/a
	Changes in sediment transport (erosion/accretion)	–	–	–
Longer summers and decreased snow season	Extended shipping season and use of infrastructure (Neumann and Price 2009)	+	n/a	+
	Reduced icing on vessels and infrastructure (PIANC 2009)	+	+	+
More acidic ocean	Increasing corrosion rates of vessels and infrastructure (PIANC 2009)	–	n/a	–

Key: +: potentially positive effect
–: potentially adverse effect
n/a: no significant anticipated effect
?: unknown impact

340.1.2. Increasing Air Temperature

1. Increased air temperatures will extend the length of the shipping season and allow for higher volumes of goods shipped at lower costs due to less severe cold weather (U.S.EPA 2008b).

2. Operations on vessels and associated shoreside infrastructure will need to account for higher temperatures in order to protect workers from extreme heat (U.S.EPA 2008b).

3. Air temperature increases will decrease the incidence and severity of icing in waterways and on vessels and infrastructure. On vessels, less icing will decrease the need for lowering freeboard to increase stability (Nicholls et al. 2008).

4. Higher air temperatures and corresponding elevated water temperatures will increase the likelihood that invasive species from ballast discharge survive in local waters (Kling and Sanchirico 2009).

5. Infrastructure can be affected by increased air temperatures as well, including more rapid deteriorating of paved areas and greater energy needed to cool stored goods (U.S.EPA 2008b).

340.1.3. Rising Sea Level

1. Sea level is already rising in the Ocean SAMP area, and is projected to rise at an increasing rate in the future. Sea level rise will reduce the effectiveness and decrease the life of existing coastal structures such as seawalls and revetments, docks, roads, and bridges (PIANC 2009). Sea level rise of the magnitude predicted could also potentially compromise onsite wastewater treatment systems, municipal sewage treatment plants, and stormwater infrastructure. Other risks associated with sea level rise include salt intrusion into aquifers and higher water tables that could compromise individual sewage disposal systems.

2. Higher sea levels increase the likelihood of flooding and inundation of coastal lands and infrastructure. Any given storm event will surge higher on land because the relative sea level is higher than in the past and be exacerbated in the future by more intense storms. This can affect the use of infrastructure in ports and harbors both over the short term (during a flooding event) and long term (extensive damage from inundation) and impact the ability for vessels to access the coast (for example, to unload cargo or pick up passengers) (Neumann and Price 2009).

3. Higher flood levels and storage-area inundation may also inundate contaminated (or potentially contaminated) lands, and/or infrastructure not designed to withstand flooding. These areas could require new containment methods to prevent leaching (U.S.EPA 2008b).

4. According to Titus and Richman (2001), Rhode Island has 47.1 square miles (mi^2) (122.0 square kilometers (km^2)) of land lying within 4.9 vertical feet (1.5 meters) of sea level with an additional 24 mi^2 (108.8 km^2) between 4.9 and 11.5 feet (1.5 and 3.5 meters). This 4.9-foot (1.5-meter) contour roughly represents the area that would be inundated during spring high water with a 2.3-foot (0.7 meter) rise in sea level. This sea level rise scenario is within current end-of-century projections.

5. By mid-century, the 100-year flood is expected to occur more frequently than every 25 years in nearby Woods Hole, Mass., under the high emissions scenario (Kirshen et al. 2008). By late century, it is expected to occur more frequently than every two years. The 100-year storm commonly used by the National Flood Insurance Program standards is a flood event that has a 1 percent chance of being equaled or exceeded in any given year. The

projections for Woods Hole indicate that the 1 percent annual chance flood will increase to 4 percent annual chance of occurring by mid-century and 50 percent by 2100, with associated increases in flooding and damages. These estimates are based on more recent sea level rise estimates that include a conservatively low degree of ice melt impacts.

6. When flooding overtops ports, there is large area of inland inundation because ports are typically built in flat, low-lying areas (U.S.EPA 2008b). Options for protection include, but are not limited to, elevating facilities, filling land, and/or installing shoreline protection structures. Each of these options would need to be analyzed on a case-by-case basis. Aggregate supply (sand and gravel) for armoring and fill is limited in Rhode Island due to municipal policies on sand and gravel mining and lack of publicly or privately owned land alternatives.

7. Increased sea level will reduce overhead clearance between the superstructure of ships and bridges in Narragansett and Mount Hope Bays, thereby limiting operations.

8. A corresponding potential positive impact of sea level rise may be increased navigability of waterways and a decreased need for dredging to accommodate larger-draft vessels (TRB 2008). This could positively benefit ships that pass through the Ocean SAMP area due to currently significant demands for dredging in several parts of Narragansett and Mount Hope Bays. Increased ease of navigability may also lead to an increase in shipping of goods to and from Rhode Island ports (TRB 2008).

340.1.4. Increasing Storm Intensity

1. Increased storm intensity can affect sediment movements due to increased wave heights, causing changes in erosion and accretion patterns. Differing sediment movements can affect needs for dredging, preferred shipping routes, and port operations (U.S.EPA 2008b).

Flooding and Storm Damage to R.I. Ports and Harbors

Providence: Providence's vulnerability to flooding stems from two main geographic features: its location at the head of Narragansett Bay and its low elevation downtown and along the port. During the Hurricane of 1938, Providence experienced a storm surge of more than 15 feet above mean tide level (MTL), with waves measuring 10 feet above the surge level. The hurricane flood waters inundated the city, damaged buildings and other infrastructure, and demolished the wharves of the inner harbor. Damage amounted to $16.3 million, equivalent to about $225 million in 2000 dollars (Providence 2000). In 1954, the downtown area was flooded by 12 feet of water (Vallee and Dion 1996). Damage is estimated to have been $25.1 million, about $134 million in 2000 dollars (Providence 2000).

East Providence - The worst coastal flooding in East Providence occurred in the 1938 and 1954 hurricanes, severely impacting the city's waterfront infrastructure. On two occasions the dock of the Gulf Oil Corporation was completely destroyed along with the connecting railroad. Large ships in the Providence River were torn from their moorings and tossed onto shore. For several days, debris blocked roads, railways, and waterways, creating hazardous conditions that hampered emergency and repair crews. Residential structures located along the waterfront were severely damaged or destroyed, while homes inland along the rivers were flooded (East Providence 2002).

2. Increased intensity in storms will increase periods of high waves, decreasing time for ships to unload at terminals and increasing berthing time for ships at terminals and delayed departures (U.S.EPA 2008b).

3. Increased time needed to unload cargo may result in the need for more area for anchoring of waiting vessels in port areas (U.S.EPA 2008b).

4. Additionally, offshore loading and unloading between vessels can only occur with waves below a certain height and longer than a certain wave period. With increased storm intensity, wave heights too large and with too short a wave period for transfer of goods (and personnel) will occur more frequently (U.S.EPA 2008b). This is critical since demand for natural gas in winter in Providence can be a bottleneck for distribution.

5. Increased storm intensity will also increase degradation and vulnerability of associated infrastructure. Movements of sediment due to increased storminess may also decrease safety of structures and increase probability of flooding through erosion of coastal land (PIANC 2009).

6. Increased storm intensity may lead to decreased regularity of port functions and increased need for storage capacity at container terminals (PIANC 2009). This may increase shipping delays due to suspended operations during intense storms and could decrease the reliability of marine shipping, impacting business of shippers and receivers of shipped goods (U.S.EPA 2008b).

7. More intense storms may also decrease visibility and accessibility to malfunctioning installations such as beacon lights (PIANC 2009).

8. Port security could be adversely impacted by increasingly intense storms and could result in less security (for example, malfunctioning video cameras, radar equipment, and perimeter fencing) (U.S.EPA 2008b). Alternatively, the threat to port security might be reduced due to increased storm intensity, with poor weather making it more difficult to operate equipment.

9. More intense storms, bringing more precipitation in short periods of time, will also require increased capacity of stormwater facilities adjacent to coastal infrastructure supporting port facilities (U.S.EPA 2008b).

10. Increased storm intensity will increase the likelihood of debris inhibiting navigation and/or anchoring at ports and harbors (U.S.EPA 2008b).

11. Unsafe conditions and poor visibility due to increased storm intensity may increase shipping delays and damage vessels. Using additional and enhanced aids to navigation—such as more buoys, with higher-intensity lights and more sound and electronic signals—can attempt to mitigate these impacts, but at a high cost. This may also increase the need for emergency planning and rescues, which will also incur considerable economic costs to the associated industries (TRB 2008).

340.1.5. Changing Precipitation and Weather

1. Changing precipitation and weather patterns may result in differing sedimentation and shoal formation, and may complicate navigation by either offsetting increased water levels or necessitating additional dredging (TRB 2008).

2. Decreasing wind speed could alter currents and change preferred shipping routes (PIANC 2009).

3. Changing weather combined with warmer water may cause marine organisms (phytoplankton, fish, and marine mammals) to move into existing preferred shipping lanes, causing possible problems for navigation and requiring relocating the lanes (U.S.EPA 2008b).

340.1.6. Ocean Acidification

1. Decreasing pH levels and the corresponding increase in carbonic acid in the seas may increase the rate of corrosion on vessels and infrastructure associated with marine transportation, navigation, and ports and harbors. However, increased corrosiveness is also dependent on other environmental factors that will likely be affected by climate change, including some that may have mitigating effects on corrosiveness. Existing structures and vessels may experience a shorter lifespan due to more corrosion (PIANC 2009).

340.1.7. Indirect Impacts

1. The impacts presented above are the most likely and most direct effects of the drivers of climate change upon marine transportation, navigation, and its supporting network and infrastructure. Below is a description of some of the potential indirect and cumulative impacts predicted to affect marine transportation in the Ocean SAMP area.

2. Warmer temperatures may change the seasonality of energy demands, with less energy for heating needed in winter, and more energy for cooling in summer. The net effect on energy demand is not known, but it may influence the mix of energy needed and the seasonality and amount of regional marine oil and gas shipping through the Ocean SAMP area (PIANC 2009).

3. Climate change may affect insurance coverage and could increase premiums on insured property and vessels with combined impacts from increased sea level and storm intensity. Currently, the marine transportation insurance industry is very concerned about rising costs associated with climate change. In response, they are exploring other strategies for insuring vessels and infrastructure including shifting some of the risk to customers and providing technical support and price incentives for customers to decrease exposure to risks (U.S.EPA 2008b). It has been suggested that as insurance premiums rise, reflecting increasing risk, there will be greater incentive to incorporate adaptation measures to infrastructure (Klein 2010).

4. Caldwell and Segall (2007) report that as the mean high water mark moves inland due to sea level rise, the legal boundary between private and state-owned land also moves (reported in Kling and Sanchirico 2009). This may affect issues of ownership at ports in Rhode Island and

complicate issues of planning for future impacts of climate change on coastal infrastructure if ownership of the lands upon which they lie is in question.

340.2. Recreation and Tourism

340.2.1. Introduction

1. Coastal recreation and tourism, as described in Chapter 6, Recreation and Tourism, includes but is not limited to cruise ship tourism, beach-related activities, surfing, boating, diving, and wildlife viewing. Climate change may impact people's decisions about destinations due to the implications of climate change on the coastal and marine landscape, ecosystem, and infrastructure (Agnew and Viner 2001). While the research in this area is sparse with respect to the impacts of climate change per se, the following is based on research on the effects of these potential impacts to the types of recreation and tourism related to the Ocean SAMP area. Table 3.7 presents a summary of the primary drivers of climate change with direct potential impacts to the user groups associated with recreation and tourism in the Ocean SAMP area.

Table 3.7. Climate change impacts on recreation and tourism affecting the Ocean SAMP area.

Climate Change Variable	Potential Impact	Boating and related activities	Beach related activities	Diving	Wildlife viewing
Increasing air temperatures	Allow for longer boating and cruise ship tourism seasons	+	+	+	+
Increasing sea level	(Partial) Inundation of beaches and unique coastal habitats	–	–	n/a	–
	Migration or loss of coastal lagoons, salt marshes and tidal salt flats	–	n/a	n/a	–
Increase in storm intensity	More severe storminess	–	–	–	–
	Increased erosion of beaches and unique coastal habitats	?	–	n/a	–
	Increased storm overwash and breaching	–	n/a	–	–
	Earlier hauling out of recreational boats	–	n/a	–	–
	More Block Island ferry service interruption	–	–	–	–
	More erosion causing sedimentation and shoaling of waterways	–	n/a	–	n/a
Increasing precipitation	Increased nutrients and land-based sources of pollution in the sea from runoff	–	–	–	?
	More cloudiness and decreased visibility	–	–	n/a	–
Decreasing wind speed	Decreased attractiveness for sailing and sailboat racing	–	n/a	n/a	n/a
Longer summers and decreased snow season	Extended summer season	+	+	+	?
	Warmer water will bring more algae (red tide) and jellies	n/a	–	–	?
	More periods of drought during summer could lead to water use restrictions	–	–	–	?
More acidic ocean	May adversely impact shellfish and alter food web dynamics including fish and sea bird communities	–	n/a	n/a	?
	Increased ocean acidity may increase decay rates of underwater structures	–	n/a	–	n/a

Key: +: potentially positive effect
–: potentially adverse effect
n/a: no significant anticipated effect
?: unknown impact

2. Increasing air and sea temperatures may enhance recreation and tourism activities by extending the summer season. However, warmer water may introduce harmful algal blooms and increase algae (red tide) and jellies, reducing water quality and the attractiveness of beach and other water recreational activities (Hoagland et al. 2002).

3. Sea level rise, reduced wind, more severe storms, and more winter precipitation and spring runoff may have negative consequences for recreation and tourism. Increased rainfall and runoff may increase nutrients and other land-based sources of pollution flowing into the sea,

and may increase the overflow from combined storm and wastewater sewer systems (Dorfman and Rosselot 2009). This can compromise water quality, cause algal blooms, deplete oxygen in the sea (hypoxia) and lead to more beach closures. For example, in 2008 there was a significant increase in beach closures in Rhode Island compared with 2007. Although there was an increase in water quality sampling, the increase in closures also coincided with higher rainfall during the summer months in 2008 (Dorfman and Rosselot 2009).

4. More periods of drought are projected for the summer months. This will make freshwater more scarce and could lead to water use restrictions, creating difficulty for tourism infrastructure needs.

5. Recreation and tourism activities in the Ocean State are based on the unique landscape and natural character of the coast. Climate changes that alter the natural character, affecting coastal habitat, fish, shellfish, and seabirds, will have implications for tourism and recreation. Among the unique coastal habitats that characterize southern Rhode Island are the beaches, lagoons (salt ponds), salt marshes, and intertidal communities.

6. With increases in sea level and storminess, Rhode Island's shorelines will change significantly, potentially becoming less attractive and less accessible. Barrier beaches in particular, on the south shore, will be especially vulnerable to increased erosion and landward migration as sea level rises. Increased storminess will result in increased storm overwash, breaching of barrier beaches, and damage to shoreline real estate and development on beaches and lagoon shores. A higher sea level may cause the migration or loss of habitats such as coastal lagoons and tidal salt flats that provide multiple important ecosystem services (Anthony et al. 2009). It can also result in damage or loss to coastal parks, coastal public access points, and open space. Finally, salt water intrusion in coastal aquifers that can accompany sea level rise may increase coastal freshwater scarcity and failure of onsite wastewater treatment.

7. The network of coastal lagoons, locally referred to as salt ponds, that lie along Rhode Island's south shore are important shallow marine ecosystems with historically high productivity of commercially important fish and shellfish and provide habitat for resident and migrating shorebirds and water birds. These lagoons are particularly vulnerable to changes associated with accelerated sea level rise, storms and sea surge, temperature increases and runoff from more precipitation. As sea level rise accelerates, the barrier beaches will become narrower and steeper, shortening the length of inlets to the lagoons and increasing exchange with ocean water (Bird 1994).

8. Salt marshes are other ecologically important habitats that provide a variety of ecosystem services, serving as nurseries and feeding grounds for fish, shellfish, birds, and invertebrates, filtering pollutants from groundwater and runoff, and buffering adjacent land and infrastructure from storms, erosion, and flooding. Loss of salt marsh habitat will likely occur due to accelerated sea level rise. The loss of salt marshes will negatively impact many shorebirds and commercially important species of fish and shellfish, allow more pollutants to reach coastal waters, and leave the coastline more vulnerable to storms and erosion (Frumhoff et al. 2007).

9. The retreat of beaches and the shoreline due to accelerated erosion loss and inundation may increase private property litigation. In addition, Phillips and Jones (2006) suggest that the combined impacts of warming, sea level rise, and coastal hazards will coincide with falling property values in coastal areas and loss of tourism revenue.

340.2.2. Boating

1. Boating includes but is not limited to recreational boating, sailboat racing, and sea kayaking in the Ocean SAMP area and adjacent waters (see Chapter 6, Recreation and Tourism). Additionally, the previous section covers climate change concerns for marine transportation, navigation, and related infrastructure, many of which also affect recreational boating (see Section 340.1 of this chapter).

2. In general, warmer temperatures and a longer boating season are positive impacts of projected climate change for boating (U.S.EPA 2008b).

3. Projections of greater storm intensity and more nor'easters could cause earlier hauling out of recreational boats. Increased storminess could also make it more difficult to service Block Island by ferry, potentially adversely affecting recreation and tourism opportunities (U.S. EPA 2008b). Increased storminess and less predictable weather negatively affect planning for regattas and sailboat races and reduce safety at sea. Storminess could also increase the costs of insurance premiums for marine insurance for marinas and recreational vessels.

4. Higher-intensity precipitation can cause more runoff and erosion. This in turn can cause sedimentation and shoaling of waterways, adversely affecting marine navigation (U.S.EPA 2008b; TRB 2008).

5. Reduced average wind speed decreases the attractiveness of the area for sailing and sailboat racing.

6. Ocean acidification adversely affects some marine life and may ultimately have a detrimental effect on recreational fisheries. As the ocean becomes more acidic, mussels, starfish, and even fish may be adversely impacted. Changes to these populations may affect food web dynamics, and therefore affect fish communities and seabirds as well.

340.2.3. Diving

1. Recreational diving in the Ocean SAMP area includes both offshore diving and shark cage diving. Popular diving locations include historical ship wrecks, interesting benthic communities, and popular shark sites, among others.

2. It is difficult to speculate how climate change will impact diving. Longer summers can be a positive impact, upon diving in extending the season. However, the resulting effects of climate change on marine life and ocean visibility for diving are unknown. As is the case for boating, more severe storms would be a negative impact.

3. Over the long run, more acidic seas may increase the rate of decay of underwater wrecks that attract recreational divers.

340.2.4. Wildlife Viewing

1. Wildlife viewing includes but is not limited to whale watching, birding (i.e., pelagic, shorebirds), and any other recreational activity whose main goal is to view wildlife. This includes all viewing both offshore and in coastal regions.

2. An increase in air temperature combined with an earlier spring and a later winter will give a longer season for wildlife viewing that occurs during the warm months. The shortened winter months with more precipitation and cloudiness may adversely affect viewing of seals and winter-migrating birds.

4. Barrier beaches in particular, such as Rhode Island's barrier beaches on the south shore, will be especially vulnerable to increased erosion and migration as sea level rises. The beaches serve as important habitat for shorebirds such as the piping plover and numerous coastal species (U.S.FWS 2010).

5. The impacts of changes in climate change variables will affect the number and range of marine mammals and seabirds in the Ocean SAMP area. Some species may become less abundant, and viewing of those will decline. Warm water species that are currently rare may become more abundant.

340.2.5. Cruise Ship Tourism

1. Most cruise ship tourism to Newport is concentrated in the fall. Warmer fall temperatures would have a positive impact on the cruise ship industry.

2. Since cruise ship tourism is concentrated in the fall hurricane season, increased storm intensity could adversely affect cruise ship tourism (See also Section 340.1).

340.2.6. Marinas, Yacht Clubs, and Boat Ramps

1. Sea level rise, combined with storms, and heavier winter precipitation and runoff may place some marinas, yacht clubs and boat ramps at risk of inundation, erosion, and storm damage (See also section 340.1). Adaptation actions would require investments that will increase costs of operation.

340.3. Renewable Energy

1. Climate changes could affect the design, construction, delivery and installation, maintenance, and operation of wind turbines and related infrastructure. Sea level rise, severe storms, and storm surge could damage coastal construction facilities of wind turbine components and adversely affect the delivery of parts by ship. Installation of support structures, foundations, wind towers, and wind turbines at sea could be more costly and difficult if climate becomes more unpredictable, and more intense storms and waves reduce windows of opportunity for delivery by boat to the site and installation. Maintenance over the life of the turbines could also be more difficult and costly. More intense storms will fatigue turbines and platforms more rapidly. Given the relatively long life span of wind turbines (about 30 years), design standards of platforms and blades should take future climate projections into account.

2. Although statistically significant decreases in wind speed have been documented on land at T.F. Green (See Section 310.5), it is not known how wind speed will change onshore in Rhode Island. In addition, different dynamics exist offshore in the Ocean SAMP area than exist at T.F. Green on the coast of Narragansett Bay. However, the U.S. Department of Energy's National Renewable Energy Laboratory mapped the wind resources of Rhode Island at the 50 meters (164 feet), using data provided by AWS TrueWind (See Chapter 8, Renewable Energy and Other Offshore Development, Section 810.3, and Figure 3.12 in that section), which indicate that wind speed ranges from Excellent to Superb for offshore wind turbines in the Ocean SAMP area.

340.4. Historic and Cultural Assets

1. Climate change drivers could impact the preservation and maintenance of historical and cultural assets in a variety of ways. Potential impacts include sea level rise and storm surge, which could increase erosion of coastal assets, while more severe storms and ocean acidification could increase damage to submerged assets. Due to the lack of research on the impacts of climate change on these assets, these issues will be targeted for future research in the Ocean SAMP area and results will be reported in future versions of this document.

340.4.1. Submerged

1. Decreasing pH levels in seas may increase the rate of corrosion of submerged vessels and other historic and cultural assets on the seabed.

340.4.2. Terrestrial

1. Two important historic assets in the Ocean SAMP region are the Southeast Light and North Light lighthouses on Block Island. Both are highly vulnerable to the effects of sea level rise, storms, and sea surge.

2. In 1874, when Southeast Light was built, it was located approximately 300 feet (90 meters) inland from the edge of the Mohegan Bluffs. However, due to severe erosion of the adjacent bluffs, by 1993 the lighthouse was only approximately 55 feet (17 meters) from the edge of the bluffs. Between August 10 and 28, 1993, the lighthouse was moved inland 360 feet (110 meters) to a location that geotechnical studies determined will be safe for more than a century (Reynolds 1997).

3. The location of North Light, at Sandy Point, is also subject to extensive erosion and has been rebuilt four times. The original building was constructed in 1829 on sand and gravel and subject to rapid erosion that washed it out to sea after a only few years. In 1837, its replacement, built 0.25 miles (0.4 kilometers) inland from the first site, was also lost to the sea due to erosion. In 1857, a third lighthouse was built farther inland followed by piers constructed in 1865 to fortify the structure from falling due to erosion. Noting that the structure was still highly vulnerable to coastal inundation, in 1866, Congress appropriated funds to build the fourth structure. The current lighthouse was built in 1867 and although it is 700 feet (210 meters) from the tip of Sandy Point, it is only two feet above mean high water (Lighthouse Friends 2010).

340.5. Fisheries Resources and Uses

1. As Chapter 5, Commercial and Recreational Fisheries, discusses, commercial and recreational fisheries are important uses of the Ocean SAMP area that add economic, historic, and cultural value to Rhode Island. Therefore, climate change impacts to marine fisheries in this area are of great importance.

2. As noted earlier, Rhode Island Sound and Block Island Sound ecosystems are located at the boundary of two bio-geographic provinces. Due to this, the impacts of climate change are of special concern because the fishery is based on a mix of cold- and warm-water species.

3. This section does not cover the impacts of climate change on marine transportation, navigation, and related infrastructure for the marine fishery. This is covered in Section 340.1.

340.5.1. General Impacts on Marine Fisheries

1. The main climate change drivers impacting fish populations are discussed in Chapter 2, Ecology of the SAMP Region, Section 250.2, and above in Section 330.1.3. In addition, climate change impacts on disease and invasive species are covered above in Sections 330.3.1 and 330.3.2, respectively. Changes in temperature, circulation, salinity, and food availability affect the spawning and distribution of fish and may cause changes in preferred fishing grounds for certain stocks (Murawski 1993).

2. As discussed in Chapter 5, Commercial and Recreational Fisheries, fishers who target the Ocean SAMP area often use a variety of gear types and are accustomed to modifying gear to target different stocks (for example, during different seasons). Therefore, if the types of fish in the Ocean SAMP area change, fishers may be able to adapt their fishing practices accordingly.

3. An exception is the lobster fishery. Lobstermen typically fish almost exclusively for lobster. With the prediction of northern movement of the species with increased water temperatures (as discussed in Section 330.1.2), and increased incidence of shell disease associated with increased water temperature (see Section 330.3.1), lobster fishing is likely to decline.

4. As species move and targeted fish stocks change, there could be significant impacts on fishers and fisheries in the Ocean SAMP area. Potential impacts include (1) increased time and cost to travel to fishing grounds, (2) possibly reduced catch per unit effort, (3) possibly reduced market value of more abundant southern species compared with less abundant northern species, and (4) costs of altering gear.

340.5.2. Fisheries Most Likely to be Impacted by Climate Change

1. Species that are at or near the southern extent of their range in the Ocean SAMP area are likely to move north, decreasing in abundance and/or extent of time in which they can be caught by fishers in the Ocean SAMP area (Hare et al. 2010, Nye et al. 2009, Perry et al. 2005). In addition to latitudinal changes in distribution, Nye et al. (2009) and Perry et al. (2005) also suggest that depth distributions may change as a result of climate changes. Commercially valuable species most likely to be impacted in this way include:

- American lobster (*Homarus americanus*)
- Atlantic cod (*Gadus morhua*)
- Silver hake (*Merluccius bilinearis*)
- Winter flounder (*Pseudopleuronectes americanus*)

2. Species that are at or near the northern extent of their range in the Ocean SAMP area are likely to move north, increasing in abundance and/or extent of time in which they can be caught within the Ocean SAMP waters (Hare et al. 2010, Nye et al. 2009). The species most likely affected in this way include:

    - Atlantic croaker (*Micropogonias undulates*) (Hare et al. 2007)
    - Black sea bass (*Centropristis striata*)
    - Blue crab (*Callinectes sapidus*)
    - Butterfish (*Peprilus triacanthus*)
    - Scup (*Stenotomus chrysops*)
    - Summer flounder (*Paralichthys dentatus*)

3. Warming sea temperatures in the Ocean SAMP area are likely to bring more fish species that are primarily, but not solely, targeted by recreational fishers. With increasing populations of these species, some of them may become targeted by commercial fisheries more often. Popular recreational fisheries species that are likely to occur more often include:

    - Atlantic bonito (*Sarda sarda*)
    - Bluefish (*Pomatomus saltatrix*)
    - False albacore (*Euthynnus alletteratus*)
    - Striped bass (*Morone saxatilis*)
    - Yellowfin tuna (*Thunnus albacares*)

340.6. Future Uses

1. The same wide array of climate changes and impacts would fall on potential future uses of the Ocean SAMP area and would need to be considered. Some potential future uses are climate sensitive (e.g. offshore aquaculture, protected areas, and biofouling) and potential impacts could be adverse and positive (See Chapter 9, Other Future Uses, for further discussion). Due to the time-sensitive nature of climate change drivers, these impacts would have to be considered when these uses are proposed in order to consider the effects as accurately as possible.

Section 350. Policies and Standards

1. The Coastal Resources Management Council ("Council") developed and adopted on January 15, 2008, Section 145 Climate and Sea Level Rise Policy. This policy is part of the federally adopted Rhode Island Coastal Resource Management Program (RICRMP). This is the controlling provision for the upland areas within the Council's jurisdiction and the immediate shoreline areas and seaward to a distance of 500 feet offshore. Section 350 is intended to be the controlling policy for the ocean waters from beyond the 500 foot mark out to the three-mile limit. Below is Section 145. C. Policies from the currently adopted RICRMP.

   145. C Policies:

   a. The Council will review its policies, plans, and regulations to proactively plan for and adapt to climate change and sea level rise. The Council will integrate climate change and sea level rise scenarios into its operations to prepare Rhode Island for these new, evolving conditions and make the state's coastal areas more resilient.
   b. The Council's sea level rise policies are based upon the CRMC's legislative mandate to preserve, protect, and where possible, restore the coastal resources of the state through comprehensive and coordinated long-range planning.
   c. The Council recognizes that sea level rise is ongoing and its foremost concern is the accelerated rate of rise and the associated risks to Rhode Island coastal areas today and in the future. Accordingly, for planning and management purposes, it is the Council's policy to accommodate a base rate of expected 3 to 5 foot rise in sea level by 2100 in the siting, design, and implementation of public and private coastal activities and to insure proactive stewardship of coastal ecosystems under these changing conditions. It should be noted that the 3 to 5 foot rate of sea level rise assumption embedded in this policy is relatively narrow and low. The Council recognizes that the lower the sea level rise estimate used, the greater the risk that policies and efforts to adapt sea level rise and climate change will prove to be inadequate. Therefore, the policies of the Council may take into account different risk tolerances for differing types of public and private coastal activities. In addition, this long-term sea level change base rate will be revisited by the Council periodically to address new scientific evidence.

350.1. General Policies

1. The Council recognizes that the changes brought by climate change are likely to result in alteration of the marine ecology and human uses affecting the Ocean SAMP area. The Council encourages energy conservation, mitigation of greenhouse gasses and adaptation approaches for management. The Council, therefore, supports the policy of increasing offshore renewable energy production in Rhode Island as a means of mitigating the potential effects of global climate change.

2. The Council shall incorporate climate change planning and adaptation into policy and standards in all areas of its jurisdiction of the Ocean SAMP and its associated land-based infrastructure to proactively plan for and adapt to climate change impacts such as increased storminess and temperature change, in addition to accelerated sea level rise. For example, when evaluating Ocean SAMP area projects and uses, the Council will carefully consider how climate change could affect their future feasibility, safety, and

effectiveness. When evaluating new or intensified existing uses within the Ocean SAMP area, the Council will consider predicted impacts of climate change especially on sensitive habitats, most notably spawning and nursery grounds, of particular importance to targeted species of finfish, shellfish, and crustaceans.

3. The Council will convene a panel of scientists biannually to advise on findings of current climate science for the region and the implications for Rhode Island's coastal and offshore regions, as well as the possible management ramifications. The horizon for evaluation and planning needs to include both the short term (10 years) and longer term (50 years). The Science Advisory Panel for Climate Change will provide the Council with expertise on the most current global climate change related science, monitoring, policy, and development design standards relevant to activities within its jurisdiction of the Ocean SAMP and its associated land-based infrastructure to proactively plan for and adapt to climate change impacts such as increased storminess, temperature change, and acidification in addition to accelerated sea level rise. The findings of this Science Advisory Panel will be forwarded on to the legislatively-appointed Rhode Island Climate Change Commission for their consideration.

4. The Council will prohibit those land-based and offshore development projects that based on a sea level rise scenario analysis will threaten public safety or not perform as designed resulting in significant environmental impacts. The U.S. Army Corps of Engineers (ACOE) has developed and is implementing design and construction standards that consider impacts from sea level rise. These standards and other scenario analysis should be applied to determine sea level rise impacts.

5. The Council supports the application of enhanced building standards in the design phase of rebuilding coastal infrastructure associated with the Ocean SAMP area, including port facilities, docks, and bridges that ships must pass under.

6. The Council endorses the development of design standards for marine platforms that account for climate change projections on wind speed, storm intensity and frequency, and wave conditions, and will work with the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement, Department of Interior, Department of Energy, and the Army Corps of Engineers to develop a set of standards that can then be applied in Rhode Island projects. The Council will reassess coastal infrastructure and seaworthy marine structure building standards periodically not only for sea level rise, but also for other climate changes including more intense storms, increased wave action, and increased acidity in the sea.

7. The Council supports public awareness and interpretation programs to increase public understanding of climate change and how it affects the ecology and uses of the Ocean SAMP area.

350.2. Regulatory Standards

1. Public infrastructure projects shall provide an analysis of historic and projected (medium and high) rates of sea level rise and shall at minimum assess the risks for each alternative on public safety and environmental impacts resulting from the project.

Section 360. Literature Cited

Agnew, M.D., and Viner, D. 2001. Potential impacts of climate change on international tourism. *Tourism and Hospitality Research* 3:37-60.

Allison, I., Bindoff, N.L., Bindschadler, R.A., Cox, P.M., de Noblet, N., England, M.H., Francis, J.E., Gruber, N., Haywood, A.M., Karoly, D.J., Kaser, G., Le Quéré, C., Lenton, T.M., Mann, M.E., McNeil, B.I., Pitman, A.J., Rahmstorf, S., Rignot, E. Schellnhuber, H.J, Schneider, S.H., Sherwood, S.C., Somerville, R.C.J., Steffen, K., Steig, E.J., Visbeck, M. and A.J. Weaver. 2009. The Copenhagen Diagnosis: Updating the World on the Latest Climate Science. The University of New South Wales Climate Change Research Centre (CCRC), Sydney, Australia. 60pp.

Anderegg, W.R.L., Prall, J.W., Harold, J., and Schneider, S.H. 2010. Expert Credibility in Climate Change. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 107: 12107-12109.

Anthony, A., Atwood, J., August, P., Byron, C., Cobb, S., Foster., Fry, C., Gold, A., Hagos, K., Heffner, L., Kellog, D.O., Lessis-Dibble, K., Opaluch, J., Oviatt, C., Pfeiffer-Herbert, A., Rohr, N., Smith, L., Smythe, T., Swift, J., and Vinhateiro, N. 2009. Coastal lagoons and climate change: ecological and social ramifications in U.S. Atlantic and Gulf coast ecosystems. *Ecology and Society* 14:8. http://www.ecologyandsociety.org/vol14/iss1/art8.

Attrill, M.J., and Power, M. 2002. Climatic influence on a marine fish assemblage. *Nature* 417:275-278.

Baede, A. P. M. (Ed.). 2007. IPCC Annex I: Glossary - Glossary of Terms used in the IPCC Fourth Assessment Report. http://www.ipcc.ch/pdf/glossary/ar4-wg1.pdf Accessed 14 December 2009.

Beardsley, R.C., Chapman, D.C., Brinks, K.H., Ramp, S.R., and Shlitz, R. 1985. The Nantucket Shoals Flux Experiment (NSFE79), I, A basic description of the current and temperature variability. *Journal of Physical Oceanography* 15:713-748.

Beaugrand, G., Reid, P. C., Ibanez, F., Alistair Lindley, J., and Edwards, M. 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. *Science* 296:1692-1694.

Bender, M., Knutson, T., Tuleya, R., Sirutis, J., Vecchi, G., Garner, S. and Held, I. 2010. Modeled Impact of Anthropogenic Warming on the Frequency of Intense Atlantic Hurricanes. *Science* 327:454-458.

Bird, E.C.F. 1994. Physical setting and geomorphology of coastal lagoons. In: Kjerfve, B. (ed) *Coastal Lagoon Processes.* Elsevier, Amsterdam, The Netherlands. pp. 9-40.

Bricker, S.B., Longstaff, B., Dennison, W., Jones, A., Boicourt, K., Wicks, C., and Woerner, J. 2008. Effects of nutrient enrichment in the nation's estuaries: A decade of change. *Harmful Algae* 8: 21-32.

Burgents, J.E., Burnett, K.G. and Burnett, L.E.. 2005. Effects of hypoxia and hypercapnic hypoxia on the localization and the elimination of *Vibrio campbelli* in *Litopenaeus vannamei*, the Pacific white shrimp. *Biological Bulletin* 208:159-168.

Caldeira, K. and Wickett, M.E. 2003. Anthropogenic carbon and ocean pH. *Nature* 425:365.

Canadell, J.G., LeQuéré, C., Raupach, M.R., Field, C.B., Buitenhuis, E.T., Ciais, P., Conway, T.J., Gillett, N.P., Houghton, R.A. and Marland, G. 2007. Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity, and efficiency of natural sinks. *Proceedings of the National Academy of Sciences*104:18866-18870.

Carlton, J.T. 2010. *Prospective Marine and Estuarine Invasions of the New England Coast*. In preparation. March 2010.

Castro, K.M., Factor, J.R., Angell, T. and Landers Jr., D.R. 2006. The conceptual approach to lobster shell disease revisited. *Journal of Crustacean Biology* 26:646-660.

Cazenave, A., Dominh, K., Guinehut, S., Berthier, E., Llovel, W., Ramillien, G., Ablain, M., and Larnicol, G. 2009. Sea level budget over 2003–2008: a reevaluation from GRACE space gravimetry, satellite altimetry and Argo. *Global and Planetary Change* 65:83-88.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R., and Pauly, D. 2009. Projecting global marine biodiversity impacts under climate change scenarios. *Fish and Fisheries* 10:235-251.

Church, J.A. and White, N.J. 2006. A 20th century acceleration in global sea-level rise. *Geophysical Research Letters* 33: L01602.

Coastal Resources Management Council (CRMC). 2007. *The Urban Coastal Greenways Policy For the Metro Bay Region; Cranston, East Providence, Pawtucket, and Providence; An Amendment to the Providence Harbor Special Area Management Plan*. The University of Rhode Island Coastal Resources Center and The Rhode Island Sea Grant College Program, Narragansett, RI.

Coastal Resources Management Council (CRMC). 2009. Section 145.C.3 – Climate Change and Sea Level Rise. In: *The State of Rhode Island, Coastal Resources Management Program – As Amended.* pp. 1-5, Adopted 1/15/2008, Effective 3/27/2008. Coastal Resources Management Council, The Rhode Island Sea Grant College Program, Narragansett, RI.

Cobb, J.S. 2006. What's going on with our lobsters? *41°N* 3:19-24.

Codiga, D.L., and Ullman, D.S. 2010*–draft of January 2010–Characterizing the physical oceanography of coastal waters off Rhode Island: Literature review, available observation, and a representative model simulation.* Final Report Part 1 for Rhode Island Ocean Special Area Management Plan. University of Rhode Island, Narragansett, RI.

Collie, J. In prep. Long-term data reveal climate forcing the Rhode Island Sound fish community structure. In: Sound Connections: The Science of Rhode Island and Block Island Sounds. Proceedings of the 7th Annuals Ronald C. Baird Sea Grant Science Symposium. Rhode Island Sea Grant, Narragansett, Rhode Island. October 2008.

Collie, J.S., Wood, A.D. and Jeffries, H.P.. 2008. Long-term shifts in the species composition of a coastal fish community. *Canadian Journal of Fisheries and Aquatic Sciences* 65:1352-1365.

Cook, T., Folli, M, Kicnk, J., Ford, S. and Miller, J. 1998. The relationship between increasing sea-surface temperatures and northward spread of *Perkinsus marinus* (Dermo) disease epizootics in oysters. *Estuarine, Coastal and Shelf Science* 46:587-597.

Cooley, S.R. and Doney, S.C.. 2009. Anticipating Ocean Acidification's Economic Consequences for Commercial Fisheries. *Environmental Research Letters* 4:02407-02414.

Costello, J.H., Sullivan, B.K. and Gifford, D.J. 2006. A physical–biological interaction underlying variable phenological responses to climate change by coastal zooplankton. *Journal of Plankton Research* 28:1099-1105.

Crick, H. 2004. The Impact of Climate Change on Birds *Ibis* 146 (Suppl. 1):48-56.

Daunt, F., Wanless, S., Peters, G., Benvenuti, S., Sharples, J., Gremillet, D. and Scott, B. 2006. Impacts of oceanography on the foraging dynamics of seabirds in the North Sea. In: *Top predators in marine ecosystems: their role in monitoring and management*, pp. 177-190. Boyd, I.L., Wanless, S. and Camphuysen, K., (eds.), Cambridge University Press, Cambridge, MA.

Delworth, T.L. and Dixon, K.W. 2000. Implications of the recent trend in the Arctic/North Atlantic Oscillation for the North Atlantic thermohaline circulation *Journal of Climate* 13:3721-3727.

Delworth, T.L. and Mann, M.E. 2000. Observed and simulated multidecadal variability in the Northern Hemisphere *Climate Dynamics* 16:661-676.

Domingues, C. M., Church, J.A., White, N.J., Glecker, P.J., Wijffels, S.E., Barker, P.M. and Dunn, J.R. 2008. Improved estimates of upper-ocean warming and multi-decadal sea-level rise *Nature* 453:1090-1093.

Dorfman, M. and Rosselot, K.S. 2009. *Testing the Waters – A Guide to Water Quality at Vacation Beaches*, 19th Edition. July 2009. Natural Resources Defense Council, New York, NY. pp 453.

Drinkwater, K. 2005. The response of Atlantic cod (*Gadus morhua*) to future climate change. *ICES Journal of Marine Science* 62:1327-1337.

Durant, J.M., Stenseth, N.C., Anker-Nilssen, T., Harris, M.P., Thompson, P.M. and Wanless, S. 2004. Marine birds and climate fluctuations in the North Atlantic. In: *Marine ecosystems and climate variation: the North Atlantic region*, pp. 95-105. Stenseth, N.C., Ottersen, G. Hurrell, J.W., and Belgrano, A.(eds.), Oxford University Press, New York, NY.

East Providence. 2002. Strategy for Reducing Risk from Natural Hazards in East Providence, Rhode Island: A Multi-Hazard Mitigation Strategy.

Ecosystem Assessment Program (EAP). 2009. Ecosystem Assessment Report for the Northeast U.S. Continental Shelf Large Marine Ecosystem. U.S. Dept Commerce, Northeast Fish Sci Cent Ref Doc. 09-11; 61p. Available online at: http://www.nefsc.noaa.gov/nefsc/publications

Emanuel, K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*436:686–688.

Emanuel, K., Sundararajan, R. and Williams, J. 2008. Hurricanes and global warming: results from downscaling IPCC AR4 simulations. *Bulletin of the American Meteorological Society* 89:347-367.

Fabry, V.J., Seibel, B.A., Feely, F.A. and Orr, J.C. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Maine Science* 65:414-432.

Feely, R.A., Sabine, C.L., Lee, K., Berelson, W., Kleypas, J., Fabry, V.J. and Millero, F.J. 2004. Impact of anthropogenic CO_2 on the $CaCO_3$ system in the ocean. *Science* 305:362-366.

Ford, S. 1996. Range extension by the oyster parasite *Perkinsus marinus* into the northeastern United States: response to climate change? *Journal of Shellfish Research* 15:45-56.

Frederiksen, M., Edwards, M., Richardson, A. J., Halliday, N. C. and Wanless, S. 2006. From plankton to top predators: bottom-up control of a marine food web across four trophic levels. *Journal of Animal Ecology* 75:1259-1268.

Frederiksen, M., Harris, M.P., Daunt, F., Rothery, P. and Wanless, S. 2004. Scale-dependent climate signals drive breeding phenology of three seabird species. *Global Change Biology* 10:1214-1221.

Frumhoff, P., McCarthy, J., Melillo, J., Moser, S. andWuebbles, D. 2007. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions.* Synthesis report of the Northeast Climate Impacts Assessment (NECIA). 160 pp. Union of Concerned Scientists (UCS), Cambridge, MA.

Fuentes, M.M.P.B., Limpus, C.J., Hamann, M., and Dawson, J.. 2009a. Potential impacts of projected sea level rise to sea turtle rookeries. *Aquatic conservation: marine freshwater ecosystems* 20:132-139.

Fuentes M.M.P.B., Maynard, J.A., Guinea, M., Bell, I.P., Werdell, P.J., and Hamann, M. 2009b. Proxy indicators of sand temperature help project impacts of global warming on sea turtles. *Endangered Species Research Journal*9:33-40.

Fulweiler, R.W., Nixon, S.W., Buckley, B.A., and Granger, S.L. 2007. Reversal of the net dinitrogen gas flux in coastal marine sediments. *Nature* 448:180-182.

Genner, M.J., Sims, D.W., Wearmouth, V.J., Southhall, E.J., Southward, A.J. Henderson, P.A., and Hawkings, S.J. 2004. Regional climatic warming drives long-term community changes of British marine fish. *Proceedings of the Royal Society of London B: Biological Sciences* 271:655-661.

Glynn, P.W. 1988. El Nino-Southern Oscillation. *Annual Review of Ecology and Systematics* 19: 309-345.

Grebmeier, J., Overland, J., Moore, S., Farley, E., Carmack, E., Cooper, L., Frey, K., Helle, J., McLaughlin, F. and McNutt, S. 2006. A major ecosystem shift in the northern Bering Sea. *Science* 311:1461-1464.

Greene, C.H. and Pershing, A.J. 2004. Climate and the Conservation Biology of North Atlantic Right Whales: The Right Whale at the Wrong Time? *Frontiers in Ecology and the Environment* 2:29-34.

Greene, G.H., Pershing, A.J., Kenney, R.D., and Jossi, J.W. 2003. Impact of climate variability on the recovery of endangered North Atlantic right whales. *Oceanography* 16:98-103.

Hare, J.A., Alexander, M.A., Fogarty, M.J., Williams, E.H., and Scott, J.D. 2010. Forecasting the dynamics of a coastal fishery species using a coupled climate-population model. *Ecological Applications* 20:452-464.

Hare, J. and Able, K.. 2007. Mechanistic links between climate and fisheries along the east coast of the United States: explaining population outbursts of Atlantic croaker (*Micropogonias undulates*). *Fisheries Oceanography* 16:31-45.

Harley, C.D.G., Hughes, A.R., Hultgren, K.M., Miner, B.G., Sorte, C.J.B., Thornber, C.S., Rodriguez, L.F., Tomanek, L. and Williams, S. L. 2006. The impacts of climate change in coastal marine systems. *Ecology Letters* 9:228-241.

Harvell, C.D., Mitchell, C.E., Ward, J.R., Altizer, S., Dobson, A.P., Ostfeld, R.S. and Samuel, M.D. 2002. Climate warming and disease risks for terrestrial and marine biota. *Science* 296:2158-2162.

Hawkes, L.A., Broderick, A.C., Godfrey, M.H., and Godley, B.J. 2007. Investigating the potential impacts of climate change on a marine turtle population. *Global Change Biology* 13:923-032.

Hoagland, P., Anderson, D.M., Kaoru, Y. and A.W. White. 2002. The Economic Effects of Harmful Algal Blooms in the United States: Estimates, Assessment Issues, and Information Needs. *Estuaries* 25:819-837.

Holland, G. 2009. Climate change and extreme weather. In: *Climate Change: Global Risks, Challenges and Decisio*ns, 10-12 March 2009, Volume 6:092007. IOP Conference Series: Earth and Environmental Sciences, Copenhagen, Denmark..

Holland, G.J., and Webster, P.J. 2007. Heightened tropical cyclone activity in the North Atlantic: Natural variability or climate trend? *Philosophical Transactions of The Royal Society A* 365:2695-2716.

Holman, J.D., Burnett, K.G. and Burnett, L.E. 2004. Effects of hypercapnic hypoxia on the clearance of *Vibrio campbelli* in the Atlantic blue crab, *Callinectes sapidus rathbun. Biological Bulletin* 206:188-196.

Horton, R., Herweijer, C., Rosenzweig, C., Liu, J., Gornitz, V. and Ruane, A.C. 2008. Sea level rise projections for current generation CGCMs based on the semi-empirical method. *Geophysical Research Letters* 35, L02715.

Hoyos, C.D., Agudelo, P.A., Webster P.J. and Curry, J.A. 2006. Deconvolution of the factors contributing to the increase in global hurricane intensity. *Science* 312:94-97.

Hubeny, J.B., King, J.W., Santos, A. 2006. Subdecadal to multidecadal cycles of Late Holocene North Atlantic climate variability preserved by estuarine fossil pigments. *Geology* 34:569-572.

Hurrell, J.W. 1995. Transient eddy forcing of the rotational flow during northern winter. *Journal Atmospheric Science* 52: 2286-2301.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007 - The Physical Science Basis.* Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., and Miller, H.L. (eds.). Cambridge University Press, Cambridge, UK.

Intergovernmental Panel on Climate Change (IPCC). 2001. *Chapter 6 - Coastal Zones and Marine Ecosystems. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White, K.S. (eds.), Cambridge University Press, Cambridge, UK.

Jackson, J.B.C., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A., Hughes, T.P., Kidwell, S., Lange, C.B., Lenihan, H.S., Pandolfi, J.M., Peterson, C.H., Steneck, R.S., Tegner, M.J. and Warner, R.R. 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293:629-637.

Jeffries, H.P 2001. Rhode Island's ever changing Narragansett Bay. *Maritimes* 41:1-5.

Jeffries, H.P. and Terceiro, M. 1985. Cycle of changing abundances in the fishes of Narragansett Bay. *Marine Ecology Progress Series* 25:239-244.

Jenouvrier, S., Thibault, J.C., Llefont, A.V., Vidal, P.,Ristow, D,Mougin, J.L.,Brichetti, P.,Borg, J.J., and Bretagnolle, V. 2009. Global climate patterns explain range-wide synchronicity in survival of a migratory seabird. *Global Change Biology* 15:268–279

Kaschner, K., Watson, R., Trites, A., andPauly, D. 2006. Mapping World-wide Distributions of Marine Mammal Species using a Relative Environmental suitability (RES) Model. *Marine Ecology Progress Series* 316:285-310.

Keller, A., Oviatt, C., Walker, H. and Hawk, J. 1999. Predicted impacts of elevated temperature on the magnitude of the winter-spring phytoplankton bloom in temperate coastal waters: a mesocosm study. *Limnology and Oceanography* 44:344-356.

Kennedy, V.S., Willley, R., Kieypas, J.A., Cowen, J.H., Jr., and Hare, S.R. 2002. *Coastal and marine ecosystems and global climate change: Potential effects on U.S. resources.* Pew Center on Global Climate Change, August 2002. Arlington, VA.

Kenney, R.D. 2007. Right whales and climate change: Facing the prospect of a greenhouse future. In: *The Urban Whale: North Atlantic Right Whales at the Crossroads*, pp. 436-459. Kraus, S.D. and Rolland, R.M. (eds). Harvard University Press, Cambridge, MA.

Kenney, R.D. and Vigness-Raposa, K. 2009. *Marine Mammals and Sea Turtles of Narragansett Bay, Block Island Sound, Rhode Island Sound, and Nearby Waters: An Analysis of Existing Data for the Rhode Island Ocean Special Area Management Plan.* Draft Technical Report, Graduate School of Oceanography, University of Rhode Island, May 31, 2009.

Kirby, R., Beaugrand, G., Lindley, J., Richardson, A., Edwards, M. and Reid, P. 2007. Climate effects and benthic-pelagic coupling in the North Sea. *Marine Ecology Progress Series* 330:31-38.

Kirshen, P., Watson, C., Douglass, E., Gontz, A., Lee, J. and Tian, Y. 2008. Coastal flooding in the northeastern United States due to climate change. *Mitigation and Adaptation Strategies for Global Change* 13:437-451.

Kling, D. and Sanchirico, J.N. 2009. *An Adaptation Portfolio for the United States Coastal and Marine Environment. Adaptation – An Initiative of the Climate Policy Program at RFF*.June 2009. Resources for the Future, Washington, DC.

Knight, J.R., Allan, R.J.,Folland, C.K.,Vellinga, M. and Mann, M.E. 2005. A signature of persistent natural thermohaline circulation cycles in observed climate. *Geophysical Research Letters* 32: L20708.

Knutson, T.R., McBride, J., Chan, J., Emanuel, K.A., Holland, G., Landsea, C., Held, I., Kossin, J., Srivastava, A.K. and Sugi, M. 2010. Tropical cyclones and climate change. *Nature Geoscience* 3:157-163.

Koch, S. and Paton, P. 2009. Shorebird Migration Chronology at a Stopover Site in Massachusetts. *Wader Study Group Bulletin* 116:167-174.

Klein, R.W. 2010. *Informed Decisions on Catastrophe Risk, Issue Brief.* Spring 2010 Wharton Center for Risk Management and Decision Processes, Philadephia, PA.

Kraus, S.D., Pace III, R.M. and Frasier, T.R. 2007. High investment, low return: the strange case of reproduction in *Eubalaena glacialis.* In: *The Urban Whale: North Atlantic Right Whales at the Crossroads*, pp. 172-199. Kraus, S.D. and Rolland, R.M. (eds.) Harvard University Press, Cambridge, MA.

Learmonth, J.A., MacLeod, C.D., Santos, M.B., Pierce, J.G., Crick, H.Q.P. and Robinson, R.A. 2006. Potential effects of climate change on marine mammals. *Oceanography and Marine Biology* 44:431-464.

Lenton, T.M., Held, H., Kriegler, E., Hall, J.W., Lucht, W., Rahmstorf, S. and Schellnhuber, H.J. 2008. Tipping elements in the Earth's climate system. *Proceedings of the National Academy of Sciences of the United States* 105:1786-1793.

Le Quéré, C., Raupach, M.R., Canadell, J.G., Marland, G., et al. [Author list includes over twenty more names and includes lead authors only.] 2009. Trends in the sources and sinks of carbon dioxide. *Nature Geoscience* 2:831-836.

Li, Y. and Smayda, T. 1998. Temporal variability of chlorophyll in Narragansett Bay, 1973-1990. *ICES Journal of Marine Science* 55:661-667.

Lighthouse Friends. 2010. Block Island North, RI. http://www.lighthousefriends.com/light.asp?ID=40 as of 30 March 2010.

Madsen, T., and Figdor, E. 2007. *When it rains, it pours: Global warming and the rising frequency of extreme precipitation in the United States.* Environment Rhode Island Research and Policy Center, Providence, RI.

Mann, M.E., and Emanuel, K.A. 2006. Atlantic hurricane trends linked to climate change. *Eos, Transactions, American Geophysical Union* 87:233-244.

Mann, M.E., Woodruff, J.E., Donnelly, J.P. and Zhang, Z. 2009. Atlantic hurricanes and climate over the past 1,500 years. *Nature* 460:800-883.

Mathews-Amos, A. and Berntson, D.A. 1999. *Turning up the heat: How Global Warming Threatens Life in the Sea.* World Wildlife Fund and Marine Conservation Biology Institute, Washington, D.C.

McCarty J.P. 2001. Ecological consequences of recent climate change. *Conservation Biology* 15:320-331.

McMahon, C. R., and Hays, G.C. 2006. Thermal niche, large-scale movements and implications of climate change for critically endangered marine vertebrate. *Global Change Biology* 12:1330-1338.

Morris, J.A., Jr., and Whitfield, P.E. 2009. Biology, Ecology, Control and Management of the Invasive Indo-Pacific Lionfish: An Updated Integrated Assessment. NOAA Technical

Memorandum NOS NCCOS 99. 57 pp. NOAA, National Ocean Service, Beafort, NC. http://coastalscience.noaa.gov/documents/lionfish_ percent20ia2009.pdf as of 15 April 2010.

Mrosovsky, N. and Provancha, J. 1989. Sex ratio of loggerhead sea turtles hatching on a Florida beach. *Canadian Journal of Zoology* 67:2533-2539.

Munday, P.D., Dixson, D.L., Donelson, J.M., Jones, G.P., Pratchett, M.S., Devitsina, G.V., and Døving, K.B. 2009. Ocean acidification impairs olfactory discrimination and homing ability of a marine fish. *Proceedings of the National Academy of Sciences* 106:1848-1852.

Murawski, S.A. 1993. Climate change and marine fish distributions: forecasting from historical analogy. *Transactions of the American Fisheries Society* 122:647-658.

Nakicenovic, N., Alcamo, J., Davis, G., de Vries, B., Fenhann, J., Gaffin, S., Gregory, K., Grubler, A., Jung, T.Y., Kram, T., La Rovere, E.L., Michaelis, L., Mori, S., Sankovski, A., Schlesinger, M., Shukla, P., Smith, S., Swart, R., van Rooijen, S., Victor, N., and Dadi, Z.. 2000. *IPCC Special Report on Emission Scenarios – A Special Report of IPCC Working Group III.* Nakicenovic, N. and Swart, R. (eds.). 599 pp. Cambridge University Press, Cambridge, U.K.

Narragansett Bay Estuary Program (NBEP). 2009. *Currents of Change: Environmental Status and Trends of the Narragansett Bay Region*. Final Technical Draft – August 2009. 80 pp. Narragansett Bay Estuary Program, Narragansett, RI.

National Research Council of the National Academy of Science (NAS). 2008. *Impacts of Climate Change*. Committee on Ecological Impacts of Climate Change. 70 pp. National Academy Press, Washington, D.C.

National Oceanic and Atmospheric Administration/National Ocean Service (NOAA/NOS). 2008. Tides and Currents – Mean Sea Level Trend 8452660 Newport, RI. http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8452660 percent20Newport, percent20RI as of 15 March 2010.

National Research Council (NRC). 2002. *Abrupt Climate Change: Inevitable Surprises.* National Academy Press, Washington, DC.

New England Regional Assessment Group (NERAG). 2001. *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change.* New England Regional Overview. New England Regional Assessment Group, U.S. Global Climate Change Research Program, University of New Hampshire, Durham, NH.

Neumann, J.E. and Price, J.C. 2009. *Adapting to Climate Change The Public Policy Response, Public Infrastructure.* Resources for the Future, Washington, DC.

Nicholls, R. J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Château, J., Muir-Wood, R. 2008. *Ranking Port Cities with High Exposure and*

Vulnerability to Climate Extremes: Exposure Estimates. 19 November 2008 56pp. OECD Environment Working Papers, No. 1, OECD Publishing, Washington, DC.

Nixon, S.W., Granger, S., Buckley, B.A., Lamont, M. and Rowell, B. 2004. A one hundred and seventeen year coastal water temperature record from Woods Hole, Massachusetts. *Estuaries and Coasts* 27:397-404.

Nixon, S.W., Fulweiler, R.W., Buckley, B.A., Granger, S.L., Nowicki B.L. and Henry, K.M. 2009. The impact of changing climate on phenology, productivity, and benthic-pelagic coupling in Narragansett Bay. *Estuarine, Coastal and Shelf Science* 18:1-18.

Northeast Climate Impact Assessment (NECIA). 2006. *Climate Change in the U.S. Northeast. A Report of the Northeast Climate Impacts Assessment.* Union of Concerned Scientists, Cambridge, Massachusetts.

Northeast Fisheries Science Center (NEFSC). 2009. *Ecosystem Assessment Report for the Northeast U.S. Continental Shelf Large Marine Ecosystem.* Ref Doc. 09-11, 61 pp. U.S. Department of Commerce, Ecosystem Assessment Program, Silver Spring, MD.

Nye, J., Link, J., Hare, J. and Overholtz, W. 2009. Changing spatial distribution of northwest Atlantic fish stocks in relation to temperature and stock size. *Marine Ecology Progress Series* 393:111-129.

Overpeck, J.T., and Weiss, J.L. 2009. Projections of future sea level becoming more dire. *Proceedings of the National Academy of Science* 106:21461-21462.

Oviatt, C. 2004. The changing ecology of temperate coastal waters during a warming trend. *Estuaries* 27:895-904.

Oviatt, C., Olsen, S., Andrew, M., Collie, J., Lynch, T. and Raposa, K. 2003. A century of fishing and fish fluctuations in Narragansett Bay. *Reviews in Fisheries Science* 11:221-242.

Paton, P. Pers. Comm. March 10, 2010 via email regarding climate change impacts on sea birds in the Ocean SAMP Area.

Perry, A.L., Low, P.J., Ellis, J.R. and Reynolds, J.D. 2005. Climate change and distribution shifts in marine fishes. *Science* 308:1912-1915.

Pershing, A.J., Greene, C.H., Hannah, C., Sameoto, D., Head, E., Mountain, D.G., Jossi, J.W., Benfield, M.C., Reid, P.C. and Durbin, E.G. 2001. Oceanographic responses to climate in the Northwest Atlantic. *Oceanography* 14:76-82.

Pfeffer, W.T., Harper, J.T. and O'Neel, S. 2008. Kinematic constraints on glacier contributions to 21st century sea level rise. *Science* 321:1340-1343.

Phillips, M.R. and Jones, A.L. 2006. Erosion and tourism infrastructure in the coastal zone: Problems, consequences and management. *Tourism Management* 27:517-524.

PIANC - The World Association for Waterborne Transport Infrastructure (PIANC). 2009. Climate Change and Navigation. Waterborne Transport, Ports and Waterways: A Review of Climate Change Drivers, Impacts, Responses. EnviCom Task Group 3, PIANC – The World Association for Waterborne Transport Infrastructure, Brussels, Belgium.

Pilson, M.E.Q. 1998. *An Introduction to the Chemistry of the Sea.* Prentice Hall Publishing, New Jersey.

Pilson, M.E.Q. 2008. Narragansett Bay amidst a globally changing climate. In: *Science for Ecosystem-Based Management: Narragansett Bay in the 21st Century*, pp. 35-46. Desbonnet, A., and Costa-Pierce, B.A., (eds.), Springer Publishing, New York.

Pogue, P. 2005. *Rhode Island State Hazard Mitigation Plan.* Rhode Island Emergency Management Agency, Cranston, RI.

Providence. 2000. *Strategy for Reducing Risks from Natural Hazards in Providence, Rhode Island.* Prepared by S. Shamoon, L. Watson, P. Pogue, V. Lee, J. Almeida, and R. Duhaime.

Pryor, S.C., Barthelmie, R.J., Young, D.T., Tackle, E.S., Arritt, R.W., Flory, D., Gutowski, W.J., Nunes, A. and Roads, J. 2009. Wind speed trends over the contiguous United States. *Journal of Geophysical Research* 114: D14105.

Rahmstorf, S. 2007. A semi-empirical approach to projecting future sea-level rise. *Science* 315:368-370.

Rahmstorf, S., Cazenave, A., Church, J.A., Hansen, J.E., Keeling, R.F., Parker, D.E and Somerville, R.C.J. 2007. Recent climate observations compared to projections. *Science* 316:709.

Ramanathan, V. and Feng, Y. 2008. On avoiding dangerous anthropogenic interference with the climate system: formidable changes ahead. *Proceedings of the National Academy of Sciences* 105:14245-14250.

Raupach, M.R., Marland, G. Ciais, P., Le Quéré, C., Canadell, J.G., Klepper, G. and Field, C.B. 2007. Global and regional drivers of accelerating CO_2 emissions. *Proceedings of the National Academy of Sciences* 104:10288-10293.

Reynolds, A. E. 1997. *Block Island South East Lighthouse National Historic Landmark Study Maritime Heritage Program – Maritime Landmarks Light Stations.* Block Island South East Lighthouse National Historic Landmark Study, National Park Service. September 25, 1997. http://www.nps.gov/history/MARITIME/nhl/blockisl.htm as of 15 March 2010.

Richardson, K., Steffen, W., Schellnhuber, H.J., Alcamo, J., Barker, T, Kamer, D.M, Leemans, R., Liverman, D., Munasinghe, M., Osman-Elasha, B., Stern, N. and Waever, O. 2009. *Climate Change: Global Risks, Challenges & Decisions, 2nd Edition.* Synthesis Report of the Copenhagen Climate Congress, University of Copenhagen, Copenhagen, Sweden.

Ries, J.B., Cohen, A.L. and McCorkle, D.C. 2009. Marine calcifiers exhibit mixed responses to CO_2-induced ocean acidification. *Geology* 37:1131-1134.

Rose, G. 2005. On distributional responses of North Atlantic fish to climate change. *ICES Journal of Marine Science* 62:1360-1374.

Sabine, C.S., Feely, R.A., Gruber, N., Key, R.M., Lee, K., Bullister, J.L., Wanninkhof, R., Wong, C.S., Wallace, D.W.R., Tillbrook, B., Millero, F.J., Peng, T-H., Kozyr, A., Ono, T. and Rios, A.F. 2004. The oceanic sink for anthropogenic CO_2. *Science* 305:367-371.

Sala, O.E., Chapin, F.S., III, Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oesterheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M. and Wall, D.H. 2000. Global biodiversity scenarios for the year 2100. *Science* 287:1770–1774.

Sandvik, H., Coulson, T., and Saether, B. 2008. A latitudinal gradient in climate effect on seabird demography: results from interspecific analyses. *Global Change Biology* 14:703-713.

Schellnhuber, H. J. 2009. Tipping elements in the Earth System. *Proceedings of the National Academy of Sciences* 106:20561-20563.

Schubert, R., Schellnhuber, H.J., Buchmann, N., Epiney, A., Griebhammer, R., Kulessa, M., Messner, D., Rahmstorf, S. and Schmid, J. 2006. *The Future Oceans: Warming up, Rising High, Turning Sour*. German Advisory Council on Global Change, Special Report. Berlin, Germany.

Short, F.T., Koch, E.W., Creed, J.C., Magalhães, K.M., Fernandez, E. and Gaeckle, J.L. 2006. SeagrassNet monitoring across the Americas: case studies of seagrass decline. *Marine Ecology* 27(4): 277-290.

Sills, J. (ed.). 2010. Climate Change and the Integrity of Science. *Science* 5979: 653-776.

Simmonds, M. and Issac, S. 2007. The Impacts of Climate Change on Marine Mammals: Early Signs of Significant Problems. *Oryx* 41:19-25.

Smayda, T. 1998. Patterns of variability characterizing marine phytoplankton, with examples from Narragansett Bay. *ICES Journal of Marine Science* 55:562-573.

Smetacek, V. 1984. The supply of food to the benthos. In: *Flows of Energy and Materials in Marine Ecosystems*, pp. 517-547. Fasham, M. (ed.), NATO Conference Series, Plenum Press, New York, NY.

Solomon, S., Plattner, G.-K., Knutti, R. and Friedlingstein, P. 2009. Irreversible climate change due to carbon dioxide emissions. *Proceedings of the National Academy of Sciences* 106:1704-1709.

Sorte, C.J.B. and Hofmann, G.E. 2004. Changes in latitudes, changes in aptitudes: *Nucella canaliculata* (Mollusca: Gastropoda) is more stressed at its range edge. *Marine Ecology Progress Series* 274:263-268.

Sorte, C.J.B., Williams, S.L. and Carlton, J.T. 2010. Marine range shifts and species introductions: comparative spread rates and community impacts. *Global Ecology and Biogeography*, In press.

Sparks, T. and Mason, C. 2001. Dates of Arrivals and Departures of Spring Migrants taken from the Essex Bird Reports 1950-1998. *Essex Bird Report* 1999:154-164.

Sparks, T., Roberts, D., and Crick, H. 2001. What is the Value of First Arrival Dates of Spring Migrants in Phenology? *Avian Ecology and Behaviour* 7:75-85.

Stachowicz, J.J., Terwin, J.R., Whitlatch, R.B. and Osman, R.W**.** 2002a. Linking climate change and biological invasions: ocean warming facilitates nonindigenous species invasions. *Proceedings of the National Academy of Sciences* 99:15497-15500.

Stachowicz, J.J., Fried, H., Osman, R.W. and Whitlatch, R.B. 2002b. Biodiversity, invasion resistance, and marine ecosystem function: reconciling pattern and process. *Ecology* 83:2575-2590.

Sullivan, B., Van Keuren, D. and Clancy, M. 2001. Timing and size of blooms of the ctenophore *Mnemiopsis leidyi* in relation to temperature in Narragansett Bay, Rhode Island. *Hydrobiologia* 451:113-120.

Sullivan, B.K., Costello, J.H. and Van Keuren, D. 2007. Seasonality of the copepods *Acartia hudsonica* and *Acartia tonsa* in Narragansett Bay, RI, U.S.A during a period of climate change. *Estuarine, Coastal and Shelf Science* 73:259-267.

Taylor, D. 2003. Size-dependent predation on post-settlement winter flounder, *Psuedopleuronectes americanus* by sand shrimp, *Crangon septemspinosa*. *Marine Ecology Progress Series* 263:197-215.

The Royal Society (TRS). 2005. *Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide*. The Royal Society, London, UK.

Thompson, D.W.J. and Wallace, J.M. 1998. The arctic oscillation signature in the wintertime geopotential height and temperature fields. *Geophysical Research Letters* 25: 1297-1300.

Titus, J.G., and Richman, C. 2001. Maps of lands vulnerable to sea level rise: modeled elevations along the U.S. Atlantic and Gulf coasts. *Climate Research* 18:205-228.

Transportation Research Board (TRB). 2008. *Potential Impacts of Climate Change on U.S. Transportation.* Committee on Climate Change and U.S. Transportation. National Research Council of the National Academies, National Academy of Sciences, Washington, DC.

U.S. Environmental Protection Agency (U.S.EPA). 2008a. *Effects of climate change for aquatic invasive species and implications for management and research*. EPA/600/R-08/014. 337 pp. National Center for Environmental Assessment, Washington, DC. Available from the National Technical Information Service, Springfield, VA.

U.S. Environmental Protection Agency (U.S.EPA). 2008b. *Planning of Climate Change Impacts at U.S. Ports.* 13 pp. White Paper from the Office of Policy, Economics and Innovation – Sector Strategies Division in partnership with the American Association of Port Authorities, Washington, DC.

U.S. Fish and Wildlife Service (U.S.FWS). 2010. *State of the Birds: 2010 Report on Climate Change*. 32 pp. Cornell Lab of Ornithology, Ithica, NY.

U.S. Global Change Research Program (U.S.GCRP). 2009. *Global climate Change Impacts in the United States*. Karl, T.R., Melillo, J.M. and T.C. Peterson. (eds.). 188 pp. Cambridge University Press, New York, NY.

United Nations Environment Programme (UNEP). 2009. *Climate Change Science Compendium.* McMullen, C.P. and J. Jabbour. (eds.). 68 pp. United Nations Environment Programme, Washington, DC.

Vallee, D. and Dion, M. 1996. *Southern New England Tropical Storms and Hurricanes: A ninety-seven year summary 1900-1996 including several early American hurricanes*. National Weather Service Forecast Office, Taunton, MA.

Vellinga, P., Katsman, C., Sterl, A., Beersma, J., Hazeleger, W., Church, J., Kopp, R., Kroon, D., Oppenheimer, M., Plag, H., Rahmstorf, S., Lowe, J., Ridley, J., von Storch, H., Vaughan, D., van de Wal, R., Weisse, R., Kwadijk, J., Lammersen, R. and Marinova, N. 2008. *Exploring the high-end climate change scenarios for flood protection of the Netherlands: an international scientific assessment. International Scientific Assessment.* 162 pp. KNMI, Wageningen, the Netherlands.

Walther, G., Roques, A., Hulme, P.E., Sykes, M.T., Pyšek, P., Kühn, I., Zobel, M., Bacher, S., Botta-Dukát, Z., Bugmann, H., Czúcz, B., Dauber, J., Hickler, T., Jarošík, V., Kenis, M., Klotz, S., Minchin, D., Moora, M., Nentwig, W., Ott, J., Panov, V.E., Reineking, B., Robinet, C., Semenchenko, V., Solarz, W., Thuiller, W., Vilà, M., Vohland, K., and Settele, J. 2009. Alien species in a warmer world: risks and opportunities. *Trends in Ecology and Evolution* 24:686-693.

Wanless, S., Frederiksen, M., Daunt, F., Scott, B.E., and Harris, M.P. 2007. Black-legged kittiwakes as indicators of environmental change in the North Sea: evidence from long-term studies. *Progress in Oceanography* 72:30-38

Wanless, S., Harris, M.P., Redman, P. and Speakman, J. 2005. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. *Marine Ecology Progress Series* 294:1-8.

Watanabe, M. and Nitta, T. 1998. Relative impact of snow and sea surface temperature anomalies on an extreme phase in winter atmosphere circulation. *Journal of Climate* 11: 2837-2857.

Webster, P.J., Holland, G.J., Curry, J.A., and Chang, H.-R. 2005. Changes in tropical cyclone number, duration and intensity in a warming environment. *Science* 309:1844–1846.

Whitehead, H. 1997. *Sea surface temperature and the abundance of sperm whale calves off the Galapagos Islands: implications for the effects of global warming.* Report of the International Whaling Commission 47: 941-944

Yin, J.H. 2005. A consistent poleward shift of the storm tracks in simulations of 21st century climate. *Geophysical Research Letters* 32: L18701, DOI:10.1029/2005GL023684.

Yin, J., Schlesinger, M.E. and Stouffer, R.J. 2009, Model projections of rapid sea-level rise on the northeast coast of the United States. *Nature Geoscience* 2:262-266.

Zhang, X.., Zwiers, F.W., Hegerl, G.C., Lambert, F.H., Gillett, N.P., Solomon, S., Scott, P.A. and Nozawa, T. 2007. Detection of human influence on twentieth-century precipitation trends. *Nature* 448:461-465.

Chapter 4: Cultural and Historic Resources

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Section 400. Introduction

1. In Rhode Island, historical uses of the ocean and its resources have resulted in a rich and diverse array of cultural resources underwater and in the coastal zone. These resources provide cultural, educational, recreational, environmental, and economic services that humans want and need. The significance, sensitivity, and non-renewable nature of cultural and historic resources and the special services they provide make them a challenging and important aspect of the Ocean SAMP process.

2. Through maintenance of oral traditions and unbroken cultural practices, indigenous people in Rhode Island have retained an active cultural connection to parts of the Ocean SAMP study area and adjacent coastal places for thousands of years. Located at one of the historic maritime crossroads of New England and what was becoming known as the "New World," the study area has seen five centuries of increasingly intensive uses beginning with the arrival of Europeans in North America. Today commercial fishing, recreation, and transportation are among the principal activities.

3. Whether characterized by historians, archaeologists, or cultural practitioners as districts, sites, buildings, objects, or landscapes, cultural resources reflect thousands of years of human use of the Rhode Island marine environment. Submerged pre-contact tribal landscapes and historic shipwrecks, two of the most significant marine categories, have no direct parallels on land and yet have the greatest potential to add substantially to understanding Rhode Island's past. These resources also contain ecological as well as cultural and historical information, and many are integrated into marine ecosystems as structures or as parts of the ocean floor environment. Submerged archaeological sites and landscapes are non- renewable—once gone they cannot be restored.

4. While the Ocean SAMP addresses the offshore environment, and generally does not include the adjacent coastal areas, this chapter includes both submerged cultural and historic resources within the study boundary as well as an inventory of onshore cultural and historic resources within view of the study area. The viewsheds from onshore properties with cultural, historical, or tribal significance have a relationship with the Ocean SAMP study area and visual impacts to these properties must be considered.

5. The documentation of cultural and historic resources in this chapter represents information compiled at the time of the Ocean SAMP's completion and should be used as a reference point for activities. Because of its far-reaching nature, efforts have been made to include a great deal of detailed information, rather than to risk missing potential impacts or issues by cutting it down too significantly. This chapter is deliberately structured to facilitate the incorporation of additional knowledge, new information, discoveries, and identification of culturally or historically significant landscapes, sites, or structures. Coordination and consultation with the relevant state, federal, and tribal contacts/agencies will be necessary.

Section 410. Historic Contexts and Cultural Landscapes of the Ocean SAMP Area

1. For thousands of years, people have lived along the coast of Rhode Island and ventured on its waters. From the time the shoreline as we know it today stabilized around 7,500 years ago, the ancestors of today's Narragansett Indian Tribe established large settlements along the coastline of Narragansett Bay, around the salt ponds of the south shore of the mainland and on Block Island. Native American archaeological sites are located in the vicinity of the coast, and maritime resources played an important role in the lives of native people (RIHPHC 2002).

2. The Native Americans were followed by European colonists, who were attracted to and found plentiful natural resources in coastal areas, much in the way that today, worldwide, more and more people are moving into the coastal region within 50 miles of where the land and water meet. Social, economic and military activities and their associated infrastructure have left their mark on the Ocean SAMP region, and continue to bring additional developmental pressures year by year.

3. The following sections describe the known and potential cultural resources of the study area in terms of the specific historic contexts in which the resources were created. These contexts are defined by chronological period, by historical theme and by geographical area. In recognition of the extent to which human activities in the study area have been shaped by particular aspects of its geography, a number of these contexts, both marine and land-based, are described as "cultural landscape contexts." The use of cultural landscape contexts also recognizes that different cultures or user groups may interpret history and value places in different but equally valid ways.

4. Rhode Island has a long and valued tradition of studying and preserving historical and cultural heritage on land. The Ocean SAMP represents the first comprehensive effort to study the state's underwater and maritime cultural heritage outside of Narragansett Bay. Consequently, the contexts for maritime heritage offer more detail than the terrestrial contexts. (A fuller account of land-based resources can be found in the Rhode Island Historical Preservation and Heritage Commission's published survey reports for each of the individual towns.) The maritime contexts, which describe a new frontier for historic preservation in Rhode Island, vary significantly in their depth and detail. These differences represent the current state of knowledge about cultural heritage resources in the Ocean SAMP area. They identify gaps in survey coverage, historical knowledge, and cultural perspectives that researchers and prospective developers will need to address in the future. As knowledge and data relating to the Ocean SAMP continue to grow, the CRMC will update these landscape contexts, or include new ones if required.

5. Only those aspects of Rhode Island history that influenced the Ocean SAMP area in major ways are covered in this analysis of cultural resources. Should significant new themes or cultural perspectives emerge in the future, new landscape contexts may be added to the Ocean SAMP document in future revisions.

410.1. Pre-Contact Geological History

1. During the last major advance of continental glaciers in North America, known as the Wisconsinan Glaciation, or Wisconsin Glacial Episode, much of northern North America was covered with ice (the Laurentide and Cordilleran ice sheets). Around 24-26,000 years ago, when the ice reached it final southward maximum, the edge of the Laurentide glacier was located about three miles south of Block Island in the Ocean SAMP area. The margin of Laurentide ice extended westward across northern Long Island to northern New Jersey and then to the Midwest. The margin extended eastward to Martha's Vineyard and Nantucket and then to Georges Bank. Because of the vast quantity of water frozen in the glacial ice, the sea level at that time was approximately 120-130 meters lower than it is at present (RIHPHC 2002).

2. A tundra landscape, cold but habitable, would have extended to approximately the edge of the Continental Shelf. As the glacier retreated, the meltwater caused sea levels to rise, inundating this formerly dry land. During the glacial melting, freshwater lakes dammed by ice and/or glacial deposits were formed, including a large lake in what is now Block Island Sound. The glacial lakes in Block Island and Rhode Island Sounds had probably drained by 15,500 years ago, and perhaps earlier, when the rebound of the land began due to the land being uplifted because of the release of the weight from the overlying glacial ice (RIHPHC 2002).

3. It is possible that the ancestors of today's Native American tribes were living in this landscape, although no direct evidence for submerged terrestrial sites has been found in the northeast to date. The oldest known sites in North America date back to before 13,500 years ago—when the glaciers had already pulled back from what is now Rhode Island, but before sea levels had risen to their modern level. The oldest artifacts found in Rhode Island are several thousand years more recent. These sites and artifacts, however, are simply what has survived and what has been found—there may well be older sites, submerged by the glacier meltwater, located offshore (RIHPHC 2002).

4. Reconstructing the paleo-landscape is the essential first step to predicting the locations of submerged terrestrial sites. Section 420.3 of this chapter discusses paleo-geographic landscape reconstruction in more detail. The process of inundation was not a constant, gradual influx of water. Catastrophic landscape changes probably occurred as the dams of the freshwater lakes failed, and their waters flooded out. The rate at which the sea level rose changed over time, with periods of dramatic inundation. These turbulent processes, coupled with storm activity and the normal movement of tides and currents, have probably destroyed many submerged terrestrial sites. However, under certain circumstances, such as rapid flooding of post-glacial lake shores in closed depressions, drowned terrestrial landscapes (and any archaeological deposits contained therein) may have survived. Paleosols—ancient soils preserved beneath an overburden of later sediment—have been found through coring in nearby Nantucket Sound. Where such paleosols survive, evidence for human occupation might also be found (RIHPHC 2002).

5. Geological reconstructions allow archaeologists to identify places where submerged sites may have survived. In terrestrial archaeology, predictive models based on the locations of known sites and on patterns of land use are used to identify areas considered sensitive

for archaeological resources. Such models can provide some guidance in predicting the location of submerged sites—access to freshwater resources, for instance, appears to be a constantly useful predictive factor. However, given the relative paucity of data about the early paleo-Indian use of the landscape, constructing useful models for the human choices that would have played a role in site location is still an ongoing process (RIHPHC 2002).

410.2. Narragansett Tribal History

1. Understanding human settlements within and adjacent to the Ocean SAMP region before European colonization provides guidance into the potential for culturally relevant landscapes and sites in the study area. The indigenous people of New England belonged to many tribes, each with its own history. This section provides a historical context produced by the Narragansett Indian Tribe ("Tribe"), the oldest known and still-living native culture in the State of Rhode Island.

2. The Narragansett Indian Tribe is the federally recognized and acknowledged Native American tribe in Rhode Island. Archaeological evidence and oral history of the Narragansett people suggest the Tribe's existence in the region for at least 30,000 years (Brown, pers. comm.).

3. The Narragansett Indian Tribe has maintained its cultural traditions and tribal organization in Rhode Island since the Tribe's first contact with European settlers in the early 17th century. The Narragansett Indian Tribe was recognized by the U.S. government in the Trade and Intercourse Act of 1790. In response to an action taken by the state of Rhode Island to "detribalize" the Narragansetts in 1880, the Narragansett Indian Tribe made continued efforts to challenge this State action during the 20th century, and attained formal federal acknowledgment as a Sovereign Nation and federally recognized and acknowledged Tribe of the United States government on April 11, 1983 (25 CFR § 83). Rhode Island state legislation was enacted in 1985.

4. Dr. Ella W.T. Sekatau is the present-day contact and source of oral history for the Narragansett Indian Tribe. Since the 1970s, Dr. Sekatau has served as the ethnohistorian for the Tribe, and she has been learning Narragansett history, language, religion, and medicine since birth. In addition, Dr. Sekatau is an approved Medicine Woman for the Tribe (Herndon and Sekatau 1997).

5. On April 15, 2010, Dr. Sekatau provided the following account of the Narragansett Indian Tribe's oral history and traditions, specifically for inclusion in the Ocean SAMP document. In addition, Dr. Sekatau provided the following references found in Section 450 of this chapter (Herndon and Sekatau 1997; Herndon and Sekatau 2003a; Herndon and Sekatau 2003b; Sekatau 1970; and Sekatau-Pottery).

    a. **Traditional Indian Prayer:** *Kawtantawwit taubotneanawayean wutche wameteanteaquassinish. Mishquatch maugoke*. Thank you Great Spirit for all the things that Mother Earth gives.

b. This historical report about the Narragansett People is short and will be accompanied by five publications, two published reports by Dr. Ella Wilcox Sekatau and Dr. Ruth Wallis Herndon and one report edited by Colin G. Calloway and Neil Salisbury. The report is not a page-by-page account; it simply talks about the activities of the Narragansett People of the past and their existence today, which in some cases has changed very little depending on the subjects, or changed a lot because of the circumstances of colonization for the past four hundred years. The author sometimes becomes very personal, but most times tries to avoid a line-by-line or detailed daily account. Any reader who is interested can take the references listed in the notes of the accompanying publications for more research or contact the Narragansett Indian Tribe Historic Preservation Office (NITHPO).

c. Explanations must be given with the uses of the words history and pre-history; historical and pre-historical. What has happened and what is happening with the Narragansett Indian people is ongoing history. The word pre-historical refers to the coming of colonist to this part of the world for the past five hundred years and their recordings. Numerical chronologies in many cases deny the evolution of people this side of the world.

d. The people who have become known as Narragansett returns to this area after going South with the stages of recession of the last Ice Age called the Paleoarchaic Era by some writers. For the next many thousands of years, the people hunted very large animals (i.e. and the varieties of smaller animals on the land). In this particular area there were deer, elk, moose, two types of bison, three kinds of bear, there were brown bear, black bear, and grizzly bear. There were rodents of all types and the felines and the canines. As long as these specimens lasted they were hunted by the people. The weather conditions dictated when the mammoth died out and the walrus no longer came this far south.

e. Enishkeetompauog minnimuussinnock people of the small bays and inlets and inland in what was to become known as Southern New England, Southeastern Maine, New Hampshire, Vermont, and Long Island, Southeastern New York and coastal wise South to what was to become known as Delaware had a lifestyle which was stable until colonization from people of other parts of the world. All of these areas and groups of the indigenous people were later called by names mostly by geographical areas were under the auspices of the royal sachems of the Narragansett Nation, mainly the five larger groups were Pawtuxet, Pocasset, East Niantic, West Niantic, Kauweesett, and Shauwommett which comprised the Narragansett nation.

f. When the first contacts and colonization of the early 17th century involved the nation of royal sachems of the land called by others as Narragansett, Canonicus, and Miantonomoh, were the older and younger sachems over all the groups before-mentioned. Many or most times depending upon the acquaintances or introductions to geographical areas, water courses, land, elevations, or weather conditions at certain times of the yearly habitation by non Indians were names referred to groups living there. This land covered by a very large area which included all what was to become known as Southern New England states, Long Island, Southeastern New York, and Southeastern Maine, New Hampshire, and Vermont.

g. After colonization of the 15th, 16th and 17th centuries, the colonial writers wrote and identified groups convenient for them to remember and identify as the centuries passed. We the Narragansett People know that our peoples evolved on this side of the world and did not come from elsewhere. Our existence depended upon what the territories embraced directly from the salt water, marshes, and sweet water ways that began from inland springs, ponds, and seeps. What the Earth Mother produced which included animal, fowl, amphibian, fish and the great varieties of plant life was used for the survival of people who lived according to the four main directions and the alternate direction of North, East, South, West, Northwest, Southeast, Southwest, and Northeast. The four seasons, the tides, the weather patterns of each season and the availabilities of survival materials for food, shelter, tools, weapons, utensils, decorations, and clothing all contributed to the native lifestyles.

h. The native wild turkeys were the beautiful bronze which weighed up to fifty pounds and the direct coastal and island white turkeys with a little black trim on the tails and wings in the Narragansett Bay Area. No one has written much history about the Blue Grouse in this area as well. The Blue Grouse did not do much flying so they got killed off early. They weighed in at twenty pounds. At the same time they were mentioned someone mentioned also the Dodo birds of another coastal area (the Island of Mauritius). The disappearance of these two kinds of fowl is a prime example of over harvesting. The disappearance of the blue grouse, native pidgeons, bison, as well as other fowl animals and plants contributed to destruction of ecosystems for the past four hundred years in the northeast. Narragansett have continued to use bird feathers of different kinds forever. The fur and wampum trade went hand and hand using local resources. The beaver, mink, muskrat, grey and red foxes, the three types of bear, catamount, lynx, raccoon and wolf which used to be plentiful until trade and shipments back to European countries either reduced the numbers or wiped out species. The wolf, lynx, and two species of bear are gone. Surprisingly, birds like the wild turkey were in great demand for food as well as their feathers for decoration. The local ducks and Canadian Geese which were good for food and used for some decoration we still have quantities of these fowl. The massive millions of native pigeons were used for food and sport so much that they no longer exist. Narragansett males in a few families still trap minks and muskrat, skunk and raccoon. In most cases they no longer eat the meat. They just sell the pelts. However there are many men non-Indian hunters and trappers. The beaver which disappeared in southern New England have been reintroduced in some areas.

i. Americans now raise domestic fowl like chickens, turkeys, geese which do well along coastal regions and inland. The stands of oak, walnut, pignut, chestnut, and black walnut trees furnished food for people and animals. Refer and research the places and towns in Washington County of what became known as Wickford, North Kingstown, Wakefield, Narragansett, and Westerly all of these places had access to the saltwater. Celebrations with other tribes took place at certain places specifically in days of the good month of late spring through harvest time when there was time for visiting and trade locally and inland. The Narragansett harvested great quantities of shellfish; oysters, quahaug, soft-shell steamers, lobster, razor clams, and four kinds of crab (blue shell, spider, rock and humpback), mussels, snails, and conch. All of these

shellfish depending on the size were smoked and dried for local use and trade. The Narragansett had a thriving business for shellfish for food and shellfish wampum making and decoration.

j. Many inland tribes of Indians traded their goods like copper, different kinds of stone for tool making for shells that they fashioned into wampum strings and belts which told tribal histories as did the Narragansett. Today the wampum decorations are made by Narragansett, many other Indians, and non-Indians for very successful business ventures. Surprisingly, since the 17th century the use of shell money was money needed by the Dutch, English, and Portuguese because many did not have the use of money from Europe. The uses of shell pearls found inside of oysters and sometimes clams and quahaug have prevailed for all the centuries. Naturally other kinds of shellfish have been used in many ways for decorations and recording by the indigenous natives and Americans.

k. Unlike the European colonists, the females and males were equals and were given that respect. Each had its respective responsibilities, jobs, duties, and needs. The women were responsible for the living quarters of summer individual family wigwams which were called wetu, for one building, or wetuomuck, for many buildings, because of the round shape of these family units. They were not placed close to each other. There was always space for gardens which the women took care of and enough undeveloped land in between to be able to have firewood and where small animals could be found. Only the garden areas where cleared for planting close by. The women were responsible for the care and early training of children with help of elders. The males were responsible for the hunting, most fishing, building of the framework for the summer and winter longhouses, and the brush fences around the summer homes and the great high palisades around the permanent/winter homes called longhouses (Who lived in the long houses? Everyone related to you on your mother's side of the family). The men were responsible for making the dugout and tree bark canoe for water travel inland and other places. The brush fences and high palisades were there to protect the homes from the larger types of animals which we will discuss later. The men were responsible for protecting people once colonization began. There were varied dialects spoken by the people. Man speaking to man was one dialect, woman speaking to woman was another dialect and then a general dialect was used by all when they were all together.

l. But a real change of male thinking took over after the males were cheated out of their jobs of defending land areas and water areas for trade, travel to visit other groups, to meet with government relationships. The governmental relationships we discuss here were with other tribes and their royal families. Any disagreements or disputes were settled in what we call today a democratic way. The introductions of new restrictions were adopted as well by other indigenous people in what became known as New England. In some cases, the males started to act like the colonist males. The colonists did not recognize women and after the native males had been cheated out of the normal things that they did, they had to feel important. However on the back of their minds was the thought that the women were the backbones of all groups. Most Indian males still believe in that fact today that women are the backbones of most native families, which is a fact.

m. The European invaders took over by wars and the diseases which were brought to this part of the world that killed the indigenous natives by the millions in North America, Mexico, Central and South America. The native people had no built in immunities from experiences with those diseases ever having been here. This is one of the logical explanations of the fact that our peoples evolved on this side of the world and did not migrate from elsewhere.

n. The salt waters gave much to the natives. The marshes around the sweet and the salt water, and even mixtures of sweet water joining saltwater, played a most important role in the existence in the Narragansett Indian peoples. They utilized saltwater fish, mammals, and shellfish as well as the sweet water fish, shellfish, and mammals. These creatures were used for food, clothing, parts of decorations, and shelter.

o. Plant vegetation products were not only used for food, but for clothing and shelter as well. We the Narragansett People are people who used the many trees and aquatic plants for shelter, protection, food, and decorations and medicine. Today some of the Narragansett still harvest certain plants. Bulrush from the freshwater marsh areas was used for interior house mats for walls. Cattails were used for exterior summer houses walls and fill for middle walls of the permanent or winter/longhouses. Trees growing in the coastal areas were used for framework of summer houses as well as the winter longhouses (maple, oak, white cedar, red cedar, chestnut, and walnut to mention a few that played important parts of buildings, interiors and exteriors). Cedar bark was used for canoes, mat making, twine making, clothing, black dye, disposable diapers, and sanitary napkins or rope and tump lines. White oak bark could be eaten also as well as sassafras for tea and medicine. The products of local nut trees in the coastal area; oaks, butternut, three types of walnuts, hazelnuts, were used for food and oils.

p. The so-called Woodland Era began around 1500 BC. According to modern writers, conclusions that the Narragansett nation's people had become more dependent on products from maritime resources is questionable. Questionable because the return north of the people after the recession of the Ice Age brought new ways of survival from the Southern climates. Gathering continued and agriculture of maize, beans, and squash called the Three Sisters added to dietary practices. The additional practice of raising the Three Sisters crops made life easier in the seven month preparation for the six months needs. Late March to early October was called the seven good months by the people and late October to early March were called the six months of need. Remember we are talking about the thirteen months on the Indian calendar, 28 day moon cycles during the four seasons of Spring, Summer, Fall, and Winter. Thirteen celebrations of Thanksgiving are still celebrated ceremonial by the tribal people with prayer, dancing, drumming, singing, and feasts. Activities of early, middle and late fall and winter are still practiced; i.e. the fish runs, the hunt of Indian summer, January thaw of harvesting acorns from the white oak trees, and the harvest from maple and butternut trees to make sugar in late April and early spring.

q. The very important fish runs for the Narragansett happened when the smelts the ale wifes herrings, buckies, shad, Atlantic salmon, carp, some trout which go from saltwater to fresh or the sweet water to spawn. We do not get the Atlantic salmon

runs today but the author of this history remembers catching a salmon at the Misshannock Horseshoe Falls when she was eleven or twelve years old. She thought it was extra large dace. The smelts and the ale wife/herring and shad are prey and were followed by the great bass and lamprey, which ate them up. The Narragansett and ale wife/herring fish that we call buckies were used to fertilize the ancestors' gardens until the colonists came and took over and forbade the Indians to take the salmon. With the decline of Atlantic salmon and the forbidding of Indians fishing, hunting and using the lands of their ancestors, the taking of ale wife/herring, called buckies, was allowed because they were boney fish. These fish became an important part of the Narragansett diet in the 18th and 19th century and smoked buckies are a Narragansett Indian specialty. Some of the men and women still smoke and dry fish, eels, and shellfish.

r. During the 17th century writers started classifying some of the indigenous natives by what the writers assumed. Samuel Champlain started writing us Narragansett up as Algonquin because of the similarity of lifestyles - a similarity of customs and dialect, celebration, burial practices, seasonal ceremonials and use of the salt water and sweet water and coastal travel as well as materials for survival and foods.

s. The first four decades of the 17th century, European arrivals and explorers brought in disease from Europe that killed off 80-90 percent of coastal natives. That is why the Pautuxett Narragansett never went back to Pautuxett, which place became known as new Plimoth, nor the Pautuxett summer place on the South shore of Boston. The larger numbers of Narragansett were not hit by the devastation of European smallpox and other communicable diseases such as chicken poxes, measles (regular and German), diphtheria, and tuberculoses until later.

t. Indian summer is the time in the Fall of a warm up after the colorful foliage time has passed and killing frost and first freeze up comes each year. Special immense "V" shaped corrals were made in specific places sometime over a mile wide at the entrance down to fifty or a hundred feet or less at the main point of the "V". Here the men with spears and those with arrows were placed to take down all the desired animals at the opening of the "V" corral. All ages of people were placed many feet apart and their job was to beat on and make noise as much as possible at the wide part of the "V" corral to drive the animals into and through the corral. Although human habitation in Rhode Island is close to one million people, the deer population is over abundant, while other species of animals are no longer here.

u. In 1637, the Narragansett had to deal with the English in what was called the Pequadt war. The colonists were informed who the Pequadts and Mohegans were and they were from the Mahican groups up north who disagreed with their sachems. They negotiated and came South by permission of the Narragansett about a century and half before Verrazano visited the area what was to become New England. They became two separate groups and were allowed into different places because their head sachems did not agree with each other. It is not for us to judge why the Schaghticoke split themselves from the Pequadts later.

v. In 1643 there had been relatively good relations with a few of the colonists who were having many troubles of their own fighting over who was to be boss in specific places. They had meetings in what was to become known as Hartford and New Haven, and Boston and other places. One of their discussions was the forbidding Indians hunting, gathering, and trading amongst each other. Indians were being punished and were either put in the stocks or had to pay fines.

w. Roger Williams disagreed with the leading colonists regarding the Indian rights. He was going to be sent back to England however he and others ran away to Narragansett County to the place what was to become known as the State of Rhode Island and Providence Plantations. He was ill and the Narragansett nursed him back to health. He was granted land that was called Providence Plantations once he returned to England and requested permission to return to America and be in charge of a land grant.

x. In 1643, the youngest sachem of the Narragansett Miantonomoh tried to create an alliance with the English colonists which did not work; the English offered a price for Miantonomoh's head because he did not agree with colonist policies. Colonists said he was an enemy. He was captured and upon his own request he wanted a Mohegan of his own status to commit the murder. Writers now claim that there was a long war between the Narragansett and the sub-tribal division of the Mohegan through 1650s. This was not true. There was however a disagreement with the governing bodies of the Narragansett and the Mohegan. The Mohegan said it would be easier if he went along with the colonist ways . The group still under the Narragansett said, "No."

y. The 1660s brought disagreement between Narragansett males and females alike. Some of the Royal Families of Ninigretes decided on mortgaging off tracks of land under them to pay the fines demanded by the colonists. Queen Esther, the sister of Tom Ninigrete, and other royal squaw sachems said, "No." Here we must remember the extensive lands under the royal sachems that comprise the Narragansett Nation. In the colonial writer's records very little is said about the women sachems because women were supposedly chattel according to the English lifestyle. Only when there was direct conflict with the European colonists were the women sachems spoken about. An example is Oussamequin Massasoit's wife. Fifteen years of disruptions and disagreement followed. The sons of Oussamequin wanted to gain back uses of their summer places on Cape Cod and their winter places inland around what was to become known as Taunton and Fall River. The colonists killed the older brother by poisoning him when they called him to meet in Boston. The younger brother Pomettacomett called by the colonist King Phillip sent his families to a Narragansett winter camp which moved from the permanent place to where the University of Rhode Island now is. Many families moved to the Great Swamp Area in South Kingstown, taking the King Phillip families with them. It was a custom of the indigenous natives to send their people to places they considered safe during conflicts.

z. At that time of unrest, some of the Medicine Families and the families of the War Chief Tattazone moved in to the areas that became known as parts of Connecticut, Massachusetts, New Hampshire and New York prior to the war. They moved into

areas where there was no colonist involvement yet. Because of this action of King Phillip, the colonists demanded that King Phillip's families be turned over to them as war hostages. When the Narragansett sachems said no, the Narragansett were drawn into the war. Most Narragansett sachems agreed that no Wompanoag would be given and the fighting man went on their own local fights to gain back lands that had been taken over in parts of Rhode Island. While the majority of Narragansett sachems were against what the colonists were up to and doing, the sachem Ninigrete was dealing with the colonists. While the others fought for the return and privileges and lands, Ninigrete and his associates stayed in the Watch Hill area and raised not a hand against the colonists because the colonists promised him the king's crown to be in charge of the remainder of Indians in the area.

aa. One great winter camp was in the area where the University of Rhode Island is. In 1675 when the colonist went to the great winter camp area no one was there. The colonist militia did find an Indian man who had turned Christian. They told him that it was his duty to tell them where the camp that held the King Phillip families was or he was to be killed. Oral history knows him only as Peter. Peter became a traitor as much as Ninigrete is considered to have been. Peter led the colonist militia to the winter camp in the Great Swamp in South Kingstown. The new camp was not complete because of the severe weather and a winter blizzard and freeze over. On the side where the deepest water was frozen over, that winter camp housed about 600 wigwams filled with old men, women, and children. The colonist militia finally gained entrance on the unfinished palicide place and set fire to many wigwams, driving the occupants out of the camp area killing many and winning the confrontation against the old men, women, and children. To this day the exact island in the great swamp that housed that winter camp of Narragansett and Wompanoag old men, women, and children where the massacre happened is unknown (one thing we have to relate here is that Indians did not kill the old, the women and children primarily as did the Europeans). Although old Narragansett of some families knew the location, we were told by elders that it was best not to know because the place was sacred. Albert and Lawrence knew the place but neither man told us children. Once in awhile an artifact would be given to us and we were told it came from the Great Swamp Massacre Area. Their voices would lower and the eyes would squint and snap and the mouth would turn down at the corners accompanied by guttural sounds from the throat. Sometimes they would utter a war-whoop and do a few war dance steps.

bb. 1667-1675 was a very devastating time for the Narragansett. History has been written by the colonial records of the places where the natives were killed off. The European custom of paying an amount for men, women, and children scalp locks was paid to the killers. The Narragansett as well as others in New England suffered great losses. Only those who agreed with the colonists survived. In 1705 Ninigrete was awarded chiefdom. While given recognition he granted specific land and political control to the Rhode Island Assembly and got put in charge of the reservation. Land that was formerly under the auspices of the Royal Sachems of the Narragansett Nation was reduced drastically everywhere.

cc. The practice of indentured service became the rule. Adults mostly all female became servants and indentured their children; twenty-two years for boys and nineteen year for girls. This indenture was a form of slavery for the Narragansett. The town records started another form of genocide against the Narragansett as well as other indigenous natives. The recordings of many of the children were written as "mustee," "molatto," "negro," or "black". It all depended on who was doing the recording.

dd. In 1746 some of the Narragansett on and off reservation started using the Christianity as a second way to worship God. They listened to preachings and put their "X" on written papers they did not even understand. This was a form of control the colonists exercised with people who did not understand the English language and spoke very little of it. The meeting house/church was established. The people established and ordained Samuel Niles as their preacher. Members of the Medicine Family never became Christians. We learned about the concepts of foreign religions but never embraced them to this day. Today we Narragansett have the traditional and Christian parts in all weddings, burials, and tribal meetings. However, ancient ceremonies are kept traditional. Our powwows have a combination of ancient and American revolutionized activities.

ee. The Narragansett Indian meeting house/church was established and built around 1750 after the reformation which was said to be under a man called Mr. Park since 1741. The first minister was James Simons and after him Samuel Niles was ordained and took over the responsibility of preaching with eloquence to the Narragansett and visitors. A fire destroyed the wooden structure which was twenty eight feet wide and forty feet long. In the late 1850s a stone meeting house/church was built basically using the same size and design as the wooden one in a place nearby where the old building had been built. A fire destroyed the stone meeting house/ church also which was deliberately set in 1993. Whoever put incendiary materials to help burn the interior evidently thought the destruction of the meeting house/church would destroy the Narragansett people. However, the meeting house/church was just a small part of an indigenous native group heritage. So it was rebuilt again to accommodate the Narragansett Indians as well as other Indians and friends for meetings and religious services of all kinds. The building is a place of refuge for the good of all. Today's building still has the unique architecture of the first building's two doors on the south side, windows on the east and west side and no windows on the north side.

ff. Through the passing centuries, the Narragansett people continued to celebrate the thirteen Thanksgiving celebrations that were traditional for us. The language was still spoken although this was one of the things forbidden by colonials. As long as no colonialists or the colonist Indian friends were present, the tribal language and religion were practiced.

gg. In 1775-1785 the Narragansett males took part in the service to the American Revolutionary War. Some did not want anything to do with the wars or the people. So some joined other Indians and made the journey to what was to become known as Brothertown with their families. During this time around 1777 Queen Esther of the Ningrete family died. She and her sisters never agreed with King Thomas Ninigrete. The leadership of the Narragansett was no longer recognized by the State of Rhode

Island. By 1790-1820 the State of Rhode Island started passing laws regulating tribal businesses, membership, voting rights, and giving ideas to the Tribal Council. The Americans recognized the autonomy of the Narragansett Tribal Council and appointed a treasurer who soon quit and no one took his place. In 1820, a school was established with the help of Frederick Bayles. This school was not very successful through 1830 because the appointed teachers were not educated enough to teach. In the wintertime the school was not accessible when the snows came, nor was the meeting house/church. The church group met in private homes.

hh. Things changed radically during the 1860s through the early 1880s when the State of Rhode Island illegally wrote the Narragansett Tribe was terminated. This they did without federal sanction. The Narragansett were never on the list of federally terminated recognized tribes because their numbers had been so badly reduced they were no longer a threat to the United Sates and to the military. That is why the Narragansett were not moved out of the state. Through 1880-90s the Narragansett Tribe unsuccessfully tried to sue Rhode Island for recovery of stolen and taken lands. Tribal activities especially traditional and ceremonial continued. With the turn of the century when World War I began, some of the Narragansett males joined the armed forces. No one bothered to ask why they joined. The fact was they could exhibit protecting the land again; a priority colonial conquest had taken away.

ii. At different times of the year, trade was resumed. Trading shells and shellfish took place. The Narragansett traded maize and smoked shellfish and shells with Indians in the Great Lakes regions for copper and red pipestone/catlinite, which we do not have in Rhode Island. Copper to the natives in New England was like gold and silver in other places. There was a method to get small amounts of copper produced locally. Basket making and pottery, mats made from white and red cedar, pine bark and reeds, and bead work instead of porcupine quill and bird quill works continued. Indians did not know how to make glass so the glass beads were brought from other countries and took the place of porcupine quill and bird quill embroidery.

jj. Education was very important and Indians started getting degrees. The Indian males went from apprenticeship to having their own businesses, especially carpenters, fishing, stonework, and farming and making boats. Most of the old stone walls and stiles and great foundations in the local area were made by Narragansett Indians and many still exercise the trade of stone masons.

kk. In the early 1930s the Narragansett people decided to formulate a business contract to be run by the Tribal Government and other members. A printed form of Constitution and Bylaws for the business end of The Tribe was also used to incorporate and define who and what the Tribal Government responsibilities as well as others were to be.

ll. Today the Tribal Government consists of nine Councilmen who are representatives of different family groups sitting at the top is Chief Sachem, Medicineman, and Medicine Woman as advisors. Added to this a Tribal Secretary, Assistant Tribal Secretary, Tribal Treasurer, and Assistant Tribal Treasurer, and we also have three Sub-Chiefs. Today we think about what was and how far the Atlantic Plains

extended before the water covered it because a lot has been found in the Ocean. Because of storms and maybe a little bit of global warming has changed the coastline.

mm. Narragansett men and women from the later 1930s participated in all of the military services in land, water, and the air forces, traveling and stationed in military units all over the world. From the 1960s and up services were during the Korean conflict and Vietnam War and what is happening in the Near East and the Far East today.

nn. Facing the turn of the century into the beginning of the 21st century saw the Narragansett trying to gain back some of their land in Charlestown area. The Federal Government backed The Tribe and paid for about two-thousand acres. The state is still arguing that they supersede Federal Law and that the State Laws have control. The Narragansett have a smaller reservation in Westerly; about seven or eight hundred acres currently know as The Old Crandal Farm.

oo. In the early 1980s the Narragansett people, federal lawyers, and local lawyers put together a 14-volume report to prove they were eligible for Federal Programs for Federally recognized tribes. It was miscalled and misinterpreted as a Bureau of Indian Affairs Federal Recognition. We did not have to gain something that we already had. We simply proved our continuous existence and supporting genealogy. The acknowledgement and approval for allowance to apply for many Federal Grants and Programs was gained by the Narragansett in 1983. Some funding comes in to support the Tribal Government, Social Services, Indian Health Services, Education, and Housing. Narragansett people work with the coastal resource groups and are very interested in work with the historical preservation of the areas. We have our own Historical Preservation Officer and a staff. In spite of so many forms of genocide, pitfalls, downfalls from wars, political aggression against the Narragansett Nation, we people are still here.

410.3. European Exploration and Colonial Settlement Landscape Context

1. The exploration and settlement of New England was a "vast maritime enterprise" (Bridenbaugh 1974, 10) in that conquerors and settlers traveled across the ocean and were sustained by it (St. Martin and Hall-Arber 2008). Marine resources along with coastal and oceanic trade routes ensured the physical and economic survival of European colonies in New England, including Rhode Island (Bridenbaugh 1974). The Ocean SAMP area influenced and was influenced by these human processes. Some of these influences exist today as place names, archaeological sites (known and undiscovered), and altered marine and coastal ecosystems.

2. The Exploration, Contact, and Settlement history of the Ocean SAMP area begins with the voyage of Giovanni da Verrazano in 1523. Under orders from the French crown, Verrazano explored the east coast of the present day United States from Cape Fear, North Carolina to Cape Cod, Massachusetts. In part focused on discovering the fabled "North West Passage," Verrazano also spent a considerable time interacting and trading with Indians. In April 1524, he sighted Block Island, which he described as 10 leagues from the mainland, similar size to the island of Rhodes, hilly, forested, and triangular shaped.

Observing a large number of fires on shore, Verrazano actually predicted that Block Island was heavily inhabited (Wroth 1970).

3. Prevented by weather from going ashore at Block Island, Verrazano sailed into Narragansett Bay, anchoring in Newport Harbor. There he recorded his observations on the Indian people, their leaders, homes, the openness of the countryside, the plants and animals, and the ways that they interacted with the coastal environment (Wroth 1970).

4. Following in the wake of the Dutch East India Company's sponsorship of Henry Hudson's explorations in New York beginning in 1609, the Dutch dispatched Adriaen Block on several voyages to the region. On the fourth voyage in 1614, Block's ship the *Tyger* was burnt at Manhattan. In response, he built a 42-foot coastal vessel, the *Onrust*. In the spring of 1615, Block explored the East River and passed north through Long Island Sound into what is now the Ocean SAMP area, in the process charting Block Island for the first time. The Dutch connections in New York laid down by Hudson and subsequently enhanced by the Dutch East and West India Companies exercised considerable long term influence on the history and patterns of maritime commerce through the Ocean SAMP area.

5. The cultural and political history of Rhode Island's establishment, when combined with its unique geography, explains the state's early, aggressive, and highly successful maritime enterprises. Roger Williams is considered the father of organized colonization in the state. Williams' move to Rhode Island also created conditions that contributed to Rhode Island's rapid rise as a maritime economy and colony. A religious radical with close Indian ties, Williams fled Massachusetts for Mount Hope Bay in 1636 where he received aid from the Indian chief Massasoit. Sympathetic with Williams (see Section 410.2), Massasoit granted Williams land on the east bank of the Seekonk River, north of present day Providence. Shortly thereafter, Williams was forced to move his expanding group of settlers close to present day Fox Point where he reestablished the community he called Providence (McLoughlin 1986).

6. Other dissenters followed Williams to Rhode Island: Anne Hutchinson in Pocasset (1639), William Coddington in Newport (1639), and Samuel Gorton in Shawomet (1640). In addition, William Arnold broke away from Williams and established his own community at Pawtuxet (1638), declaring allegiance to Massachusetts in the process. The result was a collection of scattered settlements led by people with diverse and sometimes controversial religious beliefs. This diversity ultimately led to a social and religious openness that proved a critical asset to Rhode Island's maritime economy (McLoughlin 1986; Bridenbaugh 1974).

7. The dispersed pattern of early settlements resulting from religious diversity and toleration multiplied the natural significance of waterborne connections in Rhode Island, especially in Narragansett Bay. Communication and commerce depended on the water. Initially, local transport was largely by canoe and most households possessed one or more them (Vickers 2005). Roger Williams, for example, used dugouts to travel the colony, and to visit and trade with local Indian leaders.

8. The Rhode Island colony was, in its essence, a maritime place, bounded by protected waters and gifted with good harbors and access to coastal natural resources. Fish, for example provided food, fertilizer, and saleable commodity. The islands, particularly Hog, Patience, Prudence, Dyer, Gould, Goat, Conanicut, Dutch and Aquidneck, were particularly important to Rhode Island's colonial settlement, survival and economic well being. Many islands had good land, trees, and fertile soil, and all had access to water. Beyond this, however, the islands in Narragansett Bay and Rhode Island Sound were critical for agriculture and animal husbandry. Pigs and goats - and later cattle, sheep and horses - were all raised on islands where they could forage and survive the winter while remaining confined and protected from wolves. Indeed, Hog and Goat Island were named for their contributions to early Rhode Island husbandry (Bridenbaugh 1974). The quest for grazing also drew attention to Block Island. At the end of 1639, William Coddington in Newport dispatched a small coastal trading vessel to Block Island with some livestock. In 1661, Dr. John Alcock and a group of men from Roxbury men built a barque and transported cattle from Braintree to Block Island. These activities represent Rhode Islander's expanded activity into previously isolated areas within the Ocean SAMP area (Bridenbaugh 1974).

9. The early agricultural development of Rhode Island was critical to its survival as a colony and its rapid maritime commercial expansion. As such, it directly influenced the Ocean SAMP area and surrounding lands. While English settlers brought their own ideas about agricultural development to Rhode Island, they also copied Native Americans' cultivation practices, particularly planting corn, which could be consumed, traded and used for animal fodder. Ultimately, animal husbandry proved easier and more lucrative than crop cultivation–and within a decade or two of settlement, Rhode Islanders, particularly those on Aquidneck Island, generated surpluses in pigs, goats, neat cattle (domestic straight-backed), sheep, and horses (Bridenbaugh 1974).

10. Pigs foraged relatively freely and fattened quickly. Sent by sea to Boston, butchers processed them into salt pork for use as food by mariners and fishermen. By 1649, cattle were also being raised for commercial markets. Agricultural surpluses, protected harbors, economic freedom, religious toleration, and lax regulation from the metropolis ensured Rhode Island's early and aggressive economic development and reinforced its ties with the ocean (Bridenbaugh 1974).

410.4. Post-Colonial Cultural Landscape Context

1. With the beginning of European colonization in the early 17th century, the open sea was Rhode Islanders' critical transportation link to the parent countries of Europe and to neighboring colonies along the Atlantic Seaboard. This marine transportation focused increasingly on trade as the colonial settlement matured, and with Newport merchants in the lead, Rhode Island became an important center of maritime commerce in the mid-18th century. This ready access to the sea stimulated areas of concentrated development on the shores of Narragansett Bay and, to a lesser extent, the Sakonnet and Pawcatuck Rivers, where protected harbors fostered the colony's principal urban centers. The ocean coast had fertile soils that attracted early settlement but it was diffuse with little in the way of villages or town centers. From Little Compton to Westerly, the shore was lined by isolated farms, some of them quite large, with their fields and pastures running down to

the water. Fishing and harvesting seaweed for fertilizing were important adjuncts to farming for the coastal population as well, though they left little permanent evidence on the land.

2. Factory-based manufacturing supplanted maritime trade as the center of the Rhode Island economy in the 19th century. Industrialization stimulated the growth of urban industrial centers led by Providence at the head of the Bay, and a concentration of population in smaller industrial communities clustered along the state's rivers. The growth of industry, urban commerce and the region's population all contributed to a steady flow of maritime travel through Rhode Island's coastal waters, and Providence emerged as an important regional port for the distribution of raw materials such as coal and cotton and for travelers between New England and the mid-Atlantic and southern states.

3. Industry largely bypassed the coastal area and the initial pattern of agricultural land use and dispersed settlement continued to define the majority of coastal Newport and Washington Counties (including Block Island) through the 19th century. However, by the middle of the century, the coastline had begun attracting seasonal visitors, as the expanding industrial and commercial economy made it possible for its successful participants to escape the hectic and noisome city to enjoy leisure time in a vacation. This seasonal use began in an informal way as visitors lodged with local farmers or in small boardinghouses.

4. Then, in the decades after the Civil War, the scale of vacationing grew and individual resorts developed where a new culture of leisure emerged. The preeminent resort community was Newport, which initially housed its summer visitors in boardinghouses and hotels, but became best known for its elaborate "cottages," private summer houses built by many of the country's wealthiest businessmen. With the opening of Bellevue Avenue and then Ocean Drive, the rocky coastline of Newport was taken up for the summer estates of wealthy summer residents from New York City and other major cities. Newport and the other coastal resorts also catered to the middle ranks of society with large hotels, boardinghouses and more modest cottage residences.

5. In addition to Newport, Jamestown, Narragansett Pier, and Watch Hill had their own concentrations of grand cottage architecture and large hotels in a coastal setting. Sakonnet, Weekapaug, Matunuck, and Misquamaquit also experienced a surge of waterside development accommodating summer tourists and there were smaller clusters elsewhere along the coast. From its roots as a somewhat isolated haven for agriculture and animal husbandry, Block Island grew into a popular tourist-attracting destination resort, a magnet for sailors and boaters of all kinds, fishermen and summertime day-trippers. Whether enjoyed from the verandas and grounds of private estates or from public beaches and shoreline trails, the picturesque beaches, rocky coast and ocean vistas were fundamental attractions that drew summer visitors of all economic levels to Newport and other points along the Rhode Island coast.

6. A key element in much of this growth was the steamboat, most notably at Block Island, where the construction of the federal breakwater in the 1870s provided the island with its first protected harbor. The new harbor could accommodate large steamboats, which greatly increased the number of summer visitors. It also enabled an expansion of the

island's fishing fleet, which in turn stimulated the growth of the year-round population. On the mainland, the federal government built a second breakwater to form the Point Judith Harbor of Refuge between 1890 and 1914. This fostered the growth of a fishing fleet as well, and the creation of the village of Galilee on the east shore of Point Judith Pond, which became a major commercial fishing harbor in the 20th century.

7. The patterns of development and land use that defined the late 19th century continued into the early 20th century, but were then interrupted by several factors. One was the economic and political turbulence that accompanied the contraction of the state's economic growth in the 1920s, followed by the Great Depression and then World War II. Another was the Hurricane of 1938, which devastated Rhode Island's coastal communities. A third was the rise of the automobile, which had perhaps the most long-lasting effect. When new development resumed after the long hiatus of depression and war, the automobile encouraged a more dispersed pattern of development in the coastal region. The open countryside that still covered much of the coastline became viable for residential subdivisions. As the summer population spread out, the large hotels that had been developed in the era of mass transit by steamboat or railroad dwindled in numbers. Many parts of the coastal region acquired a new suburban character as summer houses were adapted or rebuilt for year-round use and new subdivisions were built on former farmland. Although the amount of farm land decreased, representative examples of saltwater farms still helped define the coastal character. Block Island was the least affected by the automobile and suburbanization due to its remoteness from the mainland. Although it has experienced residential growth in the late 20th century, the island retains its rural character to a high degree.

8. As access to Block Island became more readily convenient from the 1950s onward, the Island residents have responded by adopting a land and nature preservation and protection ethos. Fittingly, it was led by a veteran Merchant Marine captain, Rob Lewis, in a tradition that has been carried on by his family, along with a host of other influential Block Islanders, such as "Birdlady" Elizabeth Dickens, and David and Elise Lapham. It was Captain Lewis who, perhaps better than others, appreciated the delicate balance between land and water, and the need to constantly find a harmony among their values. Rodman's Hollow, Black Rock and their neighboring properties were at the forefront of this Block Island conservation movement when it was formed, and efforts began in the early 1970s when Islanders inspired by Captain Lewis purchased the Hollow from potential off-Island developers. It has been their work, and the effort and commitment of Islanders through the years and still ongoing, that has led to the conservation of over 2,500 acres from the signature North Light to the sprawling Southwest corner, all replete with historical and cultural emphasis.

410.5. Military Landscape Context

1. During the post-contact period, twenty or more wars and endless conflicts that took place throughout the region have resulted in a complex military cultural landscape in the Ocean SAMP area.

2. Table 4.1 lists the conflicts, ranging from regional to global, that have had tangible influence on the Ocean SAMP area. Four centuries of conflicts have contributed to the

Ocean SAMP area landscape; however, the conflicts highlighted in bold font exercised the most influence in the Ocean SAMP area.

Table 4.1. Warfare and the Ocean SAMP area, conflicts 1634-1975

Conflict	**Years**	**Adversaries**
Pequot War	**1634-1638**	**Colonial v. Indian**
First Anglo Dutch War	1652-1654	England v. United Provinces
Second Anglo Dutch War	1665-1667	England v. United Provinces
Third Anglo Dutch War	1672-1674	England v. United Provinces
King Philip's War	**1675-1676**	**Colonial v. Indian**
King Williams War	1689-1697	England v. France
Queen Anne's War	1702-1713	Britain v. France
King George's War	1739-1749	Britain v. Spain (and France after 1744)
French and Indian War	**1754-1763**	**Britain v. France**
American Revolutionary War	**1776-1781**	**Britain v. United States**
French Revolutionary and Napoleonic Wars	1792-1814 (brief period of peace 1802-1803)	Britain and her allies v. France
Quasi–War with France	1798-1800	United States v. France
War of 1812	**1812-1814**	**United States v. Britain**
Mexican War	1846-1848	United States v. Mexico
Civil War	**1861-1865**	**Union v. Confederate**
Spanish American War	1898	United States v. Spain
World War I	**1914-1918**	**Britain, France, Russia, United States v. Germany**
World War II	**1939-1945**	**Britain, United Sates, Soviet Union v. Germany, Japan, Italy**
Korean War	1950-1953	United Nations, Republic of Korea, United States v. Democratic People's Republic of Korea
Vietnam War	1961-1975	South Vietnam, United States v. North Vietnam, Viet Cong

3. Among the wars, the American Revolution and the two World Wars (especially World War II) proved especially influential on the Ocean SAMP area's cultural landscape. The Revolutionary War altered the trajectory of Rhode Island history, reshaped its economy played host to fighting on land and at sea resulting in at least 33 historically significant shipwrecks in Rhode Island waters. Likewise, the global conflicts of the first half of the 20th century, especially World War II strongly influenced Rhode Island history and the Ocean SAMP area's cultural landscape. Naval facilities, bases, warships, fuel depots, hospitals, gun emplacements, testing ground, and shipwrecks from WWII all contributed to the fabric of the Ocean SAMP area history and many elements remain as archaeological or historic sites.

4. The outbreak of the Pequot war is tied to events that occurred within the Ocean SAMP area. In 1634, John Oldham, a trader from Massachusetts, was killed during his interactions with Indians on Block Island. In response, Massachusetts attacked, conquered and settled the island.

5. The three Anglo Wars (1652-1654, 1665-1667, 1672-1674) affected in long-term ways patterns trade and traffic through the Ocean SAMP area. New York's extraordinary influence on the history of Rhode Island and the Ocean SAMP region traces directly to the early Dutch colony of New Amsterdam and the conflicts it engendered. The regional Dutch - Rhode Island connections persisted after the English took control of New York in 1664, continuing to influence trading relationships and traffic patterns through the Ocean SAMP area for centuries.

6. During the period covering King William's War (1689-1698) and Queen Anne's War (1702-1713), the English government expended little effort to control or regulate Rhode Island. The religiously tolerant, independent-spirited, and economically motivated Rhode Islanders refused to supply soldiers or military support to New England colonial armies (McLoughlin 1986).

7. In contrast with land war, Rhode Islanders enthusiastically embraced the for-profit warfare of privateering. During the many Anglo-French wars (1689-1754) Rhode Island and other colonies licensed large numbers of privateers that sailed through the waters of the Ocean SAMP area. Privateers were privately owned armed ships licensed by the government in times of conflict and granted permission to raid enemy shipping. Privateering could be highly profitable and provided some level of naval defense for the colony. In 1690, Thomas Paine, a privateer from Jamestown, helped drive off French ships that landed on Block Island (McLoughlin 1986).

8. The late-17th and early-18th centuries blurred the distinctions between legal privateering and illegal piracy. Thomas Paine, the hero at Block Island, was suspected of piracy, and the colony produced the well-known pirates Thomas Tew and Captain Want. In the 1690s, Rhode Island reportedly welcomed the famed pirate William "Captain" Kidd (Hawes 1999). Pirate booty boosted the Rhode Island economy, fattening the purses of certain merchants and government officials who might overlook illicit cargos and questionable practices (Bridenbaugh 1974). After about 1720, piracy along the eastern seaboard of colonial America declined and the separation between illegal pirates and legal privateers became clearer.

9. During King George's War and the French and Indian War (1739 – 1749, 1754 – 1763), Rhode Island dispatched a large number of privateers during the eighteenth century wars. During King George's War (1739 – 1749) Rhode Island was home to 25 percent of all privateers in operating in America (Swanson 1991). During the French and Indian War (1754 – 1763), powerful Rhode Island merchant families such as the Browns and Bannisters dispatched fleets of privateers through the Ocean SAMP area waters.

10. The French and Indian War emptied the British government's coffers, leaving an immense war debt that threatened the national economy. The clumsy plans devised by Imperial authorities to raise revenues from the America colonies threatening the cherished semi-independence and finances of Rhode Island and sister colonies and ultimately led to the War for Independence.

11. A Maritime-based economy meant that the new heavy British hand was perhaps felt sooner and with more pain in Rhode Island than in the other British North American colonies. Rhode Island responded by becoming the first colony to take up arms against Britain, the first to propose a Continental Congress, the first to formally sever ties with the British monarchy, and the first to create a navy.

12. Armed resistance to British rule in America began on Rhode Island waters and set the stage for the development of the United States navy. In December 1763, the HMS *Squirrel* sailed through the waters included in the Ocean SAMP area and into Narragansett Bay to enforce the new regulations. Seven months later in July 1764, at the orders of two members of governor's council, gunners fired eight shots at a tender from *Squirrel* after a British-sparked mobbing incident at Newport.

13. Attacking Royal Navy vessels became a pattern in Rhode Island. Major incidents occurred in 1765 when a Royal Navy ship *HMS Maidstone* attempted to impress local sailors at Newport, and in 1769 when a mob boarded the Royal Navy ship *Liberty*, running it ashore and setting it aflame (McLoughlin 1986; Bartlett 1858; Carroll 1932).

14. The most important incident of this kind was the burning of the HMS *Gaspee* in the Providence River by disgruntled colonists in 1772. The *Gaspee* affair ranks alongside the Boston Tea Party and the Stamp Act Crisis as a large step on the road to the American Revolution (Bartlett 1858; McLoughlin 1986).

15. The colony's independent streak and eye for profits continued in the early 1770. When the other colonies banded together in refusing to accept imported British manufactures, Rhode Island claimed poverty and abstained. At expense of the other colonies, Rhode Island Sound and Narragansett Bay remained open to British commerce. At a direct cost to the other colonies, ships, goods, and money flowed through the Ocean SAMP area waters into Rhode Island's ports (McLoughlin 1986)

16. The 1773 Tea Act and the infamous Boston Tea Party fed Rhode Islanders appetite for rebellion. In 1774, Rhode Island called for a Continental Congress and became the first colony to elect delegates. During this period, British warships increased operations in Rhode Island Sound beginning to block traffic into and out of Narragansett Bay.

17. In June of 1775, the Rhode Island legislature established America's first navy, commissioning the *Washington* and the 12-gun sloop *Katy* (later renamed the sloop *Providence*). Within a few days, the *Katy* captured the Royal Navy's tender *Diana* (tender to the HMS *Rose*) off Jamestown, in some respects the first naval battle of the Revolution (Fowler 1976).

18. In October 1775, the Continental Congress passed a Rhode Island proposed resolution to create a Continental Navy. Rhode Island supplied two of thirteen new ships, the 28-gun frigate *Providence* (a different vessel from the sloop *Katy/Providence),* and the 32-gun frigate *Warren*. The following month, Rhode Island sea captain Esek Hopkins became the Continental Navy's first commander-in-chief (Fowler 1976).

19. Some of the United States Navy's earliest actions took place in Ocean SAMP area waters. In April 1776, Commander-in-Chief Esek Hopkins, captaining the *Providence*, captured a British tender *Hawk* off Block Island and a brig (bomb vessel) *Bolton*. On April 6, Hopkins' squadron engaged but did not capture HMS *Glasgow* off Point Judith. The following month, John Paul Jones, often considered the father of the American Navy, became the captain of the sloop *Providence (*the former *Katy*) (McLoughlin 1986).

20. In a dramatic prelude to the formal United States Declaration of Independence, on May 4, 1776, Rhode Island "abrogated its allegiance to the king." The waters around the Rhode Island, including the Ocean SAMP area became state waters on July 22, 1776 when Rhode Island altered the identity on its charter from "colony" to "state." (McLoughlin 1986).

21. As with earlier imperial conflicts, Rhode Island embraced privateering during the Revolutionary War, commissioning 65 privateers between May and December 1776.

22. In December 1776, the British took Newport in an amphibious assault. The subsequent three-year British occupation had dire consequences for maritime Rhode Island, ending forever the glory days of Newport-owned ships transiting the Ocean SAMP area waters on their way to distant markets. Many colonial merchants fled, taking their trade and shipping with them. Rhode Island's center of political and economic influence shifted from Newport to Providence, where it would remain after the war ended.

23. By cutting off Rhode Island's customary access to the sea, the British naval control of the Ocean SAMP area waters and Narragansett Bay brought serious hardships for patriots in Providence. Only supplies sent overland to Providence from Connecticut prevented starvation.

24. Patriot forces maintained an offensive strategy on Rhode Island waters despite superior British forces. In October 1778, American patriot, Silas Talbot commanding a 2-gun sloop captured the 22-gun Royal Navy Brig *Pigot* that had been blockading Sakonnet (McLoughlin 1986).

25. The British occupation of Newport and control of the entrance to Narragansett Bay had trapped the new frigates *Providence* and *Warren* along with the sloop *Providence* at the

head of the bay. In February 1778, the *Warren* slipped the blockade, followed a month later by the *Providence*. The Continental ship *Columbus* failed in its bid for the open sea, running aground and burning in the Ocean SAMP area near Point Judith.

26. In March 1778, France recognized the United States of America and entered the war as an ally. This changed war's character from a colonial rebellion to a broader European and Atlantic conflict. The French king sent a fleet under French Admiral d'Estaing, to assist the Continental forces. One of its first actions involved supporting an unsuccessful American effort to liberate Newport in the summer of 1778.

27. The French fleet comprised 12 ship-of-the-line, 4 frigates and 2,800 marines, a force far more powerful than the British frigates and smaller vessels stationed in Rhode Island. Faced with certain capture, between July 29 and August 8, 1778 the British forces sunk, scuttled or burned all of their vessels. English losses including the sloops *Kingsfisher* and *Falcon*, the galleys *Alarm* and *Spitfire*, and the frigates *Lark*, *Cerberus*, *Orpheus*, *Juno* and *Flora* as well as 13 transport ships in Newport Harbor (Abbass 2000). Today, many of these wrecks are likely eligible for the National Register of Historic Places

28. Despite these successes, the American and French efforts to take Newport stalled. The British, however, finally withdrew from the Island and Newport on their own accord in October 1779.

29. In July 1780, a French fleet under Admiral Ternay and carrying troops commanded by the comte de Rochambeau arrived in Newport. French warships stayed through the following winter. In March 1781, General Washington and Rochambeau, who would become the architects of the British defeat at Yorktown, held a series of strategic meetings at Newport. Shortly thereafter, the French evacuated Rhode Island (McLoughlin 1986).

30. Although a center for the US navy during the American Revolution, Rhode Island did not reap any naval rewards during the post war years. The Navy Acts of 1794 or 1798 failed to direct significant navy resources toward the state. The only significant federal navy project was the construction of the frigate General Greene in Warren in 1799.

31. Between 1798 and 1800, the United States fought the so-called Quasi-War with France. Rhode Islanders participated enthusiastically, sending out many privateers to stalk French merchant ships.

32. The War of 1812 brought a mixed reaction in Rhode Island. The state government opposed the war, however, the lucrative prospects of privateering enticed many Rhode Islanders into action. One Bristol privateer, the *Yankee* captured 40 vessels worth a total of $5,000,000 (Coleman 1963). No battles took place in Rhode Island; however, the heavy presence the British Navy's off the east coast, including in Long Island Sound and in parts of the Ocean SAMP area, hampered Rhode Island's maritime activities.

33. Rhode Islanders served in the early U.S. Navy with distinction. Perhaps the most important of these were members of the Perry family of South Kingstown. Christopher Perry served during the Revolution and the Quasi-War with France. His eldest son,

Oliver Hazard Perry commanded the US fleet at the Battle of Lake Erie (1814) during the War of 1812. His younger son, Matthew C. Perry, commanded a famous expedition that opened Japan to trade in 1853-1854 (Rhode Island Historical Society 1993).

34. Despite Rhode Island's illustrious contributions and fine harbors, the Navy did not become an important presence in the State until the outbreak of the Civil War (1861-1865) (Rhode Island Historical Society 1993).

35. The Civil War (1861-1865) finally renewed a relationship between Rhode Island and the U.S. Navy, a relationship that would continue for the next 150 years. At the beginning of the war, the Union government, concerned about the proximity of the Naval Academy at Annapolis in the south, relocated it to Newport. Despite strong efforts to keep the Academy in Rhode Island, it returned to Annapolis after the war.

36. Despite losing the academy, the Navy's presence in Rhode Island increased exponentially during the last 30 years of the 19th century. In 1869, underwater mines and explosive warfare technology were in their infancy and the Navy established a torpedo experimentation and development facility on Goat Island.

37. The Newport torpedo development, testing, training and manufacturing station is central to the history of the propeller-driven torpedo in America. The navy subsequently established testing ranges inside Narragansett Bay and in parts of the Ocean SAMP area in Rhode Island Sound.

38. The Navy expanded operations to include Rose (1883) and Gould (World War I) Islands. During World War I, the Newport Torpedo Station added depth charges and mines to its manufactures. During World War II, the station had 13,000 employees who manufactured 57,653 torpedoes, about a third of all torpedoes manufactured in the United States. In 1942, the Navy authorized the station to proof-fire 100 torpedoes a day. Through testing and actual warfare, unexploded torpedoes and other ordinance are historically significant, if potentially dangerous components of the military landscape of Narragansett Bay and parts of the Ocean SAMP area.

39. The station renamed the Naval Underwater Systems Center moved to Coddington Cove in 1951. In 1992, the Coddington Cove facility became the Naval Underwater Warfare Center (Rhode Island Historical Society 1993). These research and development activities were highly important during the Cold War between the U.S. and Soviet Union.

40. Education has remained an important military activity in Rhode Island. In 1883, the Navy established the Naval Training Station at Coasters Harbor Island. Operations on land in Newport and at sea in Narragansett Bay and Rhode Island Sound expanded during the first half of the 20th century. During World War II, over 300,000 recruits passed through the station. After the war, the Naval Training Station evolved into Officers Candidate School (Rhode Island Historical Society 1993; Schroder 1980).

41. The Navy established the Naval War College at Newport in 1884. First led by Admiral Stephen B. Luce the college recognized increasing connections between science and warfare. The College's highly influential second president, Alfred T. Mahan, along with

the technological and tactical challenges presented in the Spanish American War (1898), silenced many of the institution's critics. In 1992, the College became an accredited degree-granting institution (Rhode Island Historical Society 1993).

42. The United States Atlantic Fleet developed strong connections with Rhode Island, Narragansett Bay and Rhode Island Sound during the first half of the 20th century. On the eve of the Second World War, six battleships, eight cruisers, thirty destroyers, two submarines, two destroyer tenders and two supply ships along with many smaller vessels were based in Rhode Island.

43. Naval facilities developed to service this growing Navy presence. In 1900, the Navy created the Bradford Coaling Station near Melville, near the site of the Portsmouth Grove Civil War hospital. Again Stephen Luce, although now retired, was involved in this decision. By 1917, the coaling station had developed into a general fueling facility, with extensive oil storage capacity. By 1937, it could store 13 million gallons of fuel. More capacity was added during World War II.

44. Military naval and military activities in Rhode Island and its waters during the Second World War. Providence yards built Liberty ships and the famed Herreshoff shipyard built small boats for the Navy.

45. In 1940, the Navy broke ground on what would become the Quonset Naval Air Station, one of two naval air stations on the east coast. Used first as a training facility it became a command center for the First Naval District. "Quonsett-based aircraft carriers and planes participated actively in antisubmarine warfare, convoy escort duties, and air and sea rescue missions, as well as in air patrol operations in coastal waters." (Schroder 1980). In 1942, the Navy built a Naval Auxiliary Air Facility in Charlestown with an on the ground deck for carrier landing practice. The skies above the Ocean SAMP area saw thousands of over-flights by military aircraft, several crashed in or near the Ocean SAMP area.

46. In October 1941, adjacent to Quonset at Davisville, the Navy built the Construction Battalion Training Center (Camp Endicott) It served as a training center for newly formed Naval Construction Companies who built facilities and protected themselves while under fire. Over 100,000 men trained at Davisville during the war. A Civil Engineer Officers Training School was added in 1944.

47. Camp Endicott also stored materials and equipment for construction of advance bases overseas. In 1944, almost half a million long tons of advance base materials were shipped out of the Davisville facility. During the war, engineers at Endicott developed pontoons that were used as dry docks, bridges, ferries and barges. The private sector G.A. Fuller Company developed and manufactured 32,253 portable corrugated steel shelters that became famous as Quonset Huts (Schroder 1980).

48. Other naval facilities developed in Rhode Island during World War II included: a naval supply depot at Coddington Cove (1942); the naval net depot that built steel anti-submarine nets (1941); a marine Barracks at Coddington Cove (1943); a naval magazine on Prudence Island (April 1942); a communication station at Beavertail (1941); a small arms firing range at Sachuest Point (1942); a naval operating base in Newport (August

1941); an anti-aircraft training center at Price's Neck near Brenton Point (1942); an inshore patrol facility on Long Wharf in Newport; and a demagnetizing facility at Gould Island used counteract mines or torpedoes attracted to ships or detonated by magnetism (Schroder 1980).

49. In 1942, the Navy built a Motor Torpedo Boat (Patrol Torpedo Boat) Squadrons Training Center at Melville (February 1942). By 1944, the center's 28 PT boats worked extensively in the Rhode Island coastal waters and acted as listening posts farther out to sea (Schroder 1980).

50. Between 1952 and 1973, the Cruiser-Destroyer Force Atlantic based out of Newport. In 1973, the Navy dramatically downsized its Rhode Island presence, causing serious economic damage. The War College remained open as did the Navy Undersea Warfare Center and smaller navy unit, known as Surface Group 4, comprising mostly frigates and minesweepers (Rhode Island Historical Society 1993).

51. The history described above influenced the Ocean SAMP study area in many ways over the past 300 years. Conflict and peacetime Navy operations have left a rich repository of submerged archaeological sites. By far the greatest numbers of potential and known sites are tied to World War II and/or the development of Naval facilities in Rhode Island during the later-19th and 20th centuries. These resources include vessels lost by accident, vessels deliberately sunk as part of weapons testing, derelicts, military aircraft, merchant marine vessels sunk during war, ordnance, and other lost or abandoned military equipment. The locations of these resources are known, many others certainly await discovery.

52. Shipwrecks and other submerged archaeological sites tied to the American Revolutionary War are central to understanding the importance of the military landscape of the Ocean SAMP area. Rhode Island's coastal waters have perhaps the largest number of known Revolutionary War shipwreck sites in the United States. The intensity of American, British and French military activity in Rhode Island from 1775-1778, makes it probable that unidentified vessel losses occurred and that yet unknown Revolutionary War shipwrecks await discovery in or near the Ocean SAMP area.

53. Rhode Island was one of the great centers of American privateering during many of the Wars between the late 17th century and the end of the War of 1812 and a number of related shipwrecks almost certainly occurred in the Ocean SAMP area. Two privateers are known to have been lost in Rhode Island waters, one of which might be in the Ocean SAMP area. It is probable that more await discovery.

54. Known and potential military-related shipwrecks from other periods of Rhode Island history also contribute to the submerged military landscape. While few in numbers and less characteristic of the overall landscape, some of these may be highly significant. Military vessels from the late-17th century or early-18th century, as yet unknown, if discovered they would contribute significantly to our understanding of Rhode Island history.

55. The known cultural resources that contribute to the military cultural landscape are listed in Table 4.2 below.

Table 4.2. Submerged cultural resources associated with the military landscape

Vessel/Aircraft	Type	Date of Loss	Located within Ocean SAMP Area
Admiral Parker	Armed Schooner	9/22/1777	Possibly – lost off Watch Hill.
USS Alexander J. Luke	Destroyer Escort	10/22/1970	Possibly – sunk off Newport, possibly out at sea.
USS Bass	Submarine	3/12/1945	Yes – Off Block Island.
Black Point	Collier	5/5/1945	Yes - Rhode Island Sound.
USS Columbus	Frigate	3/28/1778	Possibly – lost off Point Judith.
F6F Hellcat	Fighter Aircraft	10/22/1945	Possibly – crashed off Charlestown.
F6F Hellcat	Fighter Aircraft	8/17/1944	Yes – Salt Pond, Block Island.
USS Leyden	Steam Tug	1/21/1903	Yes – Block Island.
PB4Y Liberator	Navy Aircraft	1/31/1944	Yes – Rhode Island Sound.
USS Lightship #73	Lightship	9/14/1944	Possibly – Near Buzzard's Bay Entrance Tower.
USS L-8	Submarine	5/26/1926	Yes – Rhode Island Sound.
Minerva	Navy Transport	10/21/1778	Possibly – lost off Westerly.
USS Revenge	Armed schooner	1/8/1811	Possibly – lost near Watch Hill Reef.
USS Scout Patrol 907	Scout Patrol	9/18/1918	Possibly – Burned at entrance to Narragansett Bay.
Sisters	Navy Transport	11/7/1777	Possibly – lost near Point Judith.
AD-5W Skyraider Trainer	Navy Aircraft	12/27/1957	Possibly – crashed off Charlestown.
USS Snowden	Destroyer Escort	6/27/1969	Possibly – towed out to sea and used as a target for bombing and strafing.
HMS Syren	Frigate	11/7/1777	Possibly – lost off Point Judith.
Triton	Navy Transport	11/10/1777	Possibly – lost near Point Judith.
Two Brothers	Privateer	3/11/1777	Possibly – lost near Westerly.
Two Mates	Schooner	11/7/1777	Possibly – lost near Point Judith.
USS Waller	Destroyer	2/2/1970	Possibly – sunk as target off Rhode Island.
PT-95	PT-Boat	9/4/1945	Possibly – destroyed at Rhode Island.
PT-96	PT-Boat	9/7/1945	Possibly – destroyed at Rhode Island.
PT-97	PT-Boat	9/7/1945	Possibly – destroyed at Rhode Island.
U-853	Submarine	5/5/1945	Yes – off Block Island.

410.6. Fisheries Landscape Context

1. Chapter 5, Commercial and Recreational Fisheries, describes commercial and recreational fishing in and around the Ocean SAMP area. It also identifies important historical elements related to the current state of fishing, target species, fishing ports and communities. This hunting and gathering of the living marine resources in the Ocean SAMP area has affected broad areas of the landscape. Sometimes these relationships and their related cultural heritage resources are obvious such as in pre-contact shell middens. Often, however, the influences and material culture of fishing and harvesting have been overlooked by archaeologists and historians.

2. Studying the effects of historical fishing on marine populations and habitats is an important new area of scholarship that is adding critical baseline information about pre-commercial or pre-industrial ecosystems and the extent and potential effects of fishing. Understanding existing ecological conditions requires knowledge of the past as well as current human influences and activities. The condition of species have influenced, in important ways, human activities that extend back millennia in the Ocean SAMP area. The many known and undiscovered or unrecognized components of this landscape, such as historic fishing vessels, fish traps, working and remnant piers, and the altered habitats of historic fishing groups represent untapped opportunities to gain important knowledge about human activities and their relationships with the marine environment of the Ocean SAMP area. Many of these resources, including unique or representative fishing vessels and the archeological remains of traps and piers that are 50 years old or older could potentially be considered as candidates for the National Register of Historic Places. Fixed on shore, the presence of historic submerged piers or fish traps are easier to determine and locate. The locations of many fishing vessels, however, are unknown—indeed, the number of vessels lost in the area prior to and since the European contact remains unknown. This is an important historical and archaeological research question and has implications for the citing of new structures in the Ocean SAMP area.

410.6.1. Rhode Island Fisheries

1. The commercial fisheries of Newport and Sakonnet Point have origins dating back to the 17th century (Hall-Arber et al. 2001). Colonial fishermen in Rhode Island operated a "hook and line" fishery utilizing small skiffs, or set seine nets along the shore. The small fish caught with seines were used primarily as manure in the fields. (Olsen et al. 1980). During the mid-1800s, the use of staked and floating fish traps, set close to shore, came into prominence as a fishing technique, eclipsing the hook and line method. This new method of fishing was much more efficient (Olsen et al. 1980). At the time, traditional hook and line fishermen claimed that the waters of Rhode Island were being overfished by these new technologies.

2. The development of the fishing industry coincided with the development of markets for fish and with the ability to store and transport fish. Toward the turn of the 19th century, fish could be shipped by steamship from Newport to New York, or via railroad. In 1876, construction was completed on Government Harbor (now Old Harbor) on Block Island's east side, which led to an expansion of the fishing industry and the accommodation of larger vessels that could go farther out to sea for a longer time (RIHPHC 1991). In 1889,

there were a reported 127 million pounds of fish landed in Rhode Island, of which 89 percent were menhaden (Olsen and Stevenson 1975). Menhaden plants, which rendered the fish for oil, were common throughout the New England coastline around the turn of the century.

3. During the 1920s and 1930s, menhaden began to disappear off the coast of New England as stocks were overfished, and many of the menhaden plants were forced to close. Fishermen were pushed to pursue other species (Poggie and Pollnac, eds. 1981). In the 1930s, the first otter trawls were used off Rhode Island (Olsen and Stevenson 1975). Marine diesel engines were also introduced around this time, allowing fishermen to travel further offshore in pursuit of fish (Poggie and Pollnac, eds. 1981). Trawling quickly became the dominant method of fishing, and trap fishermen soon began criticizing trawlers for a decline in stocks.

4. During the 1960s, significant stocks of lobsters which had not previously been fished were discovered offshore, providing a large boost to landings and value in the state's lobster fishery (Sedgwick et al. 1980). Around this time, traps replaced trawling as the dominant method for catching lobsters offshore, and this also significantly boosted lobster landings and revenues (Poggie and Pollnac, eds. 1981).

5. As in other states around the country, the presence of foreign fishing fleets was a contentious issue in Rhode Island in the 1960s through the mid-1970s, until the passage of the Magnuson Stevens Fishery Conservation and Management Act in 1976, which declared a 200-mile limit on U.S. waters. Rhode Island offshore fisheries continued to grow even during the time of massive fishing efforts by foreign fleets, as some of the offshore stocks were not heavily exploited by foreign fleets, and were thus targeted by Rhode Island vessels. This led to rapid expansion of Rhode Island fisheries in the late 1970s and early 1980s. In 1979, there were a record 264 offshore vessels landing at Rhode Island ports, although some of these vessels were home-ported elsewhere.

6. Rhode Island's important squid fishery began in the late 1800s as a bait fishery, and a market for human consumption developed during the 1960s. From the late 1960s through early 1980s, squid was heavily exploited in Rhode Island waters by foreign fishing fleets. After the departure of foreign vessels from U.S. waters, Rhode Island vessels were among the first to target squid in large numbers; Rhode Island commercial landings for squid increased by an order of magnitude from 1981 through 1992 (DeAlteris et al. 2000).

7. During the 1980s, the commercial fishing industry in Rhode Island was growing, increasing by 24 percent in total landings from 1980 through 1987, while landings in the other New England states declined by 37 percent. This increase was due in part to an increase in fish consumption nationwide, to the increased harvesting of what at the time were underutilized species (such as squid and butterfish), and also to a significant increase in international exports from Rhode Island, particularly to Japan. This growth was also aided by public investment into the fishing industry during the late 1970s and 1980s, including the development of piers at both Newport and Galilee (Intergovernmental Policy Analysis Program, University of Rhode Island, 1989).

410.6.2. Fishing and Subsistence on Block Island

1. Modern archaeological investigations suggest that Indian people living on Block Island depended heavily on marine plant and fish life as early as 3,000 years ago (Tveskov 1997). There is historical evidence of significant Indian fishing during the late 17th century on Block Island. Two centuries later, beach walkers regularly discovered examples of Indian fishing technology in the form of heavy grooved stone sinkers (Livermore 1877).

2. Fish and marine vegetation directly and indirectly influenced diets and ecological conditions on Block Island, promoting sustainable agriculture. Beginning in the late 18th century, possibly earlier, Block Island farmers (many of them also fishermen) used seaweed to protect crops from extreme weather and to nourish the heavily worked soil. Farmers also mixed seaweed with fish offal and soil to create compost. These marine resources and local agricultural practices maintained the soil's fertility despite centuries of intensive use. Livermore, the island's principal early historian, noted that Islanders gathered over 6,000 cords of seaweed valued at $10,000 in 1875. By that time many Islanders maintained the exclusive right to collect weed from specific areas. A large area of public beach, however, remained opened to all islanders. Such divisions are important markers on the island's historic cultural landscape (Livermore 1877).

3. Commercial fishing has long and important history in New England and the Ocean SAMP area. Intimately tied to early exploration and settlement in the region during the 16th century, fish enticed thousands of ships and tens of thousands of European mariners and fisherman to cross the North Atlantic to the Americas. They discovered and charted off-shore banks and interacted with native people. In terms of economic value, the fish caught and processed by the French and English fishermen outstripped the more famous New World treasures of gold and silver extracted by the Spanish Empire (Fagan 2006; Pope 2004).

4. Cod was the most important species for the Atlantic markets. Abundance combined with low level of oil in the flesh made it possible to store dried salted cod for extended periods. Cod, caught in the fall and the spring of the year, was the most important commercial species for Block Island fishermen in the 19th century. In 1880, Block Island fisheries employed 263 people, producing in excess of one million pounds of fish, roughly three-quarters of which was dry cod. Fishermen also caught other species such as dogfish and mackerel. In the 19th century, fishermen from other Rhode Island ports and neighboring states competed with Block Islanders (Goode 1884).

5. In late 19th and early 20th century, Block Islanders attempted to maintain proprietary connections to their local environment and resisted the introduction of new fishing technologies to "their" waters in the 1880s (Goode 1884). One important exception was the introduction in the late 1860s of fish traps or pound nets. Pound nets required that many pilings be driven into the seafloor, the remnants of which might exist in regularly spaced intervals in near-shore areas around the island (Livermore 1877; Goode 1884). The rough Atlantic environment made maintaining traps challenging, but archaeological remnants may well remain.

410.6.3. Historic Shipwrecks of Fishing Vessels

1. Shipwrecks, particularly of fishing vessels, occurred throughout the centuries in Rhode Island and remain a common occurrence in the Ocean SAMP area during the present day. In the historical record, fishing can be an elusive subject. Accounts of the transporting and selling of fish are available for some places and periods. In the later 19th century, government-generated statistics become more common. However, in the distant past and in more recent times, the records of individual fishing voyages remain rare and if in existence, they often reveal little information about actual fishing activities, much less fishing life. Official documents between the 16th through the early 19th centuries seem to have rarely recorded (or at best under-recorded) the losses of early fishing vessels. Based on examinations of manuscript and federal records by Ocean SAMP investigators, this pattern seems to hold true in the late 19th and early 20th centuries, particularly when it comes to smaller fishing vessels.

2. The potential for unreported but historically significant commercial fishing vessel wrecks in the Ocean SAMP area and surrounding waters is extremely high. The most important individual wrecks would be the rare early commercial fishing vessels of 16th through the mid 19th centuries. However, when considered as part of a larger fisheries landscape in Rhode Island and in the Ocean SAMP area, fishing vessels and associated technologies from the late 19th century through the 20th century have the potential to provide an unbroken, representative, and highly illuminating archaeological record. These types of cultural heritage have extraordinary potential to add significant new knowledge in many areas, particularly in terms of the environment and culture. Often overlooked because of apparent commonality and unromantic uses, it is essential to note that any commercial fishing vessel built 50 years ago or more may be eligible for the National Register of Historic Places (if the vessel meets other necessary criteria). Research is clearly needed to identify these resources and to develop standards to evaluate these wrecks for purposes of study, public use, and historic preservation.

3. Cultural heritage research relating to commercial fishing is in its early stages in neighboring Massachusetts, where archaeologists and biologists at Stellwagen Bank National Marine Sanctuary have discovered the locations of several wrecked fishing vessels. Efforts are underway to evaluate and nominate some of these wrecks to the National Register of Historic Places. Many similar wrecks exist in the Ocean SAMP area and adjacent waters. While not all of these wrecks may merit preservation, the older vessels certainly require inventory and assessment—a level of study that will generate an improved understanding of the Ocean SAMP area's cultural and natural heritage.

4. At present, there is no solid estimate of the number and composition of historic shipwrecks related to commercial fishing in the Ocean SAMP area. There is also no direct historical evidence of the earliest vessels that likely passed through the Ocean SAMP area during the second half of the 16th century. It is possible that one or more of these craft wrecked in the Ocean SAMP area.

410.6.4. Historic Harbor Features

1. Commercial fishing drove the development of harbor facilities in the Ocean SAMP area in the 17th through the 20th centuries. In 1670's, the first legislation supporting the construction of a pier at Block Island cited the encouragement of fishing as its principle justification. Subsequent successful and unsuccessful efforts to establish safe harbors on the island focus on fish. In 1816, Block Island fisherman constructed the "pole harbor" near present day old harbor. Consisting of pilings driven into the bottom and boulders, the pole harbor offered adequate shelter in normal conditions. If stormy weather threatened, fishermen pulled their boats onto the shore. By 1870s and the opening of the Government Pier, the pole harbor consisted of 750 pilings (Goode 1884; Mendum 1897). For the next two centuries and beyond, all efforts to build harbor facilities at Block Island had strong ties to the fisheries (Livermore 1877; Goode 1884).

410.7. Marine Transportation and Commercial Landscape Context

1. While none of Rhode Island's cargo ports or naval facilities are within the Ocean SAMP area, cargo ships, support vessels and military craft traverse the Ocean SAMP area *en route* to the Rhode Island ports of Providence, Quonset/Davisville, and Newport in Narragansett Bay, and the Massachusetts port of Fall River (which includes Fall River and Somerset) in Mount Hope Bay.

2. In the 1620s, Dutch shallops (coastal vessels) from New Amsterdam (later New York) regularly transited the Ocean SAMP area and entered Narragansett Bay. In 1625, Dutch traders established a base on Dutch Island in Narragansett Bay where they conducted a lucrative trade with the native peoples.

3. English settlers that arrived in Rhode Island in the 1630s reshaped maritime traffic in the Ocean SAMP area dispatching merchant ships both to Massachusetts and New York. In 1634, the first English cargo of maize (Indian grown) was shipped out of Rhode Island, through the Ocean SAMP area, to Boston. Although European settlers on Aquidneck Island embraced and expanded the commercial connections with Massachusetts, they also fostered links with New Amsterdam. The latter had widespread implications, since trade with Manhattan resulted in increasing numbers of Rhode Island merchant ships in Long Island Sound, Block Island Sound and along the Connecticut shore (Bridenbaugh 1974).

4. During the 1640s, Rhode Islanders cultivated modest amounts of tobacco, which they exchanged for English manufactured goods, including textiles and ironware. William Coddington and William Withington were two of the earliest pioneers in this regard (Bridenbaugh 1974).

5. The influx of Quakers into Rhode Island, which started in 1657 and accelerated after 1672, greatly affected patterns of trade and transportation in the Ocean SAMP area. Quakers brought with them extensive regional and international commercial connections and Rhode Island Sound became the thoroughfare through which they operated.

6. Although Rhode Island shipbuilders constructed relatively large vessels during the 18th century, earlier vessels built in the colony, skiffs, pinnaces, shallops, ketches, were very

small. Ranging from 16-30 tons these vessels were used for trade and/or fishing. In 1649, Captain Jeremiah Clarke built a barque called the *Sea Flower* and, in so doing, became the first Rhode Island merchant to own a vessel larger than a shallop. In general, barques ranged from 30-50 tons. By the early 18th century, Rhode Islanders started building sloops with some regularity. Early centers of boatbuilding included Portsmouth, Newport, Wickford, and Dighton on the Taunton River (Bridenbaugh 1974). In 1708, Rhode Island merchants owned a total of 24 vessels. That number increased to 80 vessels by 1731, 120 vessels by 1740 and more than 500 by 1763 (McLoughlin 1986).

7. As Rhode Island's economy grew in the second half of the 17th and the early 18th centuries, Newport both led the way and benefitted the most from the expansion. Providence followed closely behind and became preeminent after the American Revolution.

8. In the 18th century Newport and Providence merchants made money in the strengthening Atlantic economy, shipping sugar, molasses, whale oil, spermaceti candles, livestock, fish, lumber, wheat, and slaves to ports on the Atlantic rim. Sometimes Rhode Island merchants participated in the infamous triangle trade of sugar, rum and slaves. Some merchant families like the DeWolfs generated huge profits from the slave trade, while others like the Browns, suffered periodic commercial setbacks. Virtually all ships *en route* to European and Caribbean ports passed through the Ocean SAMP area.

9. In the years following the American Revolution, Providence merchants pursued opportunities in the newer trades with South America, Australia, and Asian ports. The port of Providence remained preeminent into the 1820s and 1830s (Albion et al 1970; Kellner and Lemons 2004). One of America's earliest China Trade vessels, the *Ann and Hop*e, was lost off the coast of Block Island in January 1806.

10. The 19th century saw a pronounced decline in the volume and economic significance of Rhode Island's foreign commerce, particularly when compared to Boston and New York. Where Newport had been one of colonial North America's busiest ports, by 1832 the total tonnage of ships arriving from abroad to the Rhode Island ports of Providence, Bristol and Newport amounted to less than 30,000 tons. By contrast, Boston also recorded over 158,000 tons of arrivals from foreign ports and New York port more than 400,000 tons. Significantly, nearly all of the Rhode Island arrivals were American vessels—many of them possibly Rhode Island owned. About 13 percent of Boston's arrivals and more than 25 percent of New York's were foreign bottoms (22nd Cong. 2nd sess. S. Doc. 109). By 1849, the Rhode Island total had fallen to under 23,000 tons (with Newport only 3200 tons). That same year saw Boston's arriving foreign commerce reach 451,000 tons and New York 1,118,000 tons (27th Cong. 2nd Sess. S. Doc. 356).

11. Steam navigation became a component of Rhode Island's maritime sector in the early 1820s and grew in importance over the century. Rhode Island's first steamboat was reportedly the *Firefly* that operated between Newport and Providence in 1817. More significant, however, was the establishment of steam packet service between New York and New England by way of Long Island Sound. The first Long Island Sound-style steamboat, *The Fulton*, was launched in 1814 by Elihu Bunker, and by the early 1820s, all passengers traveling to or from Boston by steamboat passed through Providence (and

the Ocean SAMP area). After 1847, Fall River, Massachusetts replaced Providence on the New York/ Boston route, however, all of the steam traffic continued to pass through Ocean SAMP area waters (Albion 1972).

12. In 1869, there were 31 steamboats constituting about 27,000 tons in the Rhode Island fleet, a figure that compared favorably with neighboring New England states-- trailing Connecticut and Massachusetts--but surpassing Maine and New Hampshire. In addition, many of the Rhode Island steamboats were larger and reflected interregional rather than local routes (Report of Commerce and Navigation for the Fiscal Year 1869). This pattern was more pronounced in 1879, a year that Providence and Fall River each rivaled Boston in the tonnage of steamboats calling at their wharves. When combined, the volume of coastwise steamboat traffic entering Providence and Fall River reached an estimated 1,800,000 tons, surpassing New York port by nearly 300,000 tons (46th Congress, 2nd Session H.Exec.Doc. 7).

13. The combination of steam, brightly painted wooden hulls and deckhouses, and a desire for speed, in combination with primitive harbor facilities and other navigation hazards led to significant steamboat disasters in or near the Ocean SAMP area. Among them, the burning of Lexington in 1840; the grounding and destruction of the *Atlantic* on the northern end of Long Island Sound in 1846 (immortalized by a Currier and Ives lithograph). In Rhode Island off Watch Hill in 1872, the steamboat *Metis* collided with a schooner and sank. In 1880, the *Rhode Island* grounded and broke up near Bonnet Shores in Narragansett Bay. In 1907, the *Larchmont* was destroyed in a collision southeast of Watch Hill (See also Section 410.9). These were major disasters; many smaller steamboats including tugs and cargo vessels also suffered accident and loss in or near the Ocean SAMP area.

14. As the volume of maritime commerce along the Atlantic coast grew, the federal government assumed responsibility for establishing aids to navigation and protecting public safety with a system of lighthouses and lifesaving stations. Lighthouses established on Block Island, Sakonnet Point, Point Judith and Watch Hill (as well as in the Bay) are important representatives of this enduring federal program. One U.S. Lifesaving Service station remains on the west side of Block Island, another at Narragansett Pier and there are historic U.S. Coast Guard stations at Newport, Point Judith and Block Island.

15. Much of the domestic traffic through the Ocean SAMP area during the nineteenth century escaped formal documentation. Fishing vessels, yachts, tugs, and small steamers had little need to file paperwork. One area, coal (see also section 410.9) left a deep impression in historical documents and in the archaeological record. During the later nineteenth and early twentieth centuries, large quantities of coal transported by a fleet comprised of hundreds of vessels contributed to the highest levels of traffic and human activity in the recorded history of the Ocean SAMP area. In 1893, more than 60,000 vessels passed by Point Judith. (55th cong. 2d session House Document 60, Harbors of Refuge at Point Judith, Block Island, and Great Salt Pond, etc. 1903). Another stream of vessels passed south and east of Block Island and missed passing Point Judith. If counted, they would add thousands more voyages to the 60,000 figure.

16. In the early 20th century, during the 14 years known as "Prohibition," maritime activity in Rhode Island's offshore waters expanded to include the illegal transport of alcoholic beverages. Rum supply vessels typically lined up offshore beyond federal jurisdiction and supplied "rum-runners," small boats that could outrun Coast Guard enforcement vessels while smuggling alcohol back to shore. One source indicates that rum supply vessels serving Rhode Island communities anchored in the Ocean SAMP area about 15 miles southeast of Block Island, and that rum runners used the three entrances to Narragansett Bay to their advantage in attempting to avoid enforcement vessels (Hale 1998).

17. To understand the cultural and historical significance of the Ocean SAMP area it is crucial to recognize that maritime activity in Rhode Island underwent a dramatic transformation during the nineteenth century. While the state's foreign trade declined in significance, this did not mark a reduction in maritime traffic through state waters. Domestic maritime traffic through the Ocean SAMP area grew rapidly along with New England's industrial economy and urban areas; see also Section 410.9. Introduced early in the century, steamboats reached their peak as a passenger transport system simultaneously with the busiest era of coastwise commercial trade.

18. Although statistical tracking of domestic shipping in the United States was inconsistent, it is clear that overall vessel traffic levels through the Ocean SAMP area climbed exponentially during the nineteenth century, and that Rhode Island maintained a strategically important maritime sector. At the very time that Rhode Island's foreign maritime commerce was declining, growing numbers of steamboats and coastal merchant vessels transformed the Ocean SAMP area waters into a segment of a northeastern U.S. maritime highway equivalent in significance to the modern I-95 interstate.

19. For more detail on marine transportation, navigation and infrastructure in the Ocean SAMP area, see Chapter 7: Marine Transportation, Navigation, and Infrastructure.

410.8. Recreation and Tourism Landscape Context

1. The Ocean SAMP area and adjacent coastal communities have a long history as centers of marine recreational activity and as seaside tourism destinations. Since the mid-19th century, tourists have traveled to Rhode Island to enjoy the natural beauty of the South County beaches and to enjoy popular seaside resorts. Throughout the latter part of the 19th century, coastal areas were increasingly viewed as desirable destinations for vacation and recreation, and new forms of transportation enabled access to such locations. Coastal transport was flourishing at this time, and much of this trade was in the transport of passengers via steamboat between urban centers and seaside resort locations (Labaree et al. 1998). Companies such as the Fall River Line provided overnight steamboat service from New York, via the protected waters of Long Island, Block Island, and Rhode Island Sounds, to resort towns such as Newport, or to Fall River to connect with a Boston-bound train (Labaree et al. 1998). Passenger steamships also provided transport to Block Island, and to Narragansett Bay coastal camps and amusement parks such as Rocky Point in Warwick and Bullock's Point in Riverside (Albion et al. 1970).

2. Newport, dubbed the "City by the Sea," is considered by some sources to be the oldest summer resort in the nation. Many wealthy individuals from East Coast cities such as

New York and Philadelphia cruised to Newport by yacht through Ocean SAMP waters to enjoy what were considered the ideal sailing waters of Block Island Sound and Narragansett Bay. As such, Newport's rise as a resort community was due in part to its location adjacent to the Ocean SAMP area waters. Yachting and recreational boating had expanded dramatically in popularity in the late-19th and early-20th centuries throughout the U.S. due to the increase in discretionary income and leisure time amongst the upper classes. Narragansett Bay and the adjacent ocean waters have been popular locations for yacht racing activities and regattas since 1860. From 1930 to 1983, America's Cup racing was based out of Newport and the races were held just outside of Narragansett Bay off Brenton Point. Increasingly large crowds of visitors came to Newport and the adjacent waters; by one count, 100,000 people converged on Newport for the 1983 race (Kellner and Lemons 2004).

3. Block Island has also become a popular tourist destination since that time. The late nineteenth century marked a new era of tourism for the island, and the development of boarding houses, hotels, and cottages took place in a sequential pattern and led to a dramatic increase in the annual summer population on the island. (RIHPHC 1991) In addition to seaside tourism, Block Island has historically been a popular destination for recreational boaters and sailors. A 1948 cruising guide, *Yachting in North America*, identifies Block Island as a recommended destination.

4. For more detail on recreation and tourism in the Ocean SAMP area, see Chapter 6, Recreation and Tourism.

410.9. Energy Landscape Context

1. For nearly 300 years, the production and transfer of energy has shaped the cultural landscape of the Ocean SAMP area and adjacent coastal areas. At first, this shaping took place on land, but in the nineteenth century began to encompass the oceans.

2. For more than one thousand years before the European invasion of New England, Block Island supported large Indian populations who met their energy needs by taking sustainable quantities of wood from the island's dense forests. When Europeans settled Block Island in 1662, they commenced altering an ecosystem and visual landscape created through centuries of deliberate Indian activity (Cronon 1983). The limited coverage of trees and miles of stone fences marking the island today resulted from a heedless consumption of energy that soon exhausted the Island's forests. In 1721, Simon Ray, a town elder warned that the wasteful consumption of trees could force the community to abandon the Island for lack of fuel and building material. Survival came not from rational conservation but the discovery of Block Island's vast beds of peat. Derived from wet compressed decomposed organic matter, peat is the geological ancestor of coal. Using peat for fuel required Block Islanders to engage in the time consuming and laborious process of digging, flattening, stacking, and drying. Known as "tug" on Block Island, the fuel was carefully stored in "tug houses," built for this purpose. Between about 1750 (possibly earlier) and 1860, peat provided the only reliable source of energy on Block Island (Livermore 1877). The work required to gather and process peat made it an expensive source of energy when measured in the terms of human time and

effort. In effect, Block Islanders have been paying a premium for energy for nearly three hundred years.

3. An 1846 shipwreck in Cow Cove brought some interest in the use of coal as a new fuel for Block Island. However, it took some time for coal to be accepted on the Island with the shift from native peat to imported coal coming with the 1873 completion of federal protected harbor and landing (Old Harbor). Begun in 1870, the harbor ushered in a new era on the Island. According to Reverend Samuel Livermore, a Block Island historian writing in 1877, more construction had taken place on the island in the previous five years, than in the 50 year that preceded it. Livermore also described in the installation of the Island's first coal furnace, in the First Baptist Church in 1875. By that year, Islanders had gotten past their fears of the new energy source and had shifted to the coal for their household stoves.

4. New England's dependence on energy, delivered by sea through the Ocean SAMP area, resulted from major historical processes that transformed the United States into the world's leading industrial economy. Three processes directly associated with Rhode Island created unprecedented demands for fuel in New England: the introduction of stationary industrial steam engines and their application to textile milling, the expansion of heat intensive metal manufacturing processes, and the replacement of wood by coal for industrial energy. Just as industrialization shaped Rhode Island's historic landscapes on land, it exercised parallel effects in the Ocean SAMP area, leading or contributing substantially to hundreds of accidents and deaths through shipwrecks and to major alterations to the environment through the construction or improvement harbors, dredging of shipping channels, construction or improvements to lighthouses, docks, and lifesaving stations.

5. Although the "Ocean State," Rhode Island's history is more commonly associated with industry than the ocean. Many landmark moments in U.S. industrial history occurred in Rhode Island. In 1780, the Brown family installed the second industrial steam engine in the United States. Used to pump water, the engine kept an iron mine in service to supply a successful Brown blast furnace (Hunter 1985). Ten years later in a historic partnership, Moses Brown and the English millwright Samuel Slater constructed the first Arkwright-style textile mill in the United States (Coleman 1963). Like other American mills of the period, the motive power came from flowing water. However, in another Rhode Island first occurring in 1827, Slater established a steam-powered textile mill at Providence. Slater's steam mill also effectively inaugurated the New England energy lifeline. The anthracite coal used to fuel the mill originated from Pennsylvania's Schuylkill region (Coleman 1963). The several hundred-mile journey from mine to mill followed a freshwater path to Philadelphia where, loaded on a ship it embarked on a sea voyage that would pass through the Ocean SAMP area into Narragansett Bay and up to Providence.

6. The spread of the stationary steam engine such as the one used by Slater, facilitated the growth of industry in New England, and freed it from geographic dependence on waterpower. Stationary steam allowed industry to centralize in urban areas where mill, factory, and foundry operators could find readily available pools of skilled and unskilled labor, excellent sources of capital, and well developed ports and railway connections (Hunter 1985). Providence became the national capital for stationary steam with the

1849 patenting of the locally developed and manufactured Corliss Engine. With improved fuel efficiency and operational consistency, the Corliss became the nation's most important steam engine with nearly 500 constructed in Providence before the Civil War (Hunter 1985).

7. The Corliss works was one of many energy intensive precious and base metal enterprises that transformed Rhode Island into America's most industrialized state. By 1880, Rhode Island's steam engines produced 38.1 horsepower per acre; nearly double Massachusetts (21.3), four times New Jersey (9.8), and nine times New York (4.9) (Hunter 1979). Rhode Island's concentrated style of industrialization occurred across the urban areas of southern New England. Between 1850 when Americans burned an estimated 0.36 lbs of coal per capita and 1918, coal consumption grew 77-fold nationwide. A sizable proportion of this increase occurred in New England. By 1907, Americans consumed nearly 5 tons of coal per capita annually (Schurr 1960). In the industrialized areas of New England, the per capita consumption was much higher. That year, over 10 million tons of coal arrived at New England ports, 3.5 million in Providence alone. In 1918, perhaps the peak year for the coal trade, the regional figure of coal shipped by sea reached nearly 20 million tons (Graaebner 1974; Gordon 1978; *Atlantic Deeper Waterways Commission* 1908).

8. Unlike America's other industrializing regions, New England lacked native coal in industrial quantities. For New England's industries to thrive, they relied on inexpensive coal mined in Virginia, West Virginia, Kentucky, Ohio, and Pennsylvania and transported as cheaply as possible. During the second half of the nineteenth century an *ad-hoc* and grossly inefficient system of coal transportation by sea developed. Canals, rivers and railroads carried coal to the major Atlantic ports where it was loaded on a grimy armada of schooners, schooner-barges, and barges that sailed or steamed north to a bewildering array of destinations. Figure 4.1, reproduced below, depicts the general flow of coal from mine to New England. (It does not represent the several ports that shipped coal through much of the period when coal transportation to New England expanded. By the 1920s, coal shipping had centralized in Virginia). In 1903, midway through the expansion of the coal trade, the principal coal companies reported delivering product to 142 separate destinations, most of them in New England. The quantities sent were huge, but many of the vessels were not, and the trade required the constant employment of hundreds of vessels, many as small as 200 tons. In January of that year, Boston received 333,000 tons of coal and Providence 181,000 tons (57th Cong. 2nd Sess. H. Doc. 15 pts 7,8 & 9 *Monthly Summary of Commerce and Finance of the United States for the Fiscal Year 1903*).

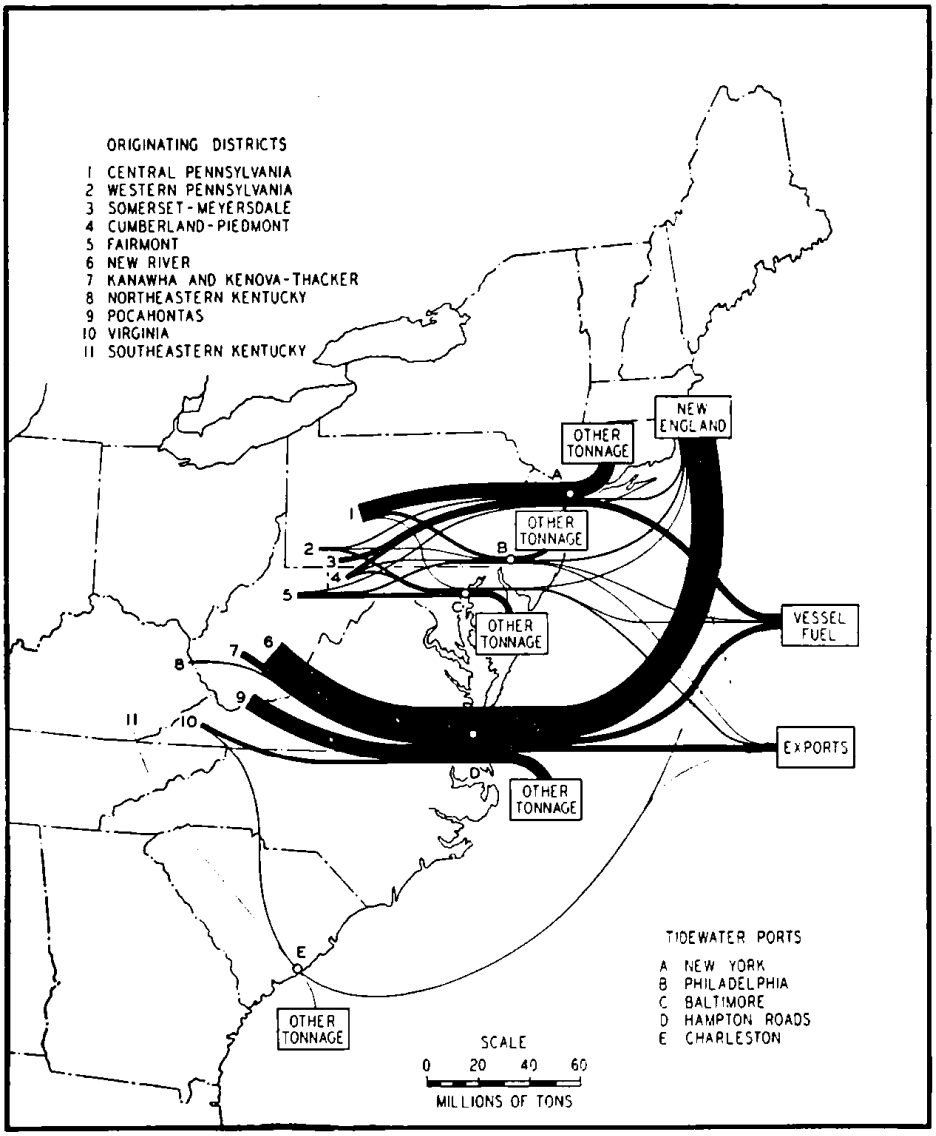


Figure 4.1. Tidewater shipments of bituminous coal, 1929. (Reproduced from Fritz and Veenstra, *Regional Shifts in the Bituminous Coal Industry*, p. 89.)

9. The large quantities of coal transported by a fleet comprised of hundreds of vessels contributed to the highest levels of traffic and human activity in the recorded history of the Ocean SAMP area. During the peak decades of coal, maritime traffic dwarfed the contemporary levels described in Chapter 7, Marine Transportation, Navigation, and Infrastructure, exceeding it by orders of magnitude in term of the numbers of ships and transits. In 1893, more than 60,000 vessels passed by Point Judith. Most of these (34,000) were classified as schooners. Barges accounted for an additional 9000 transits. It is difficult to estimate the proportion of these vessels engaged in the coal trade but it would include nearly all of the barges, and probably a significant majority of the

schooners. (55th cong. 2d session House Document 60, *Harbors of Refuge at Point Judith, Block Island, and Great Salt Pond, etc.* 1903). Another stream of vessels passed south and east of Block Island and missed passing Point Judith. If counted they would add thousands more voyages to the 60,000 figure.

10. At the beginning of the twentieth century, coal carriers followed one of two main routes through the Ocean SAMP area. Many, probably the majority, steered a course past Point Judith, sailing closer to the mainland than Block Island. Many of these small schooners came up through Long Island Sound, while others such as the *Addie Andersen*, a four-masted coal schooner bound for Providence passed east of Block Island before entering Narragansett Bay only to wreck on Whale Rock. When threatened by heavy weather, the vessels taking the offshore route sought protection on the lee sides of Block Island, a practice that contributed to many shipwrecks (55th cong. 2d session House Document 60, *Harbors of Refuge at Point Judith, Block Island, and Great Salt Pond, etc.* 1903).

11. Current data at least suggests that the majority of shipwrecks in the Ocean SAMP area involved transportation of coal to New England during a fifty year period between 1870 and 1920 when the United States developed into the world's largest industrial economy. The rapidly increasing demand for abundant AND inexpensive energy in New England led to the creation of an *ad hoc* system of transportation that relied on many low-cost and vulnerable types of vessels. Operated by poorly paid mariners, many of them black, the coal barges represented the lowest strata on the maritime social scale (*The Seaman's Bill, Hearings Held Before the Committee on Merchant Marine and Fisheries on House Bill 11372*, December 14, 1911).

12. The Ocean SAMP area's energy landscape is very important in the history of Rhode Island and greater New England. The coal vessels provided critical infrastructure without which the region would have languished economically after the Civil War. It has been a largely forgotten chapter in the state's maritime or industrial history. Where merchant vessels such as the famous Brown family East Indiaman *Ann and Hope* that wrecked at Block Island in 1815 were highly visible in cultural terms and associated with the wealth and social status of their owners, the coal vessels, with a few notable exceptions, rarely contributed to the social status to their owners, officers, or crew. Indeed other merchant mariners regarded the grimy armada of coaling vessels and their crews with mixture contempt and pity due to the low wages, harsh living conditions, mixed racial composition of the workforce, and the frequent accidents they endured (*The Seaman's Bill, Hearings Held Before the Committee on Merchant Marine and Fisheries on House Bill 11372*, December 14, 1911).

13. The rapidly growing New England coal trade operated within a unique context of obsolescence, innovation, and forced operational economy. It resulted in a complex and historically significant cultural landscape in the Ocean SAMP area consisting of shipwrecks, harbors, canals, lifesaving stations, and aids to navigation. Among the most common wrecks are those of merchant sailing vessels built in the 1850s, 1860s, and 1870s and repurposed to carry coal, towed in long lines behind steam tugs. As the demand for coal continued to grow and the supplies of older ships diminished, new classes of vessels evolved to fill the void, including some of the largest commercial sailing vessels ever built (Snow and Lee 1999). Shipyards also turned out specially

designed schooner-barges. Less majestic and more common, these sail-equipped vessels were supposed to possess some capacity for independent navigation; however, the historical and archaeological record demonstrates that this usually was not true, especially in heavy weather. Over time, however, the relentless drive for economy led to an increasing emphasis on even cheaper and easier to construct barges. These early "box-barges" had poor seagoing capacities and many foundered in Rhode Island.

14. The shipwrecks of the Ocean SAMP area's energy landscape are important heritage resources associated with the industrialization of American seafaring. While not every wreck merits preservation, they all potentially can contribute a broader understanding of human activity within the Ocean SAMP area. At the very least, many of the energy related shipwrecks could possibly be eligible for the National Register of Historic Places. In addition, specific areas of the Ocean SAMP may be eligible as cultural landscapes. Cultural resource managers in other locations are beginning to study and preserve industrial vessels such as those found in the Ocean SAMP. At the Stellwagen Bank National Marine Sanctuary in Massachusetts, NOAA archaeologists recently documented three coal schooners, *Paul Palmer*, *Frank A. Palmer*, and *Louise B. Crary* and prepared successful nominations to the National Register of Historic Places. Archaeologists working in the Great Lakes region have documented and nominated numerous industrial era steamers, schooner, schooner-barges and related craft (Marx and Lawrence 2006; Cooper and Jensen 1995). Determining which wrecks in the Ocean SAMP area's energy landscape should be included on the National Register will require a broader scale regional study. At this point, any coal vessels built more than fifty years ago are potentially eligible (if the vessel meets other necessary criteria).

15. There is no clearly defined temporal end to the coal era in the energy landscape. In 2007, as reported in Chapter 7, Marine Transportation, Navigation, and Infrastructure, more than 4 million tons of coal entered Narragansett Bay and transited through the Ocean SAMP area. The context of industrial shipwrecks, however, can be more tightly defined. During the 1920s, structural changes in the transportation of coal and advances in marine safety and navigation greatly reduced, although did not eliminate the wrecking of coal carrying vessels in the Ocean SAMP area. The centralization of coal shipping in Virginia and improvements in the receiving of coal at larger New England ports removed physical and economic roadblocks that prevented investments in safer large capacity coal barges and vessels. As long as waiting times to unload were irregular and often protracted, larger, safer, and more capital-intensive vessels could not compete with the inferior or less expensive vessel whose wrecks line the bottom and shorelines of the Atlantic Coast from Virginia through New England.

16. Coal dominates the archaeology of the Ocean SAMP area's energy landscape, but other fuels have left important marks. While the absolute volume of coal transported through the Ocean SAMP has continued to be high, its relative dominance in New England's energy lifeline slowly diminished after 1918 with rapid increases in the use of oil for fuel. In 1918, the burning of fuel oils produced the equivalent of 8% energy of the total energy produced by coal in the United States. By 1922, that figure had doubled to 16% and by 1935 reached 21.5% (Schurr 1960). Although coal in vast quantities fueled and continues to fuel New England's power plants, it was increasing amounts of petroleum in the form

of fuel oil, kerosene, and gasoline that provided the additional energy require to heat homes and power the millions of new motor vehicles then reshaping the country.

17. The history of transporting petroleum products by sea differs greatly from coal. It developed quickly and took on a highly rationalized form that included efficient port infrastructures for loading and unloading (Schurr 1960). Modern tankers first appeared in Europe in the 1880s, with the first American built tanker launched for Standard Oil in 1888. Tankers became more common with increased use of petroleum for fuel and this became increasingly true with the mass production of the automobile and the skyrocketing consumption of gasoline. In 1918, Americans consumed an estimated 74.5 million barrels of gasoline, a figure that grew 7-fold by 1939, the year that the tanker *Lightburne* ran aground and broke up on Block Island carrying a cargo of gasoline and kerosene (Schurr 1960; Snyder and Snyder 1998). The *Lightburne* was not the first petroleum-carrying vessel to wreck in Rhode Island. An older wreck with potentially more historical significance is the tanker *Llewellyn Howland* that ran aground and broke up on Seal Ledge, dumping thousands of barrels of fuel oil into the Ocean SAMP area in 1924 (Snyder and Snyder 1998). The *Howland'*s history is not well known; however, research by URI investigators suggests that it is a first generation oil tanker built in 1888, and a very likely candidate for the National Register of Historic Places.

18. Transporting energy by sea brings risks. In 1996, the *North Cape*, a barge containing 3.9 million gallons of home heating oil, grounded at Moonstone Beach in Rhode Island. The ensuing spill of 828,000 gallons was the one of the worst environmental disasters to occur in Rhode Island's waters. In terms of human use and their cultural and environmental impacts on the Ocean SAMP area, the *North Cape* grounding was but one of the latest in hundreds of energy related transportation accidents that have occurred over the past 170 years (USFWS n.d.).

19. In 2007, as reported in Chapter 7, Marine Transportation, Navigation, and Infrastructure, more than 6 million short tons of petroleum products entered Narragansett Bay via the Ocean SAMP area. In 2010, the transportation of energy dominates commercial shipping through the Ocean SAMP area, accounting for 80 percent of the volume of cargo entering Narragansett Bay.

20. The production and distribution of energy dramatically shaped in the landscape of the Ocean SAMP area and adjacent coastal places, including Block Island and Point Judith. Some of the landscape features such as historic shipwrecks associated with the transportation of coal and petroleum are easy to identify in this historical record and to associate with the energy landscape. The cultural and historical significance of this archaeological landscape is clearly high, but determining specific contributions of each individual wreck to the landscape will require further research and analysis. At a minimum level, these wrecks connect with a time in history (1870 – 1920) when the human uses within the Ocean SAMP area appeared more pronounced and its visual characteristics markedly different from 2010. In heavily traveled areas of the Ocean SAMP region, a typical day would have presented observers with an industrial maritime thoroughfare characterized by passage of hundreds of vessels and thousands of people. Modern harbors, industrial docks, dredged navigation channels, and legally proscribed shipping lanes that developed during this period are just a few of the non-shipwreck

landscape features that connect in meaningful and *documentable* ways with the Ocean SAMP area's energy landscape.

21. For more details on proposed renewable energy in the Ocean SAMP area, see Chapter 8, Renewable Energy and Other Offshore Development.

Section 420. Submerged Archaeological Sites in the Ocean SAMP Area

1. Ocean SAMP submerged cultural resource investigations were designed to give a broad understanding of the extent, significance, and types of underwater historic and archaeological sites in the area, as well the way these sites were tied into the submerged cultural landscape of Rhode Island.

2. Generating an inventory and database of known and potential submerged historic sites requires an examination of published sources and existing databases, as well as historic research, digital historic cartographic research, geophysical survey and geo-spatial database construction. While investigations of post-contact submerged cultural resources usually focus on shipwrecks, other types of submerged properties, including historic submarine cables, docks, wharfs and buildings, should also be considered. In the Ocean SAMP area, at least one of these additional types of cultural resources, historic submarine cables is important to both historic preservation and development plans.

420.1. Potential and Known Marine Archaeology Sites

1. While the Ocean SAMP area contains a rich repository of submerged historic sites, estimating the total extent of that resource base is difficult. The data necessary, whether it be historical, archaeological or geophysical, is frequently incomplete and/or inaccessible. This sometimes results in contradictory data sets that have to be carefully analyzed, amalgamated and ultimately rationalized. Only then can reliable estimates of the resource base be generated. URI researchers have made significant strides toward doing that for the Ocean SAMP.

2. Military vessels lost during war and commercial vessels after about 1840 are comparatively well documented in the historical and archaeological record. Many of the earliest and potentially most significant shipwrecks, however, are undocumented. In a similar vein, vernacular craft, including fishing boats, are poorly understood despite their place in Rhode Island history and their undeniable relationships with and effects on the ocean environment.

3. Information about shipwreck losses in the Ocean SAMP area comes in multiple forms. By far the most reliable database is held by the Rhode Island State Historic Preservation and Heritage Commission (the Official State Database), which contains listing for 1041 shipwrecks in Rhode Island state waters. The Official State Database also includes significant information collected over many years by the Rhode Island Marine Archaeology Project (RIMAP) headed by Dr. Kathy Abbass. The Rhode Island Historic Preservation and Heritage Commission (RIHPHC) and RIMAP have an ongoing strong and fruitful working relationship. In addition to the Official State Database, there exists at least two complementary datasets. First, the Northern Shipwrecks Database, comprising in excess of 100,000 shipwrecks, has at least 1,200 recorded in Rhode Island waters. Second, the National Oceanographic and Atmospheric Administration's Office of Coast Survey maintains the Automated Wreck and Obstruction Information System (AWOIS) that has 850 wrecks and obstructions for a region that extends from Long Island Sound to Cape Cod and includes Rhode Island waters.

4. Beyond these datasets, the University of Rhode Island has three databases; a working archaeological database that contains listings for 618 shipwrecks in Rhode Island waters (URI Working Database); a geophysical survey database that contains acoustic images of at least 30 shipwrecks in Rhode Island (URI Geophysical Survey Database); and a supplementary historic database, built from various sources including historic charts, and records of the US Life Saving Service, the US Coast Guard, the Navy and the Department of Commerce (URI Supplementary Historic Database).

5. The URI Supplementary Historic Database currently contains listings for 584 wrecking events in Rhode Island prior to 1908 as well as considerable information about non-shipwreck submerged cultural resources.

6. The historic cartographic research to support this database focused on geo-rectifying historic navigation charts for Block Island. The charts for 1914, 1934, 1957, 1966, 1968, 1970, 1971, 1972, 1973, 1975, 1977, 1978, 1985, 1996, 1997, and 1999 were geo-referenced and laid on top of the modern navigation chart. A similar procedure was followed with navigational charts for Block Island Sound, although in this case the process was less exhaustive. It did, however, incorporate data from the 1901 navigation chart of Block Island Sound which in turn was based on survey data from 1848. URI researchers also geo-rectified 1934 and 1999 charts of the Block Island Sound. In the process of doing this work they identified what was almost certainly the first modern hydrographic survey of Block Island waters – completed by the US Coast Survey in 1839. From these charts, researchers were able to map historic navigation corridors, hazards to navigation, obstructions, shipwrecks, shoaling, shoreline changes and patterns of maritime commerce.

7. All databases described above can be augmented with published dive guides - the most important of which are Marlene and Don Snyder's books *Rhode Island Adventure Diving* and Rhode Island Adventure Diving II; and Henry Keatts and George Farr's book, *The Bell Tolls: Shipwrecks & Lighthouses, Volume 1, Block Island*.

8. Outside government agencies, organized avocational groups, and academic institutions there are a wide array of people that possess critical information about shipwrecks and other submerged archaeological sites in Rhode Island. Among these are local users including commercial and recreational fishermen, and non-academic shipwreck experts including John Stanford and Mark Munro.

9. All of these databases and sources of information have strengths and weaknesses. While there is considerable overlap, there are also significant discrepancies between the datasets. As part of the Ocean SAMP process, researchers at the University of Rhode Island started to augment the Official State Database with extensive data from elsewhere. The final rationalized product will be an improved estimate of the location and extent of submerged cultural resources in the Ocean SAMP area. While this work is not yet complete, the progress made to date does allow for some preliminary analysis of the shipwreck resources in Rhode Island waters.

10. During the last 300 years, there have been at least 1,200 maritime accidents and disasters in Rhode Island and Rhode Island Sound that probably resulted in vessel loss and/or

deposition of cultural material. This number excludes many 17th and 18th century accidents that are much more difficult to track in the historical record. Of the 1,200 or more vessels lost in Rhode Island waters, approximately half occurred in the Ocean SAMP area. Of these, more than half have some locational association with Block Island. Other places strongly represented are the waters off Point Judith, Watch Hill and Beavertail.

11. It is difficult to know how many of the recorded maritime accidents and disasters left a material record that can be found, studied, protected and analyzed – but it is certainly a significant number. We have good location information for approximately 50 shipwrecks in the Ocean SAMP area, but given the number of known wrecks, many others clearly await discovery and assessment. The complete results from geophysical survey conducted as part of the Ocean SAMP process are not yet available, but when the archaeological processing of that data is complete, the RIHPHC will have additional information in their database. Much of the Ocean SAMP area remains un-surveyed for archaeological sites and important historic resources certainly lie in those areas.

420.2. Spatial and Temporal Distribution Patterns

1. Figure 4.2 shows the preliminary spatial distribution of reported Rhode Island shipwrecks. This data was compiled from multiple database sources, but it is yet to be fully analyzed and consolidated. Not all the shipwrecks have been confirmed and in a few instances the map contains more than one point for an individual shipwreck. Nevertheless and despite its weaknesses, the map shows identifiable spatial patterning from which some general conclusions might be drawn.

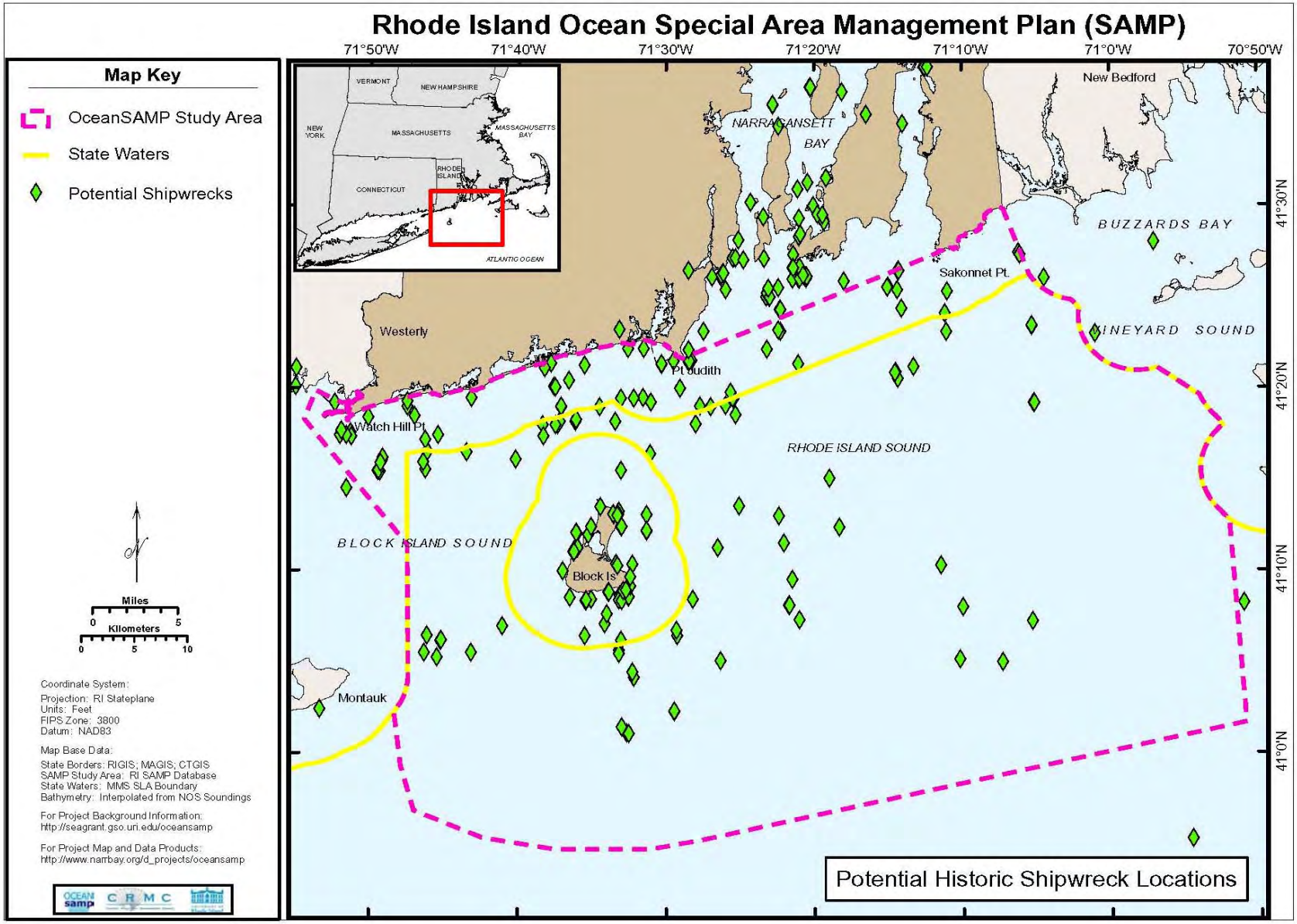


Figure 4.2. Potential historic shipwreck locations.

2. Block Island has been a focus of vessel loss in Rhode Island waters. Heavy levels of commercial traffic over the past three centuries combined with strong currents, storms and frequent periods of heavy fog created an environment in which shipwrecks on shore and collisions at sea were relatively common. The Ocean SAMP area shows another concentration of shipwrecks in a corridor that runs along the southern edge of the Rhode Island coast from Watch Hill to Point Judith. The lee shore and heavy levels of commercial and passenger traffic during the nineteenth century out of New York and along the southern coast of Connecticut and Rhode Island are largely responsible for this concentration. This heavier concentration of vessels along with dangers to navigation around Block Island, go a long way in explaining higher densities of shipwrecks in the northwestern part of the Ocean SAMP area. There is, however, an important caveat. The central-southern and southeastern parts of the Ocean SAMP area were further off shore and further away from land observation. Stricken vessels in these areas were less likely to be have been seen and less likely to have boasted survivors. In addition, there have been fewer modern attempts to map the ocean floor in the central and eastern parts of the Ocean SAMP area. As a result, our knowledge of these areas is less authoritative. They probably contain higher numbers of shipwrecks than are reflected current distribution patterns.

3. Figure 4.3 shows the temporal distribution of Rhode Island shipwrecks from the early 18th century to modern times, grouped by decade. The data comes from the URI Working Database, but analyses of other Rhode Island shipwreck databases mirror these results.

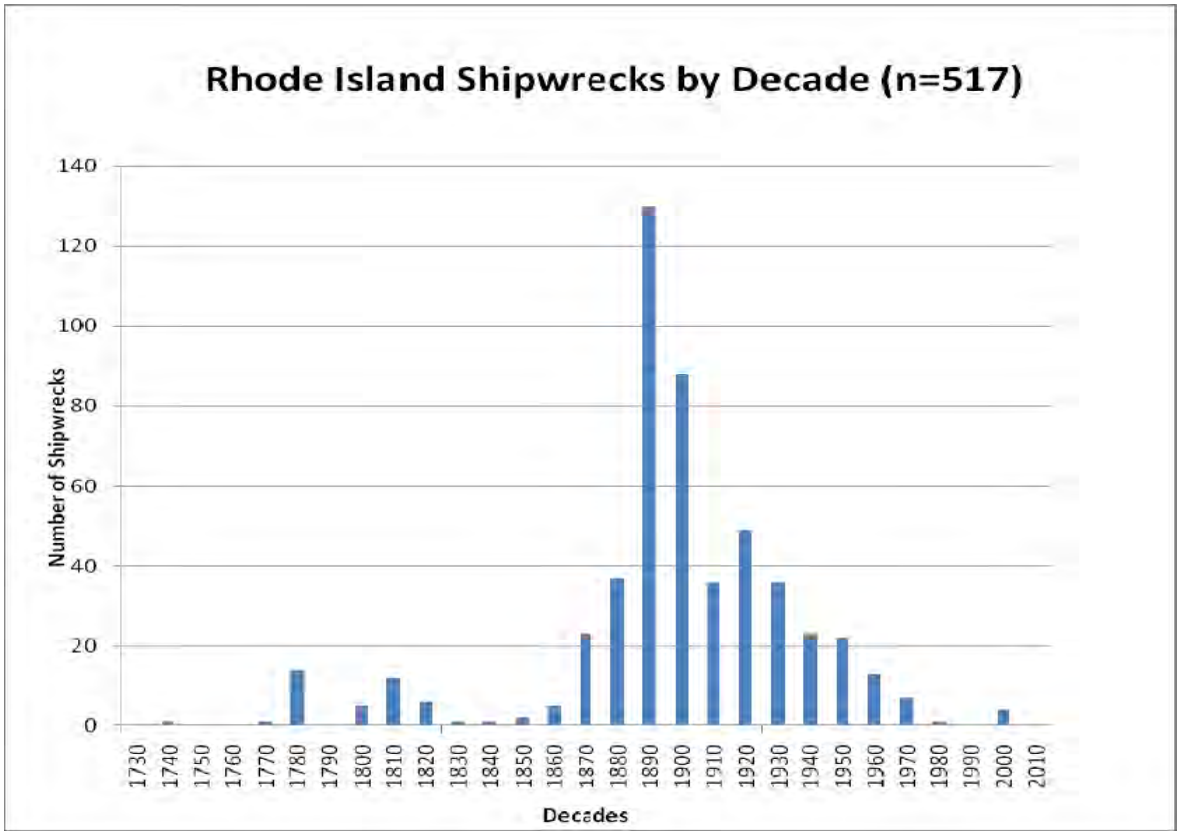


Figure 4.3. Temporal distribution of shipwrecks in the Ocean SAMP area (Mather 2010).

4. The graph shows a spike in the number of Rhode Island shipwrecks during the Revolutionary War and another during the first two decades of the nineteenth century. Starting in the 1860s, Rhode Island saw a sharp rise in the number of shipwrecks occurring in its waters. The numbers continued to rise, reaching their zenith during the 1880s. This certainly resulted from the rapid expansion of shipping activity across the Ocean SAMP area during America's most rapid period of industrial development. Demands for energy, particularly coal, in New England during the late 19th century caused hundreds of vessels a day to move through the Ocean SAMP area. Heavy traffic, hazardous waters and pre-electronic navigational instruments, provided a recipe for high losses of shipping and life. A decline in the number of shipwrecks per decade in the 20th century corresponded with improvements in navigational instruments and greater capitalization of U.S. shipping.

5. Table 4.3 lists shipwrecks in the Ocean SAMP area for which the location is known.

Table 4.3. Known shipwrecks in the Ocean SAMP study area.

Name	Type	Year Built	Year of Loss	Location	Water Depth	Description
Achilles	Freighter		1887	Off Block Island		
Annapolis	Wooden Barge	1918 at Wilmington, DE (?)	1945	Off Charlestown Breachway	85'	Lost as a result of a collision with the USN Submarine Moray. Possibly owned by P. Dougherty Co., Baltimore, MD.
USS Bass	Submarine	1924	1945	Off Block Island	160'	Converted to merchant submarine in 1940. Sunk by navy aircraft (PBY-5A) during target practice.
Belleville	Freighter	1950	1957	Off Brenton Point	25'	Headed from Boston to Philadelphia. Ran aground on Seal Ledge. Later dynamited by Corps of Engineers to remove wreckage that represented a hazard to navigation.
Black Point	Collier	1918	1945	North of Block Island, southeast of Point Judith	100'	Headed from Norfolk Virginia to Boston with 7000 tons of coal. Torpedoed by German submarine U-853. The Black Point was the last merchant ship sunk in American waters during WWII.

Name	Type	Year Built	Year of Loss	Location	Water Depth	Description
Bouquet	Barge		1906	Off Quonochontaug Beach	120’	
Crystal Lake	Steel Coal Barge		1946	South of Misquamicut Beach	130’	The Crystal Lake was one of two coal-carrying barges being towed by the tug Nottingham from Edgewater, New Jersey to Providence. She sank in heavy seas 4 miles south of Misquamicut Beach. 7 men died. The other barge had been left in New London.
Essex	Freighter (formerly Passenger Liner)	1890	1941	Southeast Point, Block Island	30’	Bound from Portugal to New York. A navigational error caused her to run aground on Southeast Point, Block Island. Close to the wreck of the Lightburne.
Explorer	Trawler	1978	1994	South of Aquidneck Island	90’	Hull pierced by floating debris (a 55-gallon drum).
George W. Humphries	Wooden Fishing Steamer	1877	1904	Brenton Reef	15’	Built in Philadelphia and owned by the American Fishing Company she ran ashore at Brenton Reef in 1904 when returning to Newport after fishing for menhaden. Navigational error.
Goliath	Tug		1942	Off Charlestown		
Grecian	Freighter	1899	1932	Off Block Island	100’	Bound from Boston to Norfolk in dense fog. Sunk after collision with a steamer called the City of Chattanooga. Later, the hulk was blown up to reduce risks to navigation.

Name	Type	Year Built	Year of Loss	Location	Water Depth	Description
F6F Hellcat	Fighter Aircraft	1941, 1942, 1943, 1944 or 1945	1945	Off Charlestown	20’	The aircraft experienced engine trouble during a patrol flight on October 21, 1945 in Rhode Island Sound. The pilot attempted to make an emergency landing at Charlestown Air Base, but was forced to make a water landing.
Hercules	Steam Tug	1880	1907	Off Misquamicut State Beach	15’	Built in Camden, NJ in 1880, home ported in New York, and owned by “Jay Steel Terminal” or more probably Jay Street Terminal, Brooklyn, NY. She had been chartered by the New York Herald in 1898 and dispatched to Cuba so that the paper’s correspondents could cover the Spanish American War. She was lost December 12, 1907 during a winter nor’easter. She struck “Old Reef”. She was bound from Newport for New London with 4 barges in tow.
Heroine	Fishing (dragger / trawler)	1899	1920	South of Watch Hill and Charlestown	80’	Built in Brooklyn NY, home ported in Boston, MA, owned by Commonwealth Fishing Company. Fishing off Block Island the fishing boat developed a leak and sank. Survivors picked up by another fishing boat, the Rose of Italy.
Idene	Fishing (dragger/ trawler)		1991	Off Block Island	85’	Scuttled off Block Island
Jennie R. Dubois	Schooner		1902	Off Block Island	90’	
L-8	Submarine	1917	1926	South of Beavertail	100'+	US Navy submarine, built during WWI and sunk as part of torpedo tests on May 26, 1926.

Name	Type	Year Built	Year of Loss	Location	Water Depth	Description
Larchmont (formerly the Cumberland)	Passenger Paddle Steamer	1907		Off Watch Hill	130’	Owned by the Joy Line. Bound from Providence to New York. Collided with the Harry Knowlton, a coastal coal schooner.
USS Leyden	Navy Steam Tug	1866	1903	Block Island	15’	Assigned to Torpedo Station, Newport. On route from Puerto Rico to Newport. Ran aground on south coast of Block Island in thick fog due to a navigational error.
Lightburne	Tanker	1919	1939	Block Island	30’	Headed from Providence to Port Arthur, TX. Ran ashore near southeast light in heavy fog and strong winds. She had 72,000 barrels of gasoline and kerosene on board at the time of her sinking.
Llewellyn Howland (formerly Wico)	Tanker	1888	1924	Off Newport	30’	Built at Tyneside, UK. Bound from Fall River to Portland, ME with 25,000 barrels of fuel oil. Struck Seal Ledge south of Aquidneck Island.
Lydia Scholfield	Three-Masted Schooner	1860	1891	Butterball Rock, South of Castle Hill.	25’	Bound from New Orleans to Providence with 7,000 barrels of cotton-seed oil. Ran ashore in heavy fog.
Mary Arnold	Tug		1940	Off Charlestown	60’	In November 1940, the Mary Arnold was towing a lighter (barge) and a dredger called the Progress from Greenwich, Conn, to Riverside near Providence. They anchored off Charlestown in a fierce storm. All vessels sank. On board the Progress were four seamen, none of whom had been to sea before.
Meteor	Collier		1926	Block Island	20’	

Name	Type	Year Built	Year of Loss	Location	Water Depth	Description
Metis	Wooden Passenger Steamer		1872	Off Watch Hill	130’	The Providence and New York Steamship Company converted the Metis from a freighter to a passenger liner in 1864. In August 1872, the ship was bound from New York, via Long Island Sound, to Providence. The vessels was overloaded and overcrowded. Sunk after collision with two-masted schooner Nettie Cushing. There was substantial loss of life.
Minerva	Spanish Brig		1810	Near Brendon Reef	20’	
Montana	Schooner Barge	1870	1907	Northwest of New Harbor, Block Island	90’	The Montana was one of two coal barges being towed by the tug Buccaneer from Baltimore to Providence in January 1907. Both were lost in a violent storm. The larger barge, the Ash, was lost 10 miles east of Fire Island, New York. The smaller barge, the Montana, was lost just northwest of New Harbor, Block Island. There is some evidence of overloading.
Neptune II	Fishing		1989	Off Sakonnet Point	85’	
Onodaga	Freighter	1905	1918	Off Watch Hill	40’	Bound from Boston to Charleston, SC with a general cargo. Headed for Long Island Sound to avoid potential U-boat attacks. Navigational error caused her to strike the reef off Watch Hill.
P. T. Teti	Tug		1972	Off Sakonnet Point	100’	

Name	Type	Year Built	Year of Loss	Location	Water Depth	Description
Progress	Dredge		1940	Off Charlestown	60’	In November 1940, the Mary Arnold was towing a lighter (barge) and a dredger called the Progress from Greenwich, Conn, to Riverside near Providence. They anchored off Charlestown in a fierce storm. All vessels sank. On board the Progress were four seamen, none of whom had been to sea before.
Puszta	Freighter	1911	1934	Block Island	20’	Built in Newcastle, UK. Owned by the Anglo-Hungarian Shipping Co. Bound from Providence to Key West. Ran aground at Clay Head, Block Island, in thick fog.
USS S-51	Submarine		1925	Off Block Island		
Spartan	Freighter		1905	Block Island	15’	
Troydon	Fishing		1995	Off Block Island	135’	
U-853	Submarine	1943	1945	Off Block Island	130’	The U-853 sank the Black Point on May 5, 1945. The US warships Amick, Atherton, Moberly and Ericsson sank the U-853 later the same day.

420.3. Submerged Telecommunication Cables and Corridors

1. Modern telecommunication cables and corridors are well understood in the Ocean SAMP area. The southern coast of Rhode Island has been heavily utilized for a succession of transatlantic communication cables. Cables currently “in service” include Transatlantic No. 12/13 (TAT-12/13), part of which runs from Green Hill, Rhode Island to Lands End, England; Gemini, part of which runs from Charlestown, Rhode Island to Oxwich Bay, near Swansea, Wales; and FLAG Atlantic 1 which runs from New York to the UK intersecting Long Island Sound and Block Island Sound. “Out of service” cables include Transatlantic No. 5 (TAT-5), part of which runs from Green Hill, Rhode Island to Conil, Spain; Transatlantic No. 6 (TAT-6), part of which runs from Green Hill, Rhode Island to St. Hilaire-de-Riez, France; and Transatlantic No. 10 (TAT-10), part of which runs from Green Hill, Rhode Island to Norden, Germany. The majority of these cables whether in service or not, run out of Green Hill, RI to the southeast and then south, passing between

3 and 9 nautical miles east of Block Island. The exceptions are TAT-12/13 and FLAG Atlantic 1, which run west of Block Island.

2. Historic cables, however, are less well understood than their modern counterparts, and under certain circumstances might be considered historic resources. They also present problems for the management of development projects. Of particular concern to marine planners in the Ocean SAMP region is the cable area off the southwest coast of Block Island, which runs across Blocks Island Sound to Montauk Point on the eastern end of Long Island. In an attempt to understand the origin of this area and its potential to house historic resources, University of Rhode Island researchers traced the cable laying history of Block Island Sound.

3. In 1880, Congress appropriated $15,000 for the U.S. Army Signal Corps to lay the first telecommunications cable from Block Island to the mainland. The work was complete in 1884. Although justified for military communications and the transmittal of weather information, Rhode Islanders clearly saw this as a way to attract Federal dollars for communication infrastructure that would allow connections with the otherwise isolated communities on Block Island. At the time, safety-at-sea was also an immediate concern. Throughout the state's history, shipwrecks and loss of life-at-sea in the Ocean SAMP area had never been higher.

4. The two-conductor cable ran from Sandy Point at the north end at the Block Island to Narragansett Pier (Annual reports of the War Department, 1899; An Act to Authorize the Laying of a Telegraph Cable from the Main Land in Rhode Island to Block Island, 14 Jan. 1880). Within two years, however, the cable was unserviceable and Congress appropriated an additional $18,350 to replace it. Lawmakers specifically recognized the importance of the Block Island cable and the role it played in connecting signal stations with life-saving stations and lighthouses. (Statutes of the United States of America, 1885-1886). In March 1888, the cable was rendered unserviceable for a second time. This time a vessel (possibly the schooner *William Jordan*), that had become stranded some time earlier, broke apart in a springtime storm and severed the cable. By the turn of the century, the Signal Corps had repaired the cable, but now started to question its military utility and its value for transmitting weather information. The cable's utility, however, for general telegraph communication, life–saving, shipping, and commerce was still acknowledged. According the Chief Signal Officer of the Army in 1889, the Block Island line, and a similar cable connecting Nantucket with the mainland, were "probably the most valuable of all the sea-coast lines, giving ….service to about 75,000 people during the hot summer months, and at the same time sending valuable vessel reports" (Annual Report of the Chief Signal Officer of the Army, 1889). He went on to question, however, the military utility of the cables and hinted at a transfer of ownership and responsibility.

5. In 1902, the Block Island cable, was transferred to the Weather Bureau, under the Department of Agriculture, on condition that the Bureau maintain it and allow military use of it during war. By this time, the salt-water environment and marine organisms (particularly *teredo*) had once again taken their toll on the communication infrastructure. The cable had become so badly deteriorated that the Department of Agriculture requested an appropriation of $40,000 for a complete replacement. This time *guttapercha* would be

used instead of rubber (Annual Reports of the Department of Agriculture, 1902; A Digest of Opinions of the Judge of the Advocates General of the Army, 1912). The current cable corridors from the north end of Block Island to the mainland stem from these years.

6. During WWII, as German submarines threatened the Atlantic coast of the United States, the U.S. military renewed its interest in signal stations and communication cables. As a result, the army and navy initiated an extensive cable laying operation, requiring governmental easements over private property on land and the designation of new cable corridors in Rhode Island Sound, Block Island Sound and Narragansett Bay. This cable infrastructure included cables that ran from Fort Greene (then near Point Judith) to Green Hill, and from there onto stations at Charlestown, Noyes Point and Watch Hill. It also included cables from Block Island to Fort Greene (near Point Judith) and Block Island to Montauk Point, Long Island. Block Island's southwest cable corridor originates from this time. Both the Block Island cables were de-accessioned between 1956 and 1957 (Submarine Cable Easements – Narragansett RI, 1957-1958, Record Group 269, GSA, 1922-1997; Submarine Cable Easements – Block Island, RI, 1956-1960, Record Group 121, Records of the Public Buildings Service, 1801-1976)

420.4. Paleo-Geographic Landscape Reconstruction

1. The strategy for doing cultural landscape reconstruction and surveying for inundated archaeological sites is fundamentally different from surveys to discover and characterize shipwrecks, because the landscape and any associated cultural sites are usually buried by continental shelf sediments. These shelf sediments have accumulated since the time of initial inundation of the landscape by global sea level rise caused by the progressive melting of continental ice sheets since the last glacial maximum. Because the time of initial inundation is a function of the original elevation of the site relative to rising sea level, the contact between the underlying sediments and the base of the shelf sediments is a time-transgressive surface. Therefore, lower elevation sites are inundated earlier than higher elevation sites.

2. The process of inundation by global sea level rise in Rhode Island and adjacent waters has been described by Oldale and O'Hara, 1980. The local stratigraphy that is produced by sea level rise has been described in detail by McMaster (1984) and Peck and McMaster (1991) and Boothroyd and August (2008).

3. The work of Peck and McMaster (1991) indicates that during inundation, a high energy surf zone environment, the shoreface, passes across the landscape, and material is actively eroded from the surface. An erosional surface covered by a later deposit of sand and gravel is indicative of the passage of the shoreface across the site. As indicated in Figure 4., the degree of erosion depends on the original topography of the site. Deep tributary valleys tend to have less erosion, whereas interfluves and trunk valleys have much more erosion. In studies of shoreline change of Rhode Island, Boothroyd indicates that preexisting sediment is removed to a depth of 1 meter below mean lower low water (MLLW) as the surf zone sweeps across the landscape (Boothroyd, pers. comm.). This means that approximately 1-2 meters of material is removed from tributary valley settings and significantly more from interfluves and trunk valleys. The present south shore of

Rhode Island provides a representative view of erosional processes and results that were active as the Sounds were flooded.

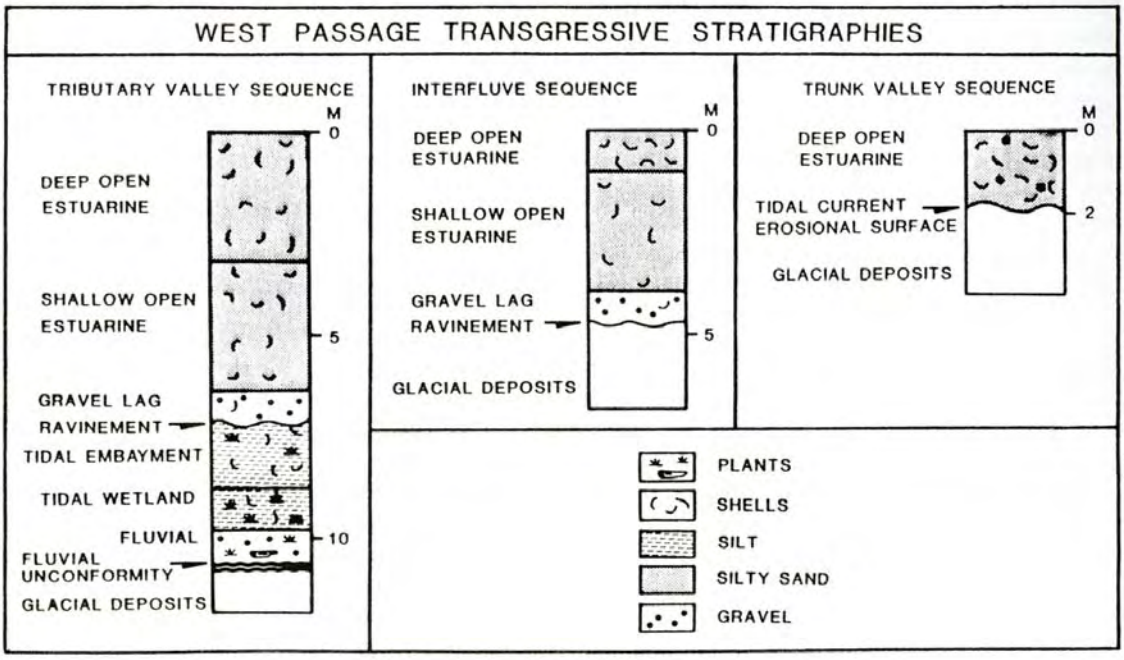


Figure 4.4. Illustration of West Passage transgressive stratigraphies (Peck and McMaster, 1991).

4. Closed topographic depressions and fresh water wetland settings that are inundated quickly and to significant depths (5-10meters water depth depending on setting) will tend to preserve the original terrestrial landscape (Robinson, pers. comm.). These settings have the highest potential for preservation of cultural landscapes and sites.

5. The erosional surface marks the altered original terrestrial surface after it has been worked by a high energy surf zone environment (Peck and McMaster 1991), but any cultural sites and artifacts that are preserved will be found in conjunction with the immediate overlying layer of sediment. This stratum can usually be readily detected and traced within a study area by high-resolution sub-bottom sonar (Coleman and McBride 2009).

6. The use of the sea level rise curve versus time (Figure 4.5), the current bathymetry, and the depth of the erosion surface below the current bottom can be used to reconstruct the cultural landscape at various points in time. The landscape scenarios shown in Figures 4.6., 4.7 and 4.8. indicate various closed depressions that may have contained post-glacial lakes. The shorelines of these lakes are likely areas for preservation of cultural sites. Rapid flooding by marine water into these basins may have preserved these sites.

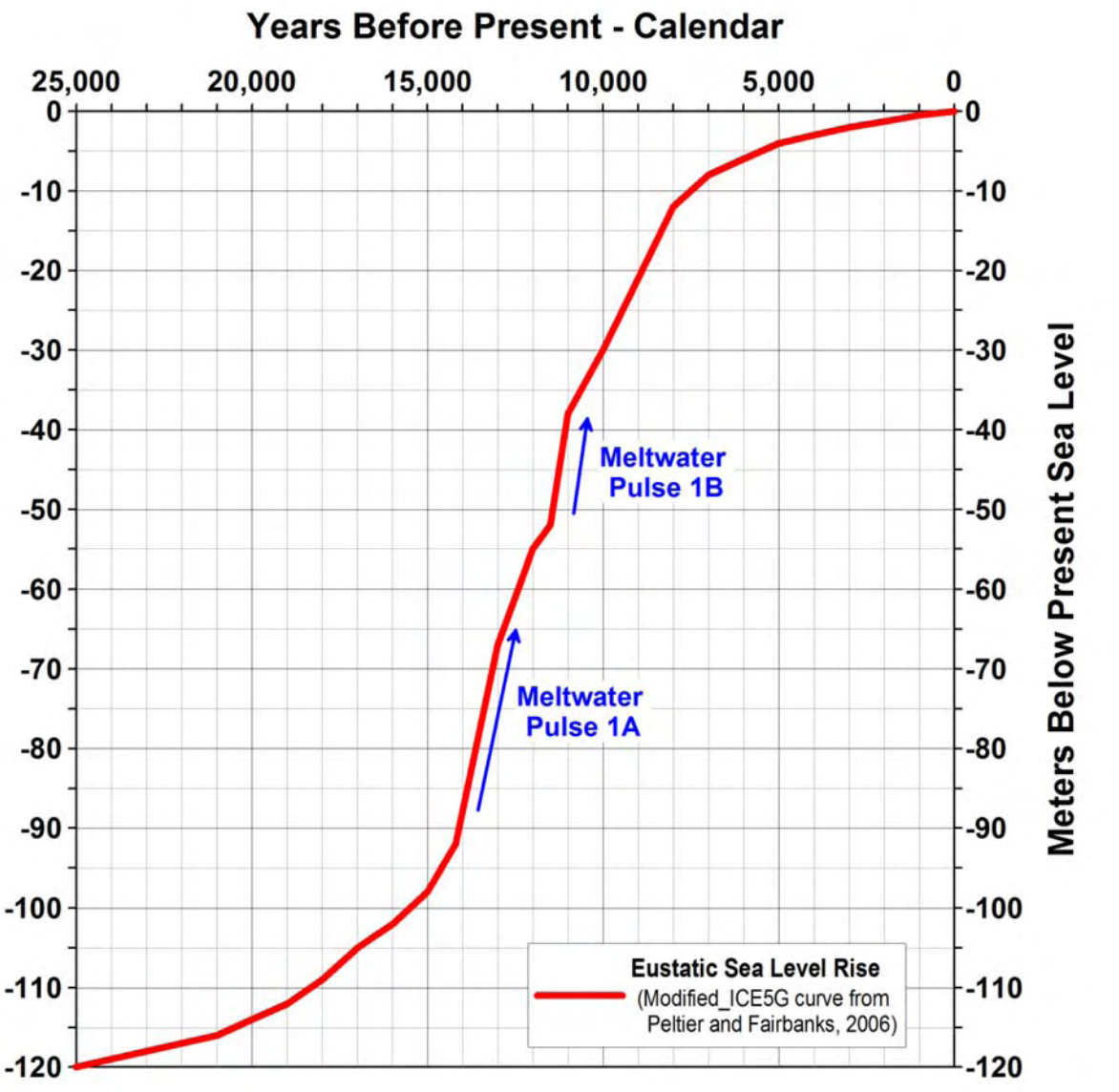


Figure 4.5. Graph of eustatic sea level rise caused by melting glacier ice (modified from Peltier and Fairbanks 2006).[1]

[1] Eustatic sea-level rise caused by melting glacier ice as the world emerged from the last glaciation. Curve illustrates slow sea-level rise from 25 – 20 thousand years ago. And then more rapid rise as the climate warmed. Meltwater pulses indicate particularly rapid rise as large sections of continental ice sheets were released to the ocean (1A – Antarctic, 1B – Laurentide) (Peltier and Fairbanks 2006).

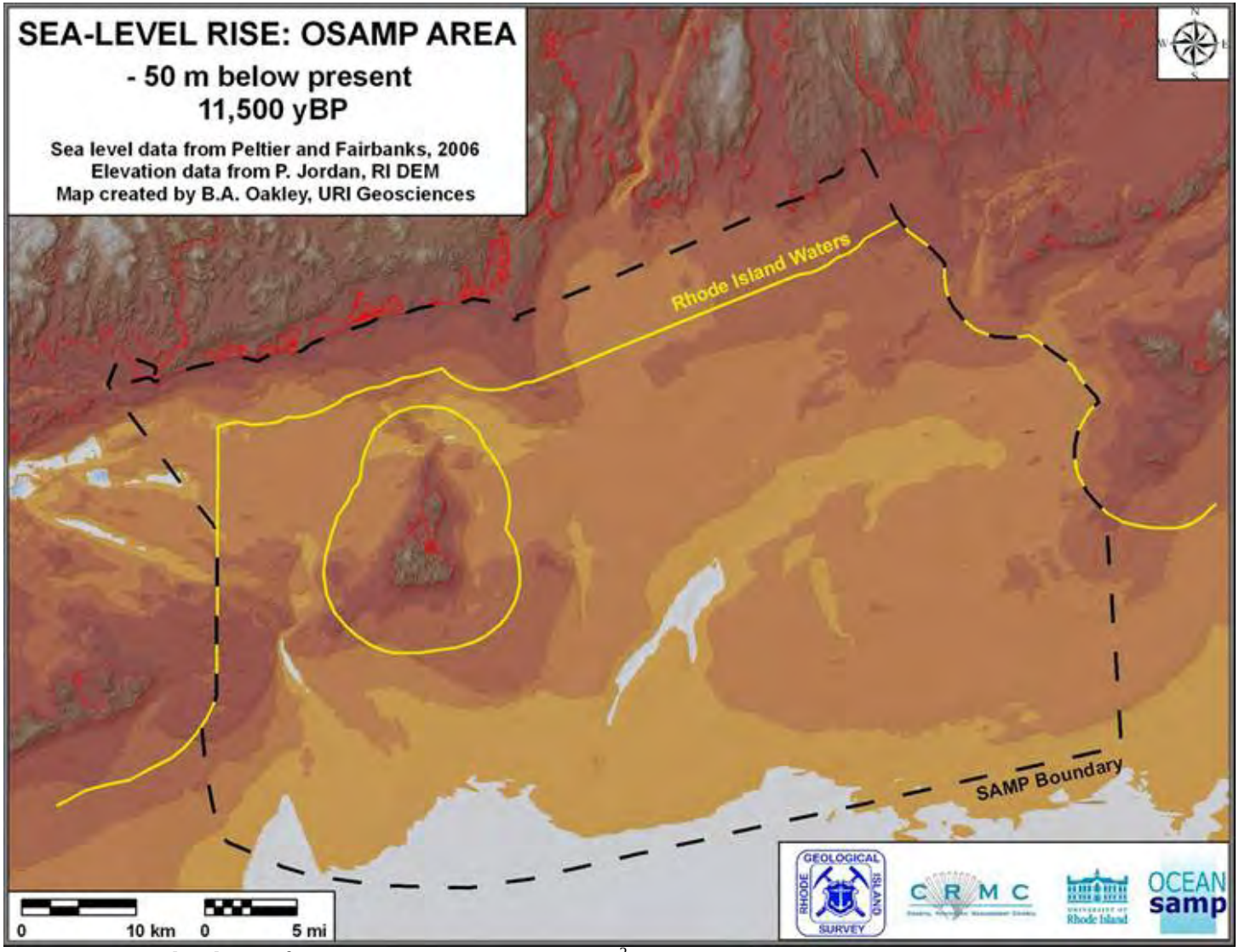


Figure 4.6. Sea level rise of Ocean SAMP area, 11,500 yBP.[2]

[2] Relative sea level was about 50 meters below present at 11,500 years before present (yBP). Brown colors represent dry land, blue represents water. Marine water is just impinging on the southern Ocean SAMP boundary. Other blue areas are possible lakes in closed depressions. The present day shoreline is shown by the red lines.

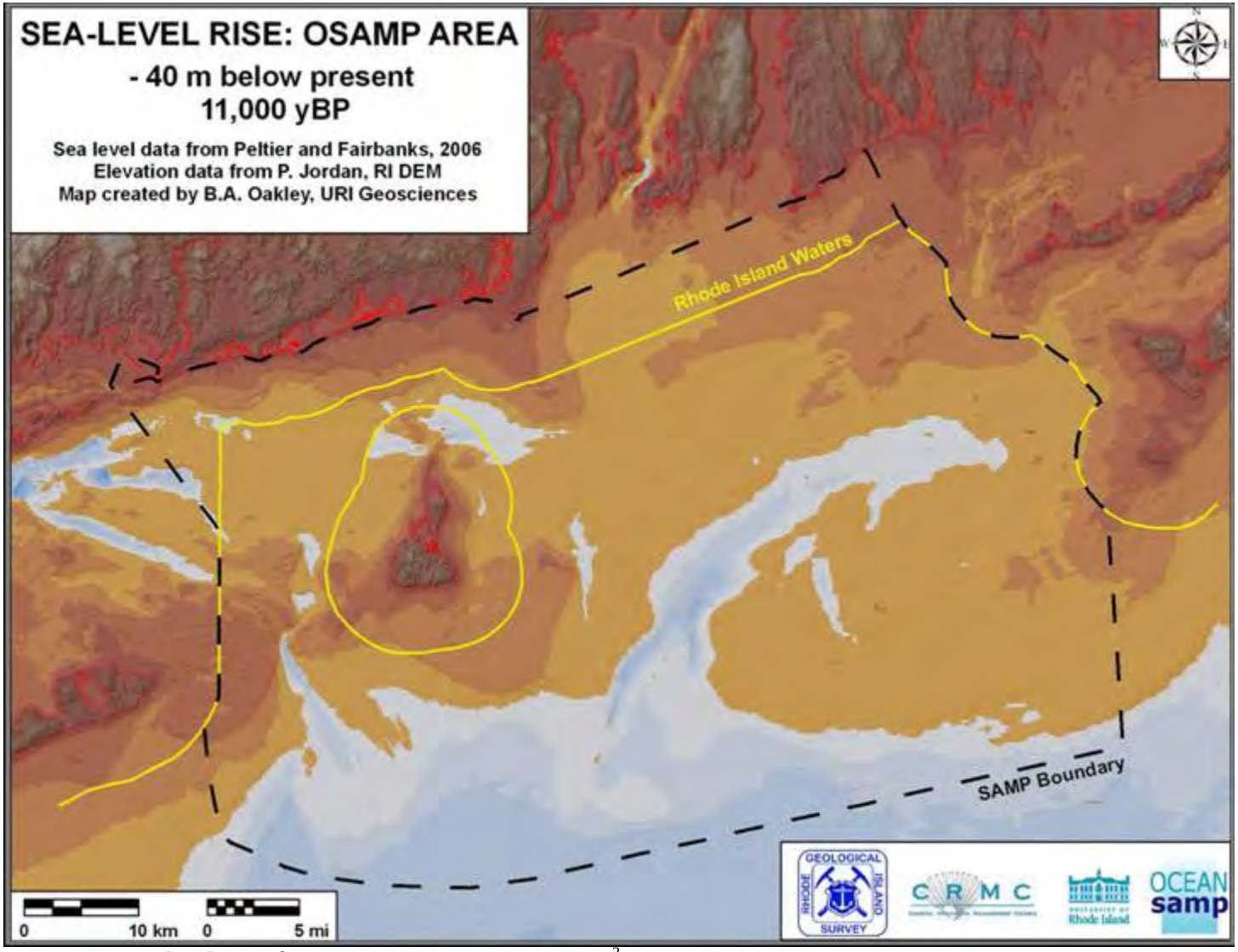


Figure 4.7. Sea level rise of Ocean SAMP area, 11,000 yBP.[3]

[3] Relative sea level at 40 meters at 11,000 yBP. Marine water has advanced into central Rhode Island Sound. The lakes shown are in part a product of the map production, some of the lakes seen in this image may have existed at an earlier time.

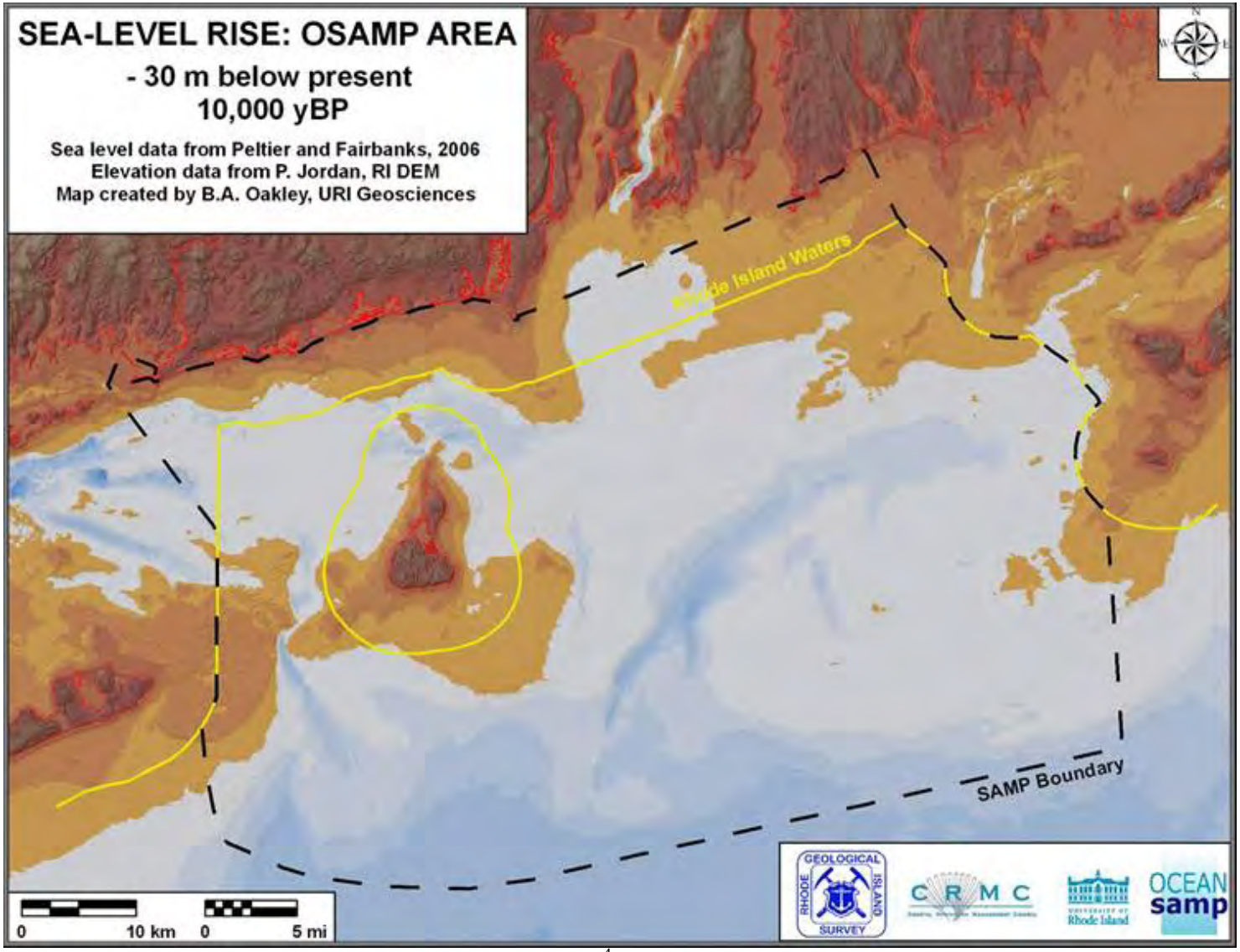


Figure 4.8. Sea level rise of Ocean SAMP area, 10,000 yBP.[4]

[4] Relative sea level at -30m at 10,000 yBP. Marine water now occupies significant parts of both Rhode Island and Block Island Sounds and Block Island has become an island.

7. Knowledge of the depth of the erosion surface below the present sediment surface can be used to assess the possible impact of cable installation on cultural resources. For example, in cases where cables might be installed, if the depth of jet plowing is shallower than the erosion surface, then there will be negligible impact.

8. Borings are needed to assess the impact of installation of future developments on cultural resources.

Section 430. Onshore Historic Sites Adjacent to the Ocean SAMP Area

1. Approximately 1,000 sites associated with Rhode Island's earliest history have been identified in the coastal zone. A number of these sites have contributed significant information to our knowledge of Rhode Island's past. Some have been listed on the National Register of Historic Places; others are included in National Register Archaeological Districts. Many archaeological sites in the coastal zone have been destroyed by development; others await discovery.

2. Rhode Island's ocean coastline has gone through several periods of change, but it has retained significant cultural resources from throughout its history. For some of these historic buildings and places that border the shore, the ocean is a fundamental aspect of their historic significance and for many others the coastal waters are an integral feature in their historic setting. A list of historic properties in the ocean coastal zone with a significant connection to the ocean follows. They include properties that are entered on the National Register of Historic Places or are candidates, potentially eligible for National Register listing. One property, Southeast Lighthouse on Block Island, is designated as National Historic Landmark.

3. The documentation of onshore land-based cultural and historic resources is important for the Ocean SAMP study area because offshore development proposals may present visual impacts to cultural and historic resources if the development is sited within the viewshed of onshore land-based sites designated as historically significant.

4. For onshore land-based sites, the overall perception of visual impacts of offshore developments is subjective and opinions vary about whether visual impacts for a given project are positive, negative, or neutral (Minerals Management Service 2007). Section 106 of the National Historic Preservation Act, however, requires that a given project's visual effect on historic resources be evaluated from National Historic Landmarks, properties listed or eligible for listing on the National Register of Historic Places, or Traditional Cultural Properties (Minerals Management Service 2010).

5. For offshore development proposals, an Area of Potential Effect (APE) is defined to include visual impacts specifically related to onshore land-based National Historic Landmarks, properties listed or eligible for listing on the National Register of Historic Places, or Traditional Cultural Properties (Minerals Management Service 2010).

6. The Criteria of Adverse Effect defined in Section 106 of the National Historic Preservation Act [36 CFR 800.5(a)(1)] states, "An adverse effect is found when an *undertaking may alter, directly or indirectly, any of the characteristics of a historic property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association."* Examples of adverse effects are listed as including, but not limited to, the following [36 CFR 800.5(a)(2)]: *"(v) Introduction of visual, atmospheric or audible elements that diminish the integrity of the property's significant historic features."*

430.1. Properties Listed on the National Register of Historic Places

1. The National Register of Historic Places is the federal government's official record of properties that have been evaluated for their significance in American history and determined to be worthy of preservation. Properties listed in the National Register include individual buildings / structures, historic districts, and archaeological sites. Rhode Island properties listed in the National Register include colonial houses, farms, Victorian neighborhoods, factory villages, diners, monuments, military bases, seacoast villages, suburban neighborhoods, etc. (RIHPHC 2010)

2. The Rhode Island Historical Preservation and Heritage Commission (RIHPHC) serves as the State Historic Preservation Office (SHPO) for Rhode Island. RIHPHC maintains records of listed and candidate properties in the state, along with survey publications for each of the Rhode Island's 39 towns, for specific neighborhoods, and for thematic projects.

3. There are 33 properties in nine Rhode Island municipalities within or adjacent to the Ocean SAMP study area listed on the National Register of Historic Places.

4. Only one property within the study area, Block Island Southeast Light in the Town of New Shoreham, is designated as a National Historic Landmark (NHL). National Historic Landmarks are buildings, sites, districts, structures, and objects that have been determined by the Secretary of the Interior to be nationally significant in American history and culture. All National Historic Landmarks are included in the National Register of Historic Places (NPS 2010). Southeast Light was built in 1874, and the National Historic Landmark Study completed for Southeast Light lists the period of significance 1874-1929. The statement of significance defines Southeast Light as, "…outstanding as one of the finest lighthouses constructed by the U.S. Light House Board in the 19th century." (Reynolds 1997)

5. Table 4.4 lists historic properties identified by RIHPHC that are in the ocean coastal zone and listed on the National Register of Historic Places, or designated National Historic Landmarks (NHL).

Table 4.4. Selected properties listed on the National Register of Historic Places in the ocean coastal zone, Little Compton to Westerly (RIHPHC, April 2010).

Town	Name of Property	Location	Date of Listing on NRHP
Charlestown	Fort Ninigret/The Niantic Fort	Fort Neck Road	4/28/1970
Charlestown	Babcock House	Quonochaontaug	1/1/1976
Jamestown	Beavertail Light	Beavertail Road	12/12/1977
Jamestown	Horsehead/Marbella	240 Highland Drive	6/16/1999
Jamestown	Fort Dumpling	Ocean Street	3/16/1972
Little Compton	Sakonnet Light Station	Little Cormorant Rock	5/10/1983
Little Compton	Stone House Inn	122 Sakonnet Point Road	4/2/2008

Town	Name of Property	Location	Date of Listing on NRHP
Middletown	St. George's School: Church of St. George, Little Chapel, & Memorial Schoolhouse	372 Purgatory Road	11/12/2004
Middletown	Smith-Gardiner-Norman Farm HD (Paradise Farm)	583 Third Beach Road	6/16/2008
Middletown	Clambake Club of Newport	353 Tuckerman Avenue	11/7/1995
Middletown	Lyman C. Josephs House	438 Walcott Avenue	5/2/1975
Narragansett	Ocean Road Historic District	Ocean Road, Hazard and Newton Avenues	8/18/1982
Narragansett	Dunmere	560 Ocean Road	9/23/2005
Narragansett	Point Judith Lighthouse	1470 Ocean Road	3/30/1988
Narragansett	Ocean Road Historic District	Ocean Road, Hazard and Newton Avenues	8/18/1982
New Shoreham	Hygeia House	Beach Avenue	10/22/2002
New Shoreham	U.S. Weather Bureau Station	Beach Avenue	8/4/1983
New Shoreham	Peleg Champlin House	Rodman Pond Lane	8/1/1982
New Shoreham	Block Island North Light	Sandy Point	5/23/1974
New Shoreham	Block Island South East Light (National Historic Landmark)	South East Light Road	8/6/1990; NHL: 9/25/1997
New Shoreham	Great Salt Pond Archaeological District		2/15/1990
New Shoreham	Old Harbor Historic District	All property within a 2,000-foot radius of the Village Square, at the intersection of Water, High, and Spring Streets	5/8/1974
Newport	Castle Hill Lighthouse	Castle Hill, off Ocean Ave., at the west end of Newport Neck	5/31/1972
Newport	Bellevue Avenue National Historic Landmark District (National Historic Landmark)	Both sides of Bellevue Avenue from Memorial Boulevard to the Atlantic Ocean at Land's End; bounded, generally, on the east by Easton Bay and on the west by properties on the west side of Bellevue Avenue	NHL: 5/11/1976
Newport	Ocean Drive National Historic Landmark District (National Historic Landmark)	Including all of Ocean Drive, from Almy Pond around and back to Wellington Ave. and Newport Harbor	NHL: 5/11/1976
South Kingstown	Theatre-by-the-Sea	Card's Ponds Road	7/10/1980
South Kingstown	Hale House	2625A Commodore Oliver Hazard Perry Highway	6/5/2007
South Kingstown	Willow Dell	2700 Commodore Oliver Hazard Perry Highway	11/21/1996
South Kingstown	Admiral Dewey Inn/ Dewey Cottage	668 Matunuck Beach Road	5/7/1992

Town	Name of Property	Location	Date of Listing on NRHP
South Kingstown	Browning's Beach Historic District	Card's Pond Road	9/5/1997
South Kingstown	Potter Pond Archaeological District		12/10/1987
Westerly	Weekapaug Inn	25 Spray Rock Road	1/25/2007
Westerly	Watch Hill Historic District	Bounded roughly by Breen, Watch Hill and East Hill Roads; Block Island sound; Little Narragansett Bay; and Pawcatuck River	9/5/1985

430.2. Selected National Register Candidate Properties

1. Table 4.5 lists candidate properties identified by the RIHPHC that are in the ocean coastal zone and considered to be eligible for nomination to the National Register of Historic Places.

Table 4.5. Selected National Register candidate properties in the ocean coastal zone, Little Compton to Westerly (RIHPHC, April 2010).

Town	Name of Property	Location
Charlestown	Arnolda Historic District	
Jamestown	Fort Burnside	Beavertail Road
Jamestown	Fort Wetherill	Fort Wetherill Road
Jamestown	Harbor Entrance Control Post	Beavertail Point
Little Compton	Warren's Point Historic District	
Little Compton	West Main Road Historic District	
Little Compton	Goosewing/Tunipus Farm	Long Highway
Little Compton	Simmons-Manchester House	106 Sakonnet Point Road
Middletown	Paradise Road Historic District	
Middletown	Renfrew Cottages	Renfrew Park
Middletown	John C. Bancroft House	675 Tuckerman Avenue
Narragansett	Fort Nathanael Greene	Old Point Judith Road
Narragansett	US Coast Guard Station	Point Judith
New Shoreham	Block Island Historic Landscape District	
New Shoreham	US Coast Guard Station	Coast Guard Road (DOE)
New Shoreham	US Life-Saving Station	Cooneymus Road
New Shoreham	Vail Cottages	Mohegan Trail
New Shoreham	Mohegan Cottage/Bit O'Heaven	Snake Hole Road
South Kingstown	Windy Meadows, Weeden and Harbet Farms Agricultural District	Matunuck Schoolhouse Road
South Kingstown	Samuel Perry Farm	645 Matunuck Schoolhouse Road
South Kingstown	Henry Palmer House	Old Succotash Road
Westerly	Weekapaug Historic District	
Westerly	Misquamicut Golf Club	Ocean View Highway

430.3. Block Island Sites Eligible for the National Register

1. Block Island sits directly within the Ocean SAMP study area and has a number of historically significant onshore properties that are either listed on the National Register, or considered to be eligible for listing. The types of historic properties on Block Island have been categorized into: early houses; structures associated with Block Island's maritime history; farms; buildings associated with Block Island as a resort; and landscape (RIHPHC 1991). Detailed inventory information on many properties considered to meet National Register eligibility criteria can be found in *Historic and Architectural Resources of Block Island, Rhode Island (*RIHPHC 1991).

2. Table 4.6 lists structures and sites from 1680 – 1948 on Block Island/Town of New Shoreham as identified by the Block Island Historical Society as either eligible for the National Register or contributing to the historic character of the island's scenic corridors, streetscapes or sense of place. (Compiled by Pamela L. Gasner for the Town of New Shoreham, 2008)

Table 4.6. Structures and sites from 1680 – 1948 on Block Island/Town of New Shoreham considered eligible for the National Register or contributing to historic character of the Island (compiled by Pamela L. Gasner for the Town of New Shoreham, 2008).

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assessor's office)	Original owner and/or building name	Past/Present building name	Setting significance
17	9		1691	1694	Aaron W. Dodge	Myrtis Littlefield/ Tom and Esther Littlefield	Scenic corridor on Old Town Road.
15	2	1	1700	1700	William B.S. Ball	Johnson's	Rural historic landscape; scenic corridor off Dories Cove Road.
3	103	1	1720	1720	Capt. Samuel Littlefield	Allen Littlefield(son); Karl Erickson; Alfred D. John; Spencer Farm; Littlefield Bee Farm	Scenic corridor off Corn Neck Road to Maze walking trails and Clayhead; rural historic landscape.
2	26		1750	1790	Elias Littlefield/ John Hayes	Edward Hayes/ Miss Susan Morgan/Ellison Property	Scenic corridor on Corn Neck Road.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
3	142		1750	1790	Nathaniel Littlefield	Littlefield Farm/Jeremiah Littlefield (Jerry's Point) Edgar Littlefield/John Littlefield/ The Littlefield Homestead	Rural historic landscape; scenic corridor on Mansion Road; historic barn; property next door to Littlefield Farm.
4	18		1760	1760	Thomas Mott	Mitchell Farm; Adrian's	Rural historic landscape; scenic corridor on Corn Neck Road; historic background buildings.
14	11		1780	1780	Samuel Allen Sr.	Frank Allen	Scenic corridor on Dickens Farm Road off Cooneymus Road.
15	13		1781	1700	Asa R. Ball	Goss Homestead	Scenic corridor off West Side Road.
18	35		1781	1781	Charles C. Mitchell	"Breezy Hill;" Reg Conley's	Scenic corridor off Center Road.
3	118		1790	1790	Silas Niles Littlefield	Abby Littlefield Home/Amazon Littlefield (Silas's Son and Capt. Of L.S.S. at Harbor) Nicholas Ball/ William O. Ball/Luella Ball	Rural historic landscape; scenic corridor on Mansion Road; historic background buildings.
2	19	1	1790	1790	Nicholas Littlefield Jr.	James Maxfield/ Jimmy Maxfield	Scenic corridor on Corn Neck Road.
11	11		1797	1797	Sylvester Mitchell	Henry C. Sprague/ Wilbur and Virginia Mitchell	Scenic corridor on Mitchell Lane.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
15	64		1800	1800	Amos W. Mitchell	Jon Grant	Rural historic landscape; scenic corridor off Dories Cove Road.
19	68		1800	1800	Abel Sprague	Adrian L. Sprague	Scenic corridor on West Side Road.
13	1		1810	1810	Horatio W. Allen	"Red Shutters"/ Rev. Stanley and Winnie Pratt	Scenic corridor on West Side Road.
19	39		1820	1812	Peleg C. Champlin	Weeden Champlin/ Susan Ball Dodge/ Mary Madison Miller/ Frederick Ritchie and Ethel Colt Ritchie/ Dr. Gerald F. Abbott	Rural historic landscape; scenic corridor on Rodman Pond Lane; listed on National Register.
18	66		1825	1825	John Carr Dodge	Natalie Mitchell/ Gill W. and Ruth Y. Peabody	Scenic corridor off Beacon Hill connecting to greenway trails.
19	51	1	1827	1825	Edward Hull Champlin	Champlin Farm/Edward Peckham Champlin (1865 - 1942)/Robert Paine Champlin and Lillian Mae Chace Champlin/ Kathryn Champlin-Kernan	Rural historic landscape; scenic corridor on Coast Guard Road (Champlin Road).

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's record)	Original owner and/or building name	Past/present building name	Setting significance
15	78		1836	1830	John Mott	Otis Mott Farm/Otis V.P.Mott/Mrs. James F. Jackson(1950)	Scenic corridor on West Side Road/ historical significance.
3	92		1840	1800	Capt. Hiram D. Ball	Hiram 'Ansel' Ball (son)/Mrs. Robert Barker/Louis Beauregard/ "Old Beauregard Homestead"	Scenic corridor off Corn Neck Road.
8	103		1840	1840	Capt. Welcome Dodge Sr.		Scenic corridor off Amy Dodge Lane (New Haven House Road).
14	21		1840	1840	Jeremiah Allen		Scenic corridor off Dickens Farm Road.
4	19	1	1840	1840	Joshua Chase Smith	Byron Littlefield	Rural historic landscape; scenic corridor off Corn Neck Road; rural laneway.
8	222		1840	1840	John Ed Willis	Richard Heller	Scenic corridor on top of High Street.
15	58	1	1845	1800	Samuel George Mitchell	Stanley Smith	Scenic corridor off West Side Road.
4	53		1850	1850	Capt. Nathaniel L. Willis	Willis Homestead	Landmark farm; scenic corridor on Corn Neck Road.
6	18		1850	1850	Almanza Littlefield Farm	Oscar Willis House/ Wagenseil	Scenic corridor on Old Town Road; historical significance.
8	19		1850	1850	Freeman M. Millikin		Scenic corridor on Mohegan Trail; rural laneway with open field and stonewalls.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
8	212		1850	1850	Capt. Arnold R. Millikin	Ambrose Rose/Anne Reed/ "Rosecrest"	Scenic corridor on Pilot Hill Road.
16	25	1	1850	1850	Silas Niles Littlefield, 2nd	William T. Martin	Rural historic landscape; scenic corridor off West Side Road and Old Mill Road.
16	71		1850	1850	Parsonage for West Side Church	duPont Family	Rural historic landscape; scenic corridor off Beacon Hill Road.
8	137		1850	1850	Caleb W. Dodge Jr.	David Dudley and Warren Doolittle III	
15	74		1850	1965	William Allen		Scenic corridor off Dunn Town Road.
15	33		1852	1790	Caleb Littlefield Rose	Tormut Rose Farm	Scenic corridor on Dories Cove Road.
2	31		1852	1860	Benjamin Littlefield	Mr. Douglas, artist; Henry Oehrle of Newport; Bella Littlefield's; Albert and Bella Littlefield Gardiner(grand niece of Benjamin)/Dr. Gerald Abbott and Tom Abbott/Barn: WWII Bunker	Scenic corridor on Corn Neck Road adjacent to Hodge Property walking trails; rural historic landscape; WW II lookout bunker in converted barn; view of North Light; historic background buildings and stonewalls.
16	73		1855	1855	Nathaniel Latham	Stephen duPont	Scenic corridor off Beacon Hill Road; rural historic landscape.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
8	66		1860	1860	Charles H. Hall	John Steffian	Scenic corridor on Mohegan Trail.
12	11		1860	1880	John P. Champlin		Scenic corridor.
6	46		1867	1867	Lorenzo Dodge	Fair View Cottage/ Bob Rice	Scenic corridor on Old Town Road intersection and Conn. Avenue.
10	17		1870	1920	School # 3	Gully School/ George Enos	Scenic corridor on Payne Road.
5	81		1877	1854	"Centre" School #2	Private home after 1933	Scenic corridor on Center Road; historical significance.
10	23	2	1877	1876	Edward S. Payne	Payne Farm/ Payne Farm Homestead	Scenic corridor off Payne Road.
2	10		1879	1878	Samuel Hayes	"Hayes Cottage"/ Gordon and Frankie Smith	Scenic corridor off Corn Neck Road.
18	24	2	1880	1850	James A. Dodge	Dodge Homestead; Erlanger's; Transue's	Scenic corridor on Beacon Hill; rural historic landscape.
9	101		1880	1872	Lovice R. Conley		Scenic corridor on Pilot Hill Road.
8	108		1880	1880	Amos D. Mitchell	Napolean B. Mitchell; Nicholas Rotz; Jay and Caral Edelberg	Scenic corridor on Amy Dodge Lane.
8	130		1880	1880	unknown	Clarence McClarren/ Ernie Howarth/ John Handy	Scenic corridor on Spring Street.
8	86		1880	1895	Spring Cottage	Venetia and John Rountree (Spring House Cottage)	Scenic corridor on Spring Street.
4	21	1	1882	1850	Ezra C. Smith	Milton Carrow	Rural historic landscape; scenic corridor off Corn Neck Road; rural laneway.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
9	106		1882	1891	Gurdon A. Millikin	"Pilot Hill House"(Boarding House)/ Fred Benson's Home/Millikin Family Homestead	Scenic corridor on Pilot Hill Road.
15	116		1883	1850	Capt. John B. Dunn	Leona Carney	Scenic corridor off Graces Cove Road; rural historic landscape; rural laneway.
18	58		1883	1860	Ray Sands Littlefield	Central House Annex	Scenic corridor on Center Road.
9	44		1884	1870	William Smith Sprague	"Spokes" Spragues/ Mable Dawley	Scenic corridor on Lakeside Drive.
17	17		1884	1870	Amos D. Mitchell and Annie R. Mitchell	Chas.J. Dodge; Browning/ Sands Littlefield/ Foy and Bea Stiefer/ Peter and Cheryl Blane	Scenic corridor on Old Town Road.
8	205	2	1884	1886	James E. Mitchell	Armenie and Ray T. Mitchell; Haida Ginsburgh	Scenic corridor on Seaweed Lane off Pilot Hill Road.
3	104	1	1884	1894	Capt. Benjamin F. Gardner	Mid Holloway	Scenic corridor on Corn Neck Road at the entrance to the Maze.
17	16		1885	1800	John 'Frank' Hayes		Scenic corridor on Old Town Road.
9	52		1885	1870	Miss Abby E. Vaill	1 of 2 Vaill cottages	
8	95		1885	1876	Enoch Rose	Linus Dodge	Scenic corridor off Spring Street.
5	79		1885	1885	William Pitt Ball	Holiday Haven	Scenic corridor on Center Road.
10	21	1	1886	1880	John R. Payne	(part of) Payne Farm; Frank C. Payne; Herb Fisher's	Rural historic landscape off Payne Road; house in original state.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
14	53		1886	1886	Samuel B. Dickens, 2nd	Emily Reeve's cottage	Scenic corridor off Cooneymus Road.
11	32	2	1886	1887	Everett D. Barlow	Mohegan Cottage/Bit O' Heaven; Judge McCabes	Scenic corridor on Black Rock Road.
17	31		1887	1887	Anderson C. Rose	Lydia A.S. and Curtis H. Sprague/ Erastus and Mary Ida Sprague/ Meyers Family	Scenic corridor on Beach Ave.
5	60		1887	1900	George W. Willis		Scenic corridor off Corn Neck Road on Indian Head Neck.
8	199		1888	1860	Horatio N. Milliken	"Millikin Cottage"/ Kikuchi	Scenic corridor on Pilot Hill.
3	127		1888		Edward Searles	Searles Mansion foundation	Scenic corridor on Mansion Road.
3	128		1888		Edward Searles	Searles Mansion foundation	Scenic corridor on Mansion Road.
16	56		1889	1840	John A. Mitchell	Cirlor Sprague/ Vera Littlefield Sprague	Scenic corridor on West Side Road.
8	207		1889	1880	William Pitt Dodge	Betty B. Dodge	Scenic corridor on Seaweed Lane.
2	46		1889	1888	Capt. Amazon Niles Littlefield	Capt. Oswald A. Littlefield; Littlefield Bee Farm	Scenic corridor on Corn Neck Road.
3	93	1	1889	1889	Hiram 'Ansel' Ball	Ansel Ball's/ Cottage Farm	Scenic corridor on Corn Neck Road.
4	70		1889	1889	David Van Nostrand	"Innisfail"/Dr. Norman Boas	Scenic corridor on Corn Neck Road.
8	52		1890	1890	Capt. Potter Carriage House		Scenic corridor on Southeast Extension.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
8	125		1891	1910	Halsey Littlefield Jr.		
15	76		1892	1898	William Crook Allen	"Sunset View Lodge"	Scenic corridor off Dunn Town Road.
15	5		1892	1900	Capt. Martin L. Rose	Grace Wheeler's	Scenic corridor off West Side Road.
11	48		1892	1901	Oliver D. Sprague	Ezra and Mary Rose/Johnston/ Comstock	Scenic corridor on Lakeside Drove.
13	35	6	1892	1903	Jesse D. Lewis	Lewis Farm Farmhouse	Rural historic landscape at Lewis Farm.
11	50		1892	1908	Thomas K.Warner		
15	99		1893	1880	Thaddeus P. Dunn	Giles P. Dunn, Sr. (son) and Ada Mitchell/ Dewey cottage	Rural historic landscape; scenic corridor on Dunn Town Road.
4	72		1893	1892	Charles F. Fairfield	"Lake Side"/ David M. Poole	Scenic corridor off Corn Neck Road.
4	74		1895	1895	Simon R. Ball Jr.	Gertrude Ball	Scenic corridor off Corn Neck Road Neck.
4	74		1895	1895	Simon R. Ball Jr.	Gertrude Ball	Scenic corridor off Corn Neck Road.
15	27		1895	1900	H.W.Dickins	Latham Farm/ Knapp Family	Scenic corridor off West Side Road.
4	48		1897	1860	Everett A. Willis	"The Bayside"	Scenic corridor on Corn Neck Road; house currently behind large privet hedge.
7	95		1897	1896	Mrs. Sarah L. Tourjee	Tourjee Cottage/ Scott Rutan	Scenic corridor on High Street.
4	48		1897	1900	Everett A. Willis	Bayside or Little Red House?	Scenic corridor on Corn Neck Road.
9	50		1898	1875	Hon. Julius Deming Perkins	"Bayberry Lodge"	

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
2	31		1900	1900	WWII Bunker 1940's converted Barn/cottage	Bella Littlefield Gardner/ Abbott Family	Scenic corridor off Corn Neck Road.
10	54	1	1900	1900	unknown	Rosie LaRue	
8	48		1901	1900	Capt. Mark L. Potter	"Pine Lodge"/Potter Place/Potter Mansion	Scenic corridor on Southeast Extension.
5	59		1904	1904	L.V. Maltby	Maltby Cottage/ "Ninicroft Lodge"/ Brownlee/ Sullivan House	Rural historic landscape on Indian Head Neck; scenic corridor off Corn Neck Road (old Cemetery Street).
15	44		1904	1940	Horace W. Dickens	"West Side View Cottage"/ Miss Kiley's	Scenic corridor off Dories Cove Road.
6	42		1905	1900	Irving M. Ball		Scenic corridor on Conn. Avenue.
6	41		1906	1890	Morris L. Negus	Negus Cottage/Martha Bodington/ C. Scott/ "Beachcomber"	Scenic corridor on Conn. Ave.
18	61		1907	1907	Primitive Methodist Church		Scenic corridor on Center Road.
15	21		1907	1910	James E. Sprague II		Scenic corridor on West Side Road.
18	52		1908	1850	Fenner Ball	"Parsonage" (1921)/ Primitive Methodist	Scenic corridor off Center Road.
6	49		1908	1908	Elgin Roberts		Scenic corridor on Old Town Road.
18	60		1913	1875	John Ernest Littlfield	Omar Littlfield's	Scenic corridor on Center Road.
2	36		1917	1911	Eugene Littlefield Rose	Gene and Lenice Rose	Scenic corridor on Corn Neck Road.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
4	55		1920	1920	Crawford cottage	little white cottage moved from Calico Hill in Town	Landmark cottage on Corn Neck Road.
4	70		1920	1920	Innisfail cottage	converted summer kitchen	Landmark cottage on Corn Neck Road.
12	14		1920	1920	Preston Dunn	Black Rock cottage	Scenic corridor on Black Rock Road.
15	106		1920	1920	Boarding House on Swede Hill		Scenic corridor on Graces Cove Road.
18	18		1920	1920	WW II Lookout Tower on Beacon Hill	Brown Family	Scenic corridor on Beacon Hill Road.
4	74		1922	1922	Simon R. Ball Jr.	Gertrude Ball	Scenic corridor on Indian Head Neck off Corn Neck Road.
18	18		1928	1920	Thomas T. Doggett	Beacon Hill Tower/ "Mariner's Monument"	Scenic corridor on Beacon Hill Road.
20	17		1932	1932	Hippocampus	Boy's camp/ Beane Family	Rural historic landscape at Beane Point.
20	10		1935	1940	U.S.Coast Guard Brick House		Scenic corridor at end of Coast Guard Road.
9	87		1940	1930	WWII Lookout Tower at Sands Pond	Turtle Hill	Scenic corridor off Sands Pond Road on Turtle Hill.
5	75	1	1940	1940	Red Gate Farm outbuilding	2 outbuildings	Scenic corridor off Center Road.
6	41		1940	1940	Negus Cottage outbuilding	laundry building	Scenic corridor on Conn. Avenue.
18	60		1942	1942	Omar Littlefield cottage	John E. Littlfield Homestead site/Omar's	Scenic corridor on Center Road.

Plat	Lot	Sub-lot	Date built (deed)	Date built (tax assess-or's office)	Original owner and/or building name	Past/Present building name	Setting significance
15	52		1943	1943	John Rose cottage		Scenic corridor on Dories Cove Road; rural historic landscape.
8	23		1945	1945	WWII Lookout	round white tower adjacent to cottage on SE side	Scenic corridor off Spring Street.

Section 440. Policies and Standards

1. The Council recognizes the rich and historically significant history of human activity within and adjacent to the Ocean SAMP area. These numerous sites and properties, that are located both underwater and onshore, should be considered when evaluating future projects.

2. The Coastal Resources Management Council ("Council") has a federal obligation as part of its responsibilities under the Federal Coastal Zone Management Act to recognize the importance of cultural, historic, and tribal resources within the state's coastal zone, including Rhode Island state waters. It has a similar responsibility under the Rhode Island Historic Preservation Act. The Council will not permit activities that will significantly impact the state's cultural, historic and tribal resources.

3. The Council will engage federal and state agencies, and the Narragansett Indian Tribe's Tribal Historic Preservation Office (THPO), when evaluating the impacts of proposed development on cultural and historic resources. The Rhode Island Historic Preservation and Heritage Commission (RIHPHC) is the State Historic Preservation Office (SHPO) for the state of Rhode Island, and is charged with developing historical property surveys for Rhode Island municipalities, reviewing projects that may impact cultural and historic resources, and regulating archaeological assessments on land and in state waters. For other tribes outside of Rhode Island that might be affected by a federal action it is the responsibility of the applicable federal agency to consult with affected tribes.

4. Project reviews will follow the policies outlined in "Section 220: Areas of Historic and Archaeological Significance" and in "Section 330: Guidelines for the Protection and Enhancement of the Scenic Value of the Coastal Region" of the State of Rhode Island Coastal Resources Management Program, As Amended ("Red Book"). The standards for the identification of cultural resources and the assessment of potential effects on cultural resources will be in accordance with the National Historic Preservation Act Section 106 regulations, 36 CFR Part 800, *Protection of Historic Properties*.

5. Historic shipwrecks, archeological or historical sites located within Rhode Island's coastal zone are Areas of Particular Concern (APCs) for the Rhode Island coastal management program. Direct and indirect impacts to these resources must be avoided to the greatest extent possible. Other areas, not noted as APCs, may also have significant archeological sites that could be identified through the permit process. For example, the area at the south end of Block Island waters within the 30 foot depth contour is known to have significant archeological resources. As a result, projects conducted in the Ocean SAMP area may have impacts to Rhode Island's underwater archaeological and historic resources.

6. Archaeological surveys shall be required as part of the permitting process for projects which may pose a threat to Rhode Island's archaeological and historic resources. During the filing phase for state assent, projects needing archaeological surveys will be identified through the joint review process. The survey requirements will be coordinated with the SHPO and, if tribal resources are involved, with the Narragansett THPO.

7. APCs may require a buffer or setback distance to ensure that development projects avoid or minimize impacts to known or potential historic or archaeological sites.The buffer or setback distance during the permitting process will be determined by the SHPO and if tribal resources are involved, the Narragansett THPO.

8. In addition to general Area of Particular Concern buffer/setback distances around shipwrecks or other submerged cultural resources, the Council reserves the right, based upon recommendations from RIHPHC, to establish protected areas around all submerged cultural resources which meet the criteria for listing on the National Register of Historic Places.

9. Projects conducted in the Ocean SAMP area may have impacts that could potentially affect onshore archaeological, historic, or cultural resources. Archaeological and historical surveys may be required of projects which are reviewed by the joint agency review process. During the filing phase for state assent, projects needing such surveys will be identified and the survey requirement will be coordinated with the SHPO and if tribal resources are involved, with the Narragansett THPO.

10. Guidelines for onshore archaeological assessments in the Ocean SAMP Area can be obtained through the RIHPHC in their document, "Performance Standards and Guidelines for Archaeological Projects: Standards for Archaeological Survey" (RIHPHC 2007), or the lead federal agency responsible for reviewing the proposed development.

440.1. Marine Archaeology Assessment Standards

1. The potential impacts of a proposed project on cultural and historic resources will be evaluated in accordance with the National Historic Preservation Act and Antiquities Act, and the Rhode Island Historical Preservation Act and Antiquities Act as applicable. Depending on the project and the lead federal agency, the projects that may impact marine historical or archaeological resources identified through the joint agency review process shall require a Marine Archaeology Assessment that documents actual or potential impacts the completed project will have on submerged cultural and historic resources.

2. Guidelines for Marine Archaeology Assessment in the Ocean SAMP Area can be obtained through the RIHPHC in their document, "Performance Standards and Guidelines for Archaeological Projects: Standards for Archaeological Survey" (RIHPHC 2007), or the lead federal agency responsible for reviewing the proposed development.

440.2. Visual Impact Assessment Standards

1. The potential non-physical impacts of a proposed project on cultural and historic resources shall be evaluated in accordance with 36 CFR 800.5, *Assessment of Adverse Effects, (v) Introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features.* Depending on the project and the lead federal agency, the Ocean SAMP Interagency Working Group may require that a project undergo a Visual Impact Assessment that evaluates the visual impact a completed project will have on onshore cultural and historic resources.

2. A Visual Impact Assessment may require the development of detailed visual simulations illustrating the completed project's visual relationship to onshore properties that are designated National Historic Landmarks, listed on the National Register of Historic Places, or determined to be eligible for listing on the National Register of Historic Places. Assessment of impacts to specific views from selected properties of interest may be required by relevant state and federal agencies to properly evaluate the impacts and determination of adverse effect of the project on onshore cultural or historical resources.

3. A Visual Impact Assessment may require description and images illustrating the potential impacts of the proposed project.

4. Guidelines for Landscape and Visual Impact Assessment in the Ocean SAMP Area can be obtained through the lead federal agency responsible for reviewing the proposed development.

Section 450. Literature Cited

A Digest of Opinions of the Judge Advocates General of the Army, 1912. 1917. Washington: Government Printing Office.

Abbass, D. K. 2000. Naval History and the Submerged Cultural Resources of Rhode Island, Volume I. Newport, RI: Rhode Island Marine Archaeology Project.

Albion, R. G., Labaree, B. W. and Baker, W. A. 1970. *New England and the Sea*. Mystic, CT: Mystic Seaport Press.

Annual Reports of the War Department for the Fiscal Year Ended June 30, 1899. 1899. Washington: Government Printing Office.

Annual Report of the Auditor of the Railroad Accounts made to the Secretary of the Interior for the Year Ending June 30, 1880. 1880. Washington: Government Printing Office.

Annual Report of the Chief Signal Officer of the Army to the Secretary of War for the Year 1888. 1889. Washington: Government Printing Office.

Annual Reports of the Department of Agriculture for the Fiscal Year Ended June 30, 1902. 1902. Washington: Government Printing Office.

Atlantic Deeper Waterways Association. 1908. *First Annual Convention Held at Baltimore November 17, 18, 19 1908: Report of the Proceedings*. Philadelphia: Atlantic Deeper Waterways Commission.

Bartlett, John Russell, 1858. *Records of the Colony of Rhode Island and Providence Plantations in New England.* Providence: Knowles, Anthony & Co.

Boothroyd, John. 2010. University of Rhode Island. Personal communication, April 2010.

Boothroyd, J. and P. August. 2008. Geologic and Contemporary Landscapes of the Narragansett Bay Ecosystem. In: *Science for Ecosystem-based Management: Narragansett Bay in the 21st Century*. Desbonnet, A. and Costa-Pierce, B., eds. Springer.

Bridenbaugh, Carl. 1974. *Fat Mutton and Liberty of Conscience, Society in Rhode Island, 1636-1690.* Providence, RI: Brown University Press.

Brown, John. 2010. Narragansett Indian Tribe Historic Preservation Office. Personal communication, April 26, 2010.

Carroll, Charles. 1932. *Rhode Island: Three Centuries of Democracy.* New York: Lewis Historical Publishing Company, Inc.

Coleman, D. F., and K. McBride, 2009. Underwater Prehistoric Archaeological Potential on the southern New England Continental shelf off Block Island. IN Ballard, R. D., ed., *Archaeological Oceanography*. Princeton University Press. pp. 200-223.

Coleman, Peter J. 1963. *The Transformation of Rhode Island 1790 – 1860*. Providence: Brown University Press.

Cooper, David J. and John O. Jensen. 1995. *Davidson's Goliaths: Underwater Archaeological Investigations of the Steamer Frank O'Connor and the Schooner-Barge Pretoria*. Madison: State Historical Society of Wisconsin.

Cronon, William. 1983. *Changes in the Land: Indians, Colonists and the Ecology of New England*. Hill and Wang.

DeAlteris, J.T.; Gibson, M.; Skrobe, L.G. 2000. Fisheries of Rhode Island (Working Draft). Narragansett Bay Summit 2000: White Paper.

Fagan, Brian. 2006. *Fish on Friday: Feasting, Fasting and the Discovery of the New World*. New York: Basic Books.

Fowler, William M. 1976. *Rebels Under Sail: The American Navy during the Revolution.* New York: Charles Scribner's Sons.

Gasner, Pamela. 2008. "Structures and Sites from 1680 – 1948 on Block Island/Town of New Shoreham" Block Island Historical Society.

Goode, G. Brown. 1884. *The Fisheries and Fishing Instustries of the United States, Section II*. Washington, DC: Government Printing Office.

Gordon, Richard L. 1978. *Coal in the U.S. Energy Market: History and Prospects*. Lexington: D.C. Heath.

Graaebner, William. 1974. "Great Expectations: The Search for Order in Bituminous Coal. 1890 – 1917. " *The Business History Review.* Vol. 48. No. 1.

Hale, Stuart O. 1998 (updated ed.). *Narragansett Bay: A Friend's Perspective.* University of Rhode Island Marine Advisory Service NOAA/Sea Grant Marine Bulletin 42.

Harbors of Refuge at Point Judith, Block Island, and Great Salt Pond, etc. 1903. 55th Cong. 2nd Sess. H. Doc 60.

Hawes, Alexander Boyd. 1999. *Off Soundings: Aspects of the Maritime History of Rhode Island.* Chevy Chase, MD: Posterity Press.

Herndon, R.H. and Sekatau, E.W. 1997. *The Right to a name: The Narragansett people and Rhode Island officials in the revolutionary era.* Ethnohistory, 44(3), 433-462.

Herndon, R.H. and Sekatau, E.W. (2003a). *Colonizing the children: Indian youngsters in servitude in early Rhode Island.* In C. Calloway & N. Salisbury (Eds.), Reinterpreting New England Indians and the colonial experience (137-173). Boston: University of Virginia Press.

Herndon, R.H. and Sekatau, E.W. (2003b) *Pauper Apprenticeship in Narragansett Country: A different name for slavery in early New England*. In Benes, P (Ed.), The Dublin Seminar for New England Folklife Annual Proceedings 2003: Slavery/antislavery in New England. Boston: Boston University Press.

Hunter, Louis C. 1979. *A History of Industrial Power in America*. Volume One: Water Power in the Century of the Steam Engine. Charlottesville: University of Virginia Press.

Hunter, Louis C. 1985. *A History of Industrial Power in America. Volume Two: Steam Power*. Charlottesville: University of Virginia Press.

Hall-Arber M, Dyer C, Poggie J, McNally J, Gagne R. 2001. New England's Fishing Communities. Cambridge (MA): MIT Sea Grant 01-15. Available from: http://seagrant.mit.edu/cmss/

Intergovernmental Policy Analysis Program, University of Rhode Island. 1989. *The Commercial Fishing Industry in Rhode Island: An Inventory, Analysis, and Assessment*. Prepared for: The Rhode Island Port Authority and Economic Development Corporation.

Keatts, Henry and George Farr. 2002. *The Bell Tolls: Shipwrecks and Lighthouses, Volume 1, Block Island.* Laurel, NY: Main Road Books.

Kellner, G. H. and Lemons, J. S. 2004. *Rhode Island The Ocean State: An Illustrated History*. Sun Valley, CA: American Historical Press.

Labaree, B. W., Fowler, W. M. Jr., Sloan, E. W., Hattendorf, J. B., Safford, J. J., and German, A. W. 1998. *America and the Sea: A Maritime History*. Mystic, CT: Mystic Seaport Press.

Livermore, Samuel. 1877. *A History of Block Island from its Discovery, in 1514 to the Present Time, 1876*. Hartford, CT: Case, Lockwood & Brainard.

Marx, Deborah and Mathew Lawrence. 2006. "Nomination of Frank A. Palmer and Louise B. Crary – Shipwreck Remains to the National Register of Historic Places."

Mather, Rod. 2010. URI Working Rhode Island Shipwreck Database. On file at Department of History, University of Rhode Island.

McLoughlin, William G. 1986. *Rhode Island, A History*. New York, NY: W. W. Norton & Co.

McMaster, R. L., 1984. Holocene stratigraphy and depostional history of the Narragansett Bay System, Rode Island, U.S.A. *Sedimentology*, 31, pp. 777 - 792.

Mendum, Samuel W. 1897. *New England Magazine*, 16, pp. 738–751

Minerals Management Service. October 2007. *Final Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use Facilities on the Outer Continental Shelf.* Online at

http://ocsenergy.anl.gov/documents/fpeis/index.cfm.

Minerals Management Service. 2010. Documentation of Section 106. Finding of Adverse Effect for the Cape Wind Energy Project (Revised). Prepared by B.M. Carrier Jones, editor, Ecosystem Management & Associates, Inc. Lusby, Maryland.

Monthly Summary of Commerce and Finance of the United States for the Fiscal Year 1903. 57th Cong. 2nd Sess. H. Doc. 15 parts 7, 8 & 9.

National Park Service. 2010. Web site, "National Historic Landmarks Program." http://www.nps.gov/history/nhl/QA.htm#1

Oldale, R. N. and O'Hara, C. J., 1980. New radiocarbon dates from the inner continental shelf off south-eastern Massachusetts and a local sea-level-rise curve for the past 12,000 yr. *Geology*, 8, pp. 102-106.

Olsen, S.: Robadue, D.; Lee, V. 1980. An Interpretive Atlas of Narragansett Bay. Coastal Resources Center, Marine Bulletin 40, University of Rhode Island.

Olsen, S.; Stevenson, D. 1975. Commercial Marine Fish and Fisheries of Rhode Island. Coastal Resources Center, University of Rhode Island: Marine Technical Report 34.

Peck, J. A., and R. L. McMaster, 1991. Stratigraphy and geologic history of Quaternary sediments in lower West Passage, Narragansett Bay, Rhode Island. *Journal of Coastal Research*, Special Issue 11, pp. 25-37.

Peltier, W.R. and R.G. Fairbanks, 2006. Global glacial ice volume and Last Glacial Maximum duration from an extended Barbados sea level record. *Quaternary Science Reviews*, 25, 3322-3337.

Poggie, J.J., Pollnac, R.B., eds. 1981. *Small Fishing Ports in Southern New England*. NOAA/Sea Grant. University of Rhode Island: Marine Bulletin 39.

Pope, Peter E. 2004. *Fish into Wine: The Newfoundland Plantation in the Seventeenth Century*. Chapel Hill, NC: University of North Carolina Press.

Report of Commerce and Navigation for the Fiscal Year 1869. Serial Set Vol. No. 1429, Session Vol. No.15, 41st Congress, 2nd Session. Annual report of the Deputy Special Commissioner of the Revenue in charge of the Bureau of Statistics, on the commerce and navigation of the United States, for the fiscal year ended June 30, 1869.

Reynolds, A., 1997. Block Island Southeast Lighthouse: National Historic Landmark Study http://www.nps.gov/maritime/nhl/blockisl.htm

Rhode Island Historical Preservation and Heritage Commission (RIHPHC), 1991. *Historic and Architectural Resources of Block Island, Rhode Island.* (In cooperation with the Block Island Historical Society) RIHPHC, Providence, RI.

Rhode Island Historical Preservation and Heritage Commission (RIHPHC), 2002. *Native American Archaeology in Rhode Island.* RIHPHC, Providence, RI. http://www.preservation.ri.gov/pdfs_zips_downloads/survey_pdfs/native_am_archaeology.pdf

Rhode Island Historical Preservation and Heritage Commission (RIHPHC). 2007. *Performance Standards and Guidelines for Archaeological Survey: Standards for Archaeological Survey"* RIHPHC, Providence, RI.

Rhode Island Historical Preservation and Heritage Commission (RIHPHC). 2010. Web site, "National Register." RIHPHC, Providence, RI. http://www.preservation.ri.gov/register/

Rhode Island Historical Society, 1993. *What a Difference a Bay Makes*. Providence, RI: Rhode Island Department of State Library Services.

Ritchie, Ethel Colt. 1980. *Block Island, Lore and Legends*. Block Island, RI: Francis M. Nugent.

Robinson, David. 2010. Fathom Research LLC. Personal communication, April 2010.

Schroder, Walter K. *Defenses of Narragansett Bay in World War II,* 1980 repr. 1996. Chapel Hill, NC: Professional Press.

Schurr, Sam H. and Bruce C. Netschert. 1960. *Energy in the American Economy, 1850 - 1975: An Economic Study of its History and its Prospects*. Baltimore: The Johns Hopkins Press.

The Seaman's Bill: Hearings Held Before the Committee on Merchant Marine and Fisheries on House Bill 11372, December 14, 1911. 1911. Washington: GPO.

Sedgwick, S., Collins, C., Olsen, S. 1980. *Commercial Fishing Facilities Needs in Rhode Island*. Coastal Resources Center, University of Rhode Island: Marine Technical Report 80.

Sekatau, E.T. 1970. *Narragansett Indian recipes: Traditional and contemporary*. Haffenreffer Museum Library.

Sekatau, E.T. (Pottery). *Narragansett Indians Teaqua: "What's going on?" pottery, past, and present.*

Snow, Ralph Linwood and Douglas K. Lee. 1999. *A Small Shipyard in Maine: Percy & Small and the Great Schooners*. Bath: Maine Maritime Museum.

Snyder, Marlene and Don Snyder. 1998. *Rhode Island Adventure Diving*. Westfield: Marlene and Don Snyder.

Snyder, Marlene and Don Snyder. 1999. *Rhode Island Adventure Diving II*. Westfield: Marlene and Don Snyder.

Statutes of the United States of America passed at the First Session of the Forty-Ninth Congress,

1885-1886. 1886. Washington: Government Printing Office.

Swanson, Carl E., 1991. Predators and Prizes: American Privateering and Imperial Warfare, 1739-1748. Columbia, SC: University of South Carolina Press.

St. Martin, K. and Hall-Arber, M. 2008. The missing layer: geo-technologies, communities, and implications for marine spatial planning. *Marine Policy* 32 (5), September 2008, pp. 779-786.

Tveskov, Mark. 1997. Maritime Settlement and Subsistence along the Southern New England Coast: Evidence from Block Island, Rhode Island. *North American Archaeologist*, 18: 4, pp. 343-361.

U.S. Fish and Wildlife Service (USFWS). N.d. *North Cape Oil Spill Restoration.* Available on line at http://www.fws.gov/Contaminants/restorationplans/NorthCape/NorthCape.cfm Last accessed March 27, 2010.

Vickers, D. 2005. *Young Men and the Sea; Yankee Seafarers in the Age of Sail.* New Haven, CT: Yale University Press.

Wroth, Lawrence C., ed. 1970. *The Voyages of Giovanni da Verrazzano, 1524-1528.* Yale: Yale University Press.

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Section 500. Introduction

1. Commercial and recreational fisheries are among the oldest and most widespread human uses of the Ocean SAMP area and are of great economic, historic and cultural value to the state of Rhode Island. Commercial fisheries sustain Rhode Island coastal communities by providing jobs to fishermen and supporting businesses and industries, as well as food for local consumption or export throughout the United States and overseas. Recreational fisheries, which here includes recreational fishing that takes place aboard for-hire party and charter boats as well as recreational anglers fishing from private boats, also support businesses and families throughout Rhode Island and are a key element of the region's recreation and tourism economy. All Rhode Island fisheries, both within the Ocean SAMP area and inside Narragansett Bay, also have significant non-market value in that they provide Rhode Islanders with a connection to the sea and to New England's rich maritime history.

2. The purpose of the Ocean SAMP is to protect sustainable existing uses, resources, and habitats, and to guide future uses of the Ocean SAMP area. While it is recognized there is a need to restore fish habitat and recover depleted stocks, the goal of the Ocean SAMP is not to engage in fisheries management. Commercial and recreational fisheries in the Ocean SAMP area are already managed by a host of different agencies and regulatory bodies which have jurisdiction over different species and/or different parts of the Ocean SAMP area. In many cases, these entities have overlapping jurisdiction over the state and federal waters of the Ocean SAMP area. Entities involved in managing fish and fisheries within the Ocean SAMP area include, but are not limited to, the Atlantic States Marine Fisheries Commission (ASMFC), the Rhode Island Department of Environmental Management (RIDEM), the New England Fishery Management Council, the Mid-Atlantic Fishery Management Council, and the NOAA National Marine Fisheries Service (NMFS).[1] For further information on fisheries management, see Chapter 10, Existing Statutes, Regulations, and Policies.

3. The objectives of this chapter are to summarize existing information about current commercial and recreational fisheries resources and activities within the Ocean SAMP area; highlight the economic, social, cultural, and historic value of these activities to Rhode Island; and outline policies for managing these activities within the context of other existing and future uses. Accordingly, this chapter focuses primarily on commercially and recreationally important species that are targeted within the Ocean SAMP area by Rhode Island fishermen. The methodology for selecting these species is outlined below in Section 510. This chapter focuses on current baseline conditions based on the best available existing data and information. Per the NMFS Northeast Regional Office Protected Resources Division, this chapter also includes discussion of finfish "Species of Concern" which may occur within the Ocean SAMP area; see Section 510 below for a list of those species included here. Available fisheries dependent and independent data from the past decade are used to establish baseline conditions. Available historic information on fisheries is included to underscore the longstanding economic and cultural importance of these activities to Rhode Island.

[1] In addition, the Rhode Island Marine Fisheries Council acts as an advisory group to the RIDEM Director.

4. This chapter has found that commercial and recreational fisheries are an important activity in the Ocean SAMP area. Twenty-eight finfish, shellfish, and crustacean species are of commercial and recreational fishing importance in the Ocean SAMP area. Commercial fishermen using otter trawls, scallop dredges, gillnets, and lobster pots harvest a diverse variety of species, and squid and lobster are consistently among the most valuable species landed in Rhode Island. Recreational fishermen fish in the Ocean SAMP area aboard both private boats and party and charter boats, and target a variety of species including striped bass, bluefish, summer flounder, and large pelagic fish. At the time of this writing, many of the more popular commercially and recreationally targeted species, including squid, summer flounder, scup, and striped bass, are not overfished, nor is overfishing occurring. However, other fisheries are depleted or in decline, and there is a need to rebuild the stocks of some species found in the Ocean SAMP area. There are a variety of state and federal entities and regulatory bodies currently addressing stock levels, largely through the development and implementation of Fishery Management Plans. Fisheries management efforts have had a number of successes in rebuilding previously overfished stocks. Whereas all of these species rely on habitat within the Ocean SAMP area, little fish habitat mapping has been done to date at a resolution that would highlight important habitats within the area. Available qualitative and quantitative data have been used to produce maps that show commercial and recreational fisheries activity throughout the Ocean SAMP area. These maps show that the entire Ocean SAMP area is used by commercial and recreational fishermen over the course of a year, but that these use patterns vary in space and time due to factors including seasonal species migrations, the regulatory environment, and market demand for seafood. Commercial and recreational fisheries have a longstanding history in Rhode Island and are closely tied to Rhode Island's coastal communities and economies; whereas commercial fisheries have an economic impact through the sale and processing of seafood products, recreational fisheries have an economic impact through the sale of fishing vessels and gear and the in-state spending of out-of-state visitors. All of these fisheries activities rely on fisheries resources and habitats, and whereas future uses may impact these resources, existing activities and trends, including fishing and other uses of the area, are already having an impact on fisheries resources in the Ocean SAMP area. Human activities such as fisheries that have been taking place for hundreds of years have influenced Ocean SAMP area resources, and conditions in the area will continue to change due to human uses, such as fishing, as well as longer-term trends such as global climate change.

5. It is acknowledged that future uses of the Ocean SAMP area may have a variety of potential effects on fisheries resources and activities. See Chapter 8, Renewable Energy and Other Offshore Development for a discussion of the potential effects of renewable energy on fish and fisheries, and see Chapter 9, Other Future Uses for a discussion of other future uses and their potential effects on fish and fisheries. In addition it should be noted that future projects will be subject to site- and project-specific regulatory review to evaluate the potential effects; see Section 560, Policies and Standards, for further information.

6. While the emphasis of this chapter is on the commercial and recreational fisheries of the state of Rhode Island and their importance to the state, it is acknowledged that fish and fishing activities are not limited to state boundaries. Fishermen from other states,

including Massachusetts, Connecticut, and New York, routinely transit through or fish within the Ocean SAMP boundary area. The fish species found in the Ocean SAMP area and the fishing activity that occurs here are undoubtedly of economic and cultural importance to these other states as well, and any impacts to fisheries resources and activities within the Ocean SAMP area could affect fishermen in other states. While the remainder of this chapter is primarily focused on the importance of fisheries to the state of Rhode Island, it is acknowledged that fishermen from outside of the state rely on these resources as well.

7. While this chapter is focused on commercial and recreational fisheries, it is acknowledged that the finfish, shellfish, and crustacean populations targeted by fishermen are fundamental parts of the Ocean SAMP ecosystem. These species rely on the availability of appropriate habitats and food sources, and the viability of these fisheries is dependent upon these resources. In addition, there are numerous finfish, shellfish, and crustacean populations within the Ocean SAMP area that are not part of directed fisheries. See Chapter 2, Ecology of the Ocean SAMP Region for an extensive discussion of the Ocean SAMP ecosystem, including other species, benthic habitat, and a discussion of broader and longer-term regional trends. It is also acknowledged that global climate change is having, and will continue to have, effects on fisheries resources and activities; see Chapter 3, Global Climate Change for further discussion.

8. Commercial and recreational fisheries are discussed together in this chapter, although it is acknowledged that there are significant differences between the commercial and recreational industries. Commercial and recreational fisheries are included together primarily because commercial and recreational fishermen target many of the same species. Recreational fisheries here include recreational anglers as well as recreational fishing that takes place aboard party and charter boats operated by professional captains running businesses. It should be noted that recreational fishing is a significant recreational activity and major contributor to Rhode Island's tourism economy; see Chapter 6, Recreation and Tourism for further discussion.

9. Aquaculture is an activity that is relevant to seafood production and is currently permitted only in state waters. Offshore aquaculture may be a potential future use of the Ocean SAMP area once a federal permitting process is established. See Chapter 9, Other Future Uses for further discussion.

Section 510. Marine Fisheries Resources in the Ocean SAMP Area

510.1. Species Included in this Chapter

510.1.1. Species Important to Commercial and Recreational Fisheries

1. This chapter's focus is on commercial and recreational fisheries, finfish, shellfish, and crustacean species that are considered most important to Rhode Island commercial and recreational fishermen operating in the Ocean SAMP area. Lists of commercially and recreationally important species were developed through the methodology outlined below and resulted in a summary list of species included below in Table 5.1.

2. Species harvested within the Ocean SAMP area that are considered to be most important to Rhode Island's commercial fisheries were identified by reviewing NMFS landings data and then reviewing this draft list with Rhode Island commercial fisheries stakeholders. Ten years (1998 – 2007) of NMFS landings data were reviewed to determine the most valuable finfish, shellfish, and crustacean species landed in Rhode Island (NMFS 2009a). For each year, the top 20 species (ranked by value) were identified. This list was then edited down to those species which occurred in the top 20 (by value) in at least 5 of those 10 years. This list was then reviewed with commercial fishermen to determine which species are actually harvested within the Ocean SAMP area. This review took place during fisheries stakeholder meetings conducted through the Ocean SAMP stakeholder process. Through this process, most shellfish were removed from this list, with the exception of sea scallops, which are harvested within the Ocean SAMP area. It should be noted that while quahogs are well known to be an important and lucrative fishery in Rhode Island, quahogs are currently harvested primarily within Narragansett Bay, not offshore in the Ocean SAMP area, and are therefore not included here. The species identified through this process are: American lobster (*Homarus americanus*); Atlantic cod (*Gadus morhua*); Atlantic herring (*Clupea harengus*); Atlantic mackerel (*Scomber scombrus*); Atlantic sea scallop (*Placopecten magellanicus)*; Black sea bass (*Centropristis striata*); Butterfish (*Peprilus triacanthus)*; Goosefish (monkfish) *(Lophius americanus);* Longfin (loligo) squid (*Loligo pealeii)*; Scup (*Stenotomus chrysops)*; Silver hake (*Merluccius bilinearis)*; Skates (unclassified); Summer flounder (*Paralichthys dentatus)*; Winter flounder (*Pseudopleuronectes americanus)*; and Yellowtail flounder (*Limanda ferruginea).* The above list was then compared with those commercially harvested species managed at the state level with quotas or other daily landing limits (RIDEM 2009), to ensure any significant species managed at the state level were accounted for. Because they appear on this list, and in addition are both found within the Ocean SAMP area, two additional species, menhaden (*Brevoortia tyrannus)* and spiny dogfish (*Squalus acanthias)*, are included in this chapter.

3. Species important to recreational fisheries were identified by reviewing Rhode Island recreational harvest and release data published in *Fisheries Economics of the United States, 2006* (NMFS 2008a).[2] This list was then compared with RI Department of Environmental Management recreational fishing regulations (RIDEM 2009), as well as information on sportfishing tournaments sponsored by the RI Saltwater Anglers

[2] This is the most recent version of this publication available.

Association (RISAA 2010). The resultant draft list of species was then reviewed with both recreational anglers and party and charter boat fishermen with the goal of determining which species are actually targeted within the Ocean SAMP area. This review took place during fisheries stakeholder meetings conducted through the Ocean SAMP stakeholder process. The species identified through this process are: Atlantic bonito (*Sarda sarda)*; Atlantic cod (*Gadus morhua*); Black sea bass (*Centropristis striata*); Bluefish (*Pomatomus saltatrix)*; False albacore (*Euthynnus alletteratus);* Scup (*Stenotomus chrysops)*; Sharks (unspecified); Striped bass (*Morone saxatilis*); Summer flounder (*Paralichthys dentatus)*; Tautog (*Tautoga onitis)*; Tunas (unspecified); and Winter flounder (*Pseudopleuronectes americanus).* Recreationally targeted sharks were further narrowed down to Shortfin mako (*Isurus oxyrinchus*), Blue (*Prionace glauca*), and Thresher (*Alopias vulpinus*), and recreationally targeted tunas were further narrowed down to Bluefin (*Thunnus thynnus*) and Yellowfin (*Thunnus albacares*). It should be noted that the species that appear on the list below may also be of commercial and recreational importance to fishermen from other states fishing in the Ocean SAMP area, or may migrate to other areas where these fish may be targeted by non-Rhode Island fishermen.

4. Table 5.1 shows the resultant list of commercially and recreationally important species found within the Ocean SAMP area:

Table 5.1. Commercially and recreationally important species.

Common Name	**Scientific Name**
American lobster	*Homarus americanus*
Atlantic bonito	*Sarda sarda*
Atlantic cod	*Gadus morhua*
Atlantic herring	*Clupea harengus*
Atlantic mackerel	*Scomber scombrus*
Atlantic sea scallop	*Placopecten magellanicus*
Black sea bass	*Centropristis striata*
Bluefish	*Pomatomus saltatrix*
Butterfish	*Peprilus triacanthus*
False albacore	*Euthynnus alletteratus*
Goosefish (monkfish)	*Lophius americanus*
Longfin (loligo) squid	*Loligo pealeii*
Menhaden	*Brevoortia tyrannus*
Scup	*Stenotomus chrysops*
Shark, blue	*Prionace glauca*
Shark, shortfin mako	*Isurus oxyrinchus*
Shark, thresher	*Alopias vulpinus*
Silver hake	*Merluccius bilinearis*
Skates (unclassified)[3]	*Raja spp.*
Spiny dogfish	*Squalus acanthias*
Striped bass	*Morone saxatilis*
Summer flounder	*Paralichthys dentatus*
Tautog	*Tautoga onitis*

[3] Skates are listed as unclassified by NMFS because they are often landed as a mix of species, with Little Skate as the predominant species

Tuna, bluefin	*Thunnus thynnus*
Tuna, yellowfin	*Thunnus albacares*
Winter flounder	*Pseudopleuronectes americanus*
Yellowtail flounder	*Limanda ferruginea*

5. The commercially and recreationally important species identified above are managed by a variety of different federal and state management entities. Table 5.2 below includes a summary of the relevant management entities for each species as well as the current status of each stock as of March 2010. As defined in the Magnuson Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801 *et. seq.* (Magnuson Stevens Act), "the terms 'overfishing' and 'overfished' mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis" (NMFS 2007c). This information is summarized from the individual species descriptions that follow below in Section 510.2, which include further details and references for each species.

Table 5.2. Management and status of species/stocks in the Ocean SAMP area.

Common name	**Management entity**	**Status of stock within Ocean SAMP area as of March 2010**
American lobster	Atlantic States Marine Fisheries Commission	Depleted; overfishing not occurring
Atlantic bonito	International Commission for the Conservation of Atlantic Tunas	Not available
Atlantic cod	New England Fishery Management Council	Overfished; overfishing is occurring
Atlantic herring	Atlantic States Marine Fisheries Commission and New England Fishery Management Council	Not overfished; overfishing not occurring
Atlantic mackerel	Mid-Atlantic Fishery Management Council	Not overfished; overfishing not occurring
Atlantic sea scallop	New England Fishery Management Council	Not overfished; overfishing not occurring
Black sea bass	Atlantic States Marine Fisheries Commission and Mid-Atlantic Fishery Management Council	Not overfished; overfishing not occurring
Bluefish	Atlantic States Marine Fisheries Commission and Mid-Atlantic Fishery Management Council	Not overfished; overfishing not occurring
Butterfish	Mid-Atlantic Fishery Management Council	Pending release of 2009 NMFS stock assessment
False albacore	International Commission for the Conservation of Atlantic Tunas	Not available
Goosefish (monkfish)	New England Fishery Management Council; Mid-Atlantic Fishery Management Council	Not overfished; overfishing is occurring
Longfin (loligo) squid	Mid-Atlantic Fishery Management Council	Not overfished; overfishing not occurring
Menhaden	Atlantic States Marine Fisheries Commission	Not overfished; overfishing not occurring
Scup	Atlantic States Marine Fisheries Commission and Mid-Atlantic Fishery Management Council	Not overfished; overfishing not occurring
Shark, blue	National Marine Fisheries Service (Consolidated Atlantic Highly Migratory Species Fishery Management Plan); Atlantic States Marine	Not available

	Fisheries Commission (Interstate Fishery Management Plan for Atlantic Coastal Sharks)	
Shark, shortfin mako	National Marine Fisheries Service (Consolidated Atlantic Highly Migratory Species Fishery Management Plan); Atlantic States Marine Fisheries Commission (Interstate Fishery Management Plan for Atlantic Coastal Sharks)	Not overfished; overfishing is occurring
Shark, thresher	National Marine Fisheries Service (Consolidated Atlantic Highly Migratory Species Fishery Management Plan); Atlantic States Marine Fisheries Commission (Interstate Fishery Management Plan for Atlantic Coastal Sharks)	Not available
Silver hake	New England Fishery Management Council	Not overfished; overfishing not occurring
Skates (unclassified)	New England Fishery Management Council	Overfishing occurring on winter skate only
Spiny dogfish	Atlantic States Marine Fisheries Commission; New England Fishery Management Council; Mid-Atlantic Fishery Management Council	Not overfished; overfishing not occurring
Striped bass	Atlantic States Marine Fisheries Commission	Not overfished; overfishing not occurring
Summer flounder	Atlantic States Marine Fisheries Commission and Mid-Atlantic Fishery Management Council	Not overfished; overfishing not occurring
Tautog	Atlantic States Marine Fisheries Commission	Overfished; overfishing is occurring
Tuna, bluefin	National Marine Fisheries Service (Highly Migratory Species Fishery Management Plan) and International Commission for the Conservation of Atlantic Tunas	Overfished; overfishing is occurring
Tuna, yellowfin	National Marine Fisheries Service (Highly Migratory Species Fishery Management Plan) and International Commission for the Conservation of Atlantic Tunas	Not overfished; overfishing not occurring
Winter flounder	Atlantic States Marine Fisheries Commission and New England Fishery Management Council	Overfished; overfishing is occurring
Yellowtail flounder	New England Fishery Management Council	Overfished; overfishing is occurring

510.1.2. Forage Fish

1. Forage fish are essential to a discussion of commercial and recreational fisheries insofar as they provide food for many of the above-mentioned targeted species. Many forage fish in this region are themselves commercially or recreationally targeted. See Section 510.4 for a brief discussion of forage fish as they relate to the above-mentioned species.

510.1.3. Threatened and Endangered Species and Species of Concern

1. This chapter also includes discussion of Threatened and Endangered finfish per the Endangered Species Act (16 U.S.C. 1531 *et. seq.*) as well as finfish listed as "Species of Concern" by the NMFS Office of Protected Resources. According to the NMFS

Northeast Regional Office Protected Resources Division, based on the best available information, no finfish currently listed as threatened or endangered are likely to occur within the Ocean SAMP area (J. Crocker, pers. comm., a). However, according to the NMFS Northeast Regional Offices Protected Resources Division (J. Crocker, pers. comm., b), the following species currently listed as "Species of Concern" could be present in the Ocean SAMP area: Alewife (*Alosa pseudoharengus)*; Atlantic halibut (*Hippoglossus hippoglossus)*; Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*); Atlantic wolffish (*Anarhichas lupus)*; Blueback herring (*Alosa aestivalis*); Dusky shark (*Carcharhinus obscurus)*; Porbeagle shark (*Lamna nasus)*; Rainbow smelt (*Osmerus mordax)*; Sand tiger shark *(Carcharias taurus)*; and Thorny skate (*Amblyraja radiate)*.[4] It should also be noted that Atlantic sturgeon are currently a candidate species for listing under the Endangered Species Act (NMFS 2010a). Accordingly, these species are included in this chapter and are discussed in detail in Section 510.5.

[4] See the NOAA NMFS Office of Protected Resources for a complete list of designated "Species of Concern": http://www.nmfs.noaa.gov/pr/species/concern/.

510.2. Life History, Habitat, and Fishery of Commercially and Recreationally Important Species

510.2.1. American Lobster (*Homarus americanus*)

1. The American lobster is a bottom-dwelling crustacean widely distributed over the North American continental shelf, occurring inshore in the U.S. from Maine through New Jersey, and offshore from Labrador, Canada through North Carolina (ASMFC 2008a). In the Ocean SAMP area, American lobsters are targeted by commercial fishermen.

Life History

2. Lobsters are long-lived, and grow incrementally through molting. During the first two years of their lives, lobsters will molt several times each year, and once or twice per year thereafter, depending on food availability and water temperature (ASMFC 2008a). Most lobsters molt in July or August; with each molt the lobster increases 14% in length and 50% in weight. Lobsters reach legal size in about five to seven years, depending on water temperature (ASMFC 2008a). In Rhode Island, minimum legal size is currently $3^{3/8}$ inches in carapace length.

3. Lobsters become sexually mature between their fifth and eighth year, and may molt as many as 25 times before reaching adulthood (Lobster Conservancy 2004). Female lobsters mate immediately after molting, and store the sperm for up to two years until they extrude their eggs, which are then fertilized. Females carry eggs on their underside for nine to eleven months before hatching. Eggs hatch from mid-May through mid-June (ASMFC 2008a). For the first two months of their lives, lobsters are planktonic, floating at the surface before they sink to the bottom. During their planktonic stage, lobsters sometimes travel great distances and may settle far from their source. Studies of lobster populations have found in some cases only a small percentage of new recruits have come from within the population, and in some cases the percentage of self-recruitment (larvae settling back into the same population) is more than 90 percent. Sources and sinks of larvae will vary from year to year depending on factors such as wind and currents (e.g. Incze et al. 2010). During the first year of their lives, lobsters remain within a meter (3.3 feet) of the spot where they settled (Wahle 1992).

Habitat

4. Lobsters are solitary and territorial. They are most abundant in shallow coastal areas, and are concentrated in rocky habitat where shelter is available, particularly among cobbles and boulders, but also occur in offshore waters. In Rhode Island, lobsters are most often found close to shore among rocks, but they will also frequently burrow in featureless mud, particularly when shelter is not available (Cobb and Wahle 1994). Offshore lobsters are most commonly found along submarine canyons on the edge of the continental shelf. Inshore lobsters typically remain within a home range of about five to ten square kilometers, although large, mature lobsters living in offshore areas will migrate inshore seasonally in the spring and summer to reproduce (ASMFC 2008a). Lobsters in Rhode Island will migrate into Narragansett Bay and other inshore areas during the summer, and return to the Sounds during the fall, traveling as much as 136 nautical miles (252 km) (Saila and Flowers 1968). Pelagic lobster larvae feed primarily on copepods and diatoms. Adults are opportunistic feeders, feeding on fish, crabs, clams, mussels, and sea urchins,

among other species. They are also cannibalistic, and will sometimes eat other lobsters (Lobster Conservancy 2004).

Fishery

5. Three separate stocks of lobsters have been recognized: the Gulf of Maine, Georges Bank, and Southern New England stocks. Lobsters are further divided into seven management areas; Rhode Island waters fall within Management Area 2. Lobsters in both state and federal waters are managed under the Interstate Fisheries Management Program administered by the Atlantic States Marine Fisheries Commission. The fishery is managed through size limits, trap limits, and the practice of cutting a notch in the tail (v-notching) of egg-bearing females. Management measures also include regulations dictating minimum wire gauge and escape vent sizes on the traps. The 2009 peer-reviewed stock assessment report by the Atlantic States Marine Fisheries Commission found overall record high stock abundance in the Gulf of Maine and Georges Bank stocks. For the Southern New England stock, however, abundance is the lowest observed since the 1980s, and recruitment is also very low, although exploitation rates have also declined (ASMFC 2009a). The stock is listed as depleted but overfishing is not occurring. There was a rebuilding program for Southern New England lobster established in 2007; the stock is expected to be rebuilt by 2022 (ASMFC 2009a).[5] According to the University of Maine Lobster Stock Assessment model used by the Atlantic States Marine Fisheries Commission technical committee, the recent abundance for Southern New England lobster from 2005-2007 averaged 14.7 million, and the abundance threshold for the stock is 25.4 million, making the stock overfished (ASMFC 2009a). The average size of lobsters taken within the Southern New England area has been declining for both males and females. NMFS reports there is an excess of effort in the lobster fishery for Southern New England. States report a number of latent licenses which, if used, would exacerbate the excess of effort (NOAA NMFS Northeast Fisheries Science Center [NEFSC] 2006a). It is not well understood what the sources of new settlers to lobster populations in the Ocean SAMP area might be, but it is important to note that this may vary depending on climatic and oceanographic factors, and lobster populations in the Ocean SAMP area may be determined somewhat by spawning and thus population trends elsewhere.

Table 5.3. Habitat characteristics of American lobster. (ASMFC 2008a; ASMFC 2009a; Cobb and Wahle 1994)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Carried on underside of females for 9 to 11 months	N/A	N/A
Larvae	Larvae go through five stages, the first four of which are planktonic. They sink to the floor in the fifth stage	Mostly pelagic	N/A
Juveniles	Shallow, rocky habitats; areas with small	Cobble, boulders,	N/A

[5] In this and all subsequent species descriptions, the terms "overfished" and "overfishing" are used to describe species' stock status. "Overfishing" is defined in the Magnuson-Stevens Act as fishing at a rate or rate or level of mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis. A stock is deemed "overfished" when the population size is determined to be less that that needed to sustain the fishery. For further information see NMFS 2010b.

	shelter-providing spaces; less than 20m in depth. Small juveniles and larvae may use salt marsh peat reefs	subtidal peat, rocky habitats	
Adults	Coastal lobsters found in rocky areas, sometimes burrow in mud substrates; offshore lobsters found along edge of continental shelf near submarine canyons	Cobble, sometimes mud or sand	-2 – 24ºC; generally inactive below 4ºC

510.2.2. Atlantic Bonito (*Sarda sarda*)

1. The Atlantic bonito, also called the skip jack, is an open-ocean fish found in temperate and tropical waters on both sides of the Atlantic. It is common along the east coast of the United States north to Cape Cod. The bonito is in the family *Scombridae* with tunas and mackerels, and is shaped like a small tuna. In the Ocean SAMP area, bonito are targeted by recreational fishermen.

Life History

2. Most bonito reach sexual maturity at two years of age, although some become sexually mature after their first year. Fecundity for females increases with age and size; large females can produce as many as three to six million eggs. Spawning usually occurs to the south of New England during the summer. Juveniles grow nearly a tenth of an inch (0.3 cm) per day in their first summer. Bonito are generally daytime feeders, feeding mostly in the morning and the evening, and sometimes leaping out of the water in large numbers while chasing prey. They can swim up to 30 or 40 miles (48 to 64 km) per hour in pursuit of prey (Ross 1991).

Habitat

3. The bonito is a schooling fish found in the open waters off the continental shelf, normally at depths of less than 200 meters (656 feet). Bonito prefer temperatures between 54 and 77 degrees Fahrenheit (12 and 25 degrees Celsius), and are most abundant at temperatures between 59 and 72 degrees (15 and 22 degrees Celsius). Bonito are found offshore off southern New England in the summer and fall, and migrate south for the rest of the year. Although they are usually an open-ocean species, they are sometimes found near the coast. Larval bonito feed on copepods and small fish larvae, while juveniles and adults eat squid and a number of fish including mackerel, alewives, menhaden, sand lance, silversides, and smaller bonito (Ross 1991).

Fishery

4. Bonito are targeted primarily as a recreational species, and are known for being fast and powerful. They are managed internationally through the International Commission for the Conservation of Atlantic Tunas (ICCAT). At present, there is no Fishery Management Plan in place for bonito; recreational anglers are not required to have a permit to fish for bonito. There are no size or bag limits for bonito.

Table 5.4. Habitat characteristics of Atlantic bonito. (Ross 1991)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles/Adults	Open ocean species, usually in waters less than 200 m deep.	Open ocean	From 12 to 25ºC, most abundant between 15 and

			22ºC.

510.2.3. Atlantic Cod (*Gadus morhua*)

1. Cod are found on both sides of the Atlantic, and range from Greenland to North Carolina in the Northwest Atlantic. Cod are assessed by NMFS as two separate stocks; one in the Gulf of Maine, and the other found on Georges Bank and Southward. Cod are targeted in the Ocean SAMP area by both commercial and recreational fishermen.

Life History

2. Cod typically move south and into deeper water in the winter and spring. The cod found in southern New England waters are probably part of a stock that migrates from Nantucket Shoals in the summer to waters off New Jersey and North Carolina in the winter where they spawn. The cod's eggs and larvae are pelagic for the first three or four months. In 1972, the median age of maturity on Georges Bank was found to be 2.9 years for females and 2.6 years for males, with the median size of both being around 50 cm (20 inches) at maturity. Studies have found significant declines in the median age and size at maturity resulting from declining stock abundance and changes in temperature (Collette and Klein-MacPhee 2002). The fecundity of females increases with age and size. The largest codfish ever recorded was caught off Massachusetts in 1895, weighing 96 kg (211.6 pounds) and measuring 183 cm (72 inches) in length. Cod weighing between 23-27 kg (51 - 60 pounds) are not unusual, but most commercially taken cod weigh only between 2.5 and 4.0 kg (5.5 and 9 pounds) (Collette and Klein-MacPhee 2002). Cod can reach a maximum of 26 to 29 years of age (Collette and Klein-MacPhee 2002).

Habitat

3. Cod are a bottom-dwelling fish, preferring rocky, pebbly, or sandy bottoms, and prefer temperatures between 32 and 50 degrees Fahrenheit (0 to 10 degrees Celsius), although they are often found on Nantucket Shoals in water temperatures as high as 59 degrees Fahrenheit (15 degrees Celsius) (Collette and Klein-MacPhee 2002). They can be found at depths of up to 1200 feet (366 meters), but more typically are found at depths between 200 to 360 feet (60 to 110 meters) (Ross 1991). In Rhode Island waters, cod can be found in shallow coastal waters from October through mid-May, and year-round on Cox Ledge. Cod spawn in the Gulf of Maine, Georges Bank, and southern New England. During their first year, cod are often found in shallow waters close to shore or on Nantucket Shoals and other shallow banks (Collette and Klein-MacPhee 2002).

4. Cod will feed on many different kinds of fish and invertebrates, but especially herring, sand lance, Atlantic mackerel, squids, silver hake, and rock crabs (Collette and Klein-MacPhee 2002). Juveniles eat mostly small crustaceans, while larvae feed on copepods and phytoplankton (Collette and Klein-MacPhee 2002). Juvenile cod are themselves prey for pollock, squid, spiny dogfish, sea ravens, and larger cod (Ross 1991), while adults are preyed upon by large sharks and dogfish (Collette and Klein-MacPhee 2002), as well as seals (Ross 1991).

Fishery

5. The Georges Bank and Southward stock supports a commercial fishery year round, and a recreational fishery from late autumn to early spring. Cod are managed by the New

England Fishery Management Council as part of the fifteen species Northeast Multispecies Fishery Management Plan, through a combination of time/area closures, gear restrictions, and minimum size limits, as well as moratoriums on permits and days-at-sea restrictions. Commercial landings of the Georges Bank and Southward stock hit a record low in 2005, and the stock remains below the long-term average. Fishing mortality has been declining since 1997, but spawning stock biomass (SSB) has also been declining since 2001. The National Marine Fisheries Service defines spawning stock biomass as: "the total weight of all sexually mature fish in the population. This quantity depends on year class abundance, the exploitation pattern, the rate of growth, fishing and natural mortality rates, the onset of sexual maturity and environmental conditions." (NEFSC n.d.). The 2004 SSB was at 10% of the SSB needed for maximum sustainable yield. The stock is thus considered overfished, and overfishing is currently occurring, meaning fishing is occurring at a rate that jeopardizes the ability of the stock to produce maximum sustainable yield (NEFSC 2006a). However, the Georges Bank and Southward stock is currently in the process of being rebuilt, and as of 2009 the Gulf of Maine stock is no longer considered overfished (NMFS 2010b).

Table 5.5. Habitat characteristics of Atlantic cod. (Northeast Fisheries Science Center [NEFSC] 2004a)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Bays, harbors, offshore banks. Usually < 70 m.	Pelagic	Most 2.0-8.5ºC for incubation.
Larvae	Most over Georges Bank, perimeter of Gulf of Maine, southern New England, continental shelf. Densest in spring. Youngest from surface to 75 m. Move deeper with age. Migrate vertically in reaction to light.	Pelagic	Most 4-8ºC in winter - spring, 7-12ºC in summer-fall.
Juveniles	Mostly in shallow waters, coastal or offshore banks, during summer. Deeper water in winter.	'Cobble' preferred over finer grains. Uses vegetation for predator avoidance.	6 - 20ºC. More tolerant of extremes than adults.
Adults	Seasonal migrations except in Gulf of Maine. Most dense Massachusetts Bay, northeast Georges Bank, Nantucket Shoals. Usually on bottom during day, may move up into water column at night. Most found between 60 and 110 meters.	Rocky, pebbly, gravelly. Avoid finer sediments.	Generally < 10ºC, varies seasonally.

510.2.4. Atlantic Herring (*Clupea harengus*)

1. Atlantic herring are pelagic species that occur in large schools, and inhabit coastal and continental shelf waters from Labrador to Virginia. The commercial fishery for herring in New England developed in the late 19th century as the canning industry was developing. An extensive foreign fishery developed on Georges Bank in the 1960s, leading to a collapse of the offshore herring stock. Today, the herring stock is completely rebuilt. Herring are often canned, or sometimes processed as frozen or salted fish by foreign ships that purchase the fish from U.S. fishermen and processing plants. Herring are also commonly used as bait in the lobster fishery, as well as the blue crab and tuna fisheries. Because of their importance as a forage species, they also have an important indirect

value for whale watching and other ecotourism industries (ASMFC 2008a). In the Ocean SAMP area, herring are targeted primarily by commercial fishermen.

Life History

2. Herring usually spawn during the fall months, producing anywhere from 30,000 to 200,000 eggs each. Eggs will hatch in ten to twelve days depending on the water temperature, and the hatchlings are about a quarter inch (0.6 cm) long. In the spring, the larvae will transform into juveniles, about an inch and a half long (4 cm). They will grow three to five inches (7 to 13 cm) the next fall, reaching ten inches (25 cm) and sexual maturity by their fourth year, and can grow up to about fifteen inches (38 cm) in fifteen to eighteen years (ASMFC 2008a). Herring may live twenty years or longer (Collette and Klein-MacPhee 2002).

Habitat

3. Juvenile herring, which are commonly called sardines, migrate from shallow, inshore waters during the summer to deeper, offshore waters during the winter months. Adult fish older than three years will migrate from their spawning grounds in the Gulf of Maine and Georges Bank to spend the winter months in southern New England and the Mid-Atlantic. Herring will spawn during October and November in the southern Gulf of Maine, Georges Bank, and Nantucket Shoals. They prefer rock, gravel, or sand bottoms between 50 feet and 150 feet (15 and 45 m) in depth for spawning (ASMFC 2008a).

4. Herring are filter feeders and feed on plankton, primarily copepods. They usually feed at night, following the zooplankton that inhabit deeper waters during the day and traveling to the surface to feed at night (ASMFC 2008a). Herring themselves play a very important role in the ecosystem, as they are a significant source of food for many species of fish, including cod, haddock, silver hake, striped bass, bluefish, monkfish, mackerel, tuna, and spiny dogfish, as well as birds and marine mammals (Collette and Klein-MacPhee 2002).

Fishery

5. Atlantic herring are managed by the Atlantic States Marine Fisheries Commission in state waters, and by the New England Fishery Management Council in federal waters. Herring is not currently considered overfished, and overfishing is not occurring at present. Fishing mortality has been low since the early 1990s. In 2007, the New England Fishery Management Council implemented a mid-water trawl ban on herring between June 1 and September 30, but no ban exists in state waters. Herring are managed based on a Total Allowable Catch (ASMFC 2008a). Read and Brownstein (2003) found the rate of consumption of herring by marine mammals to greatly exceed the total estimated rates of natural mortality of the species within the Gulf of Maine currently used in stock assessments, and predicted that as marine mammal populations increase, the consumption of herring will likewise increase. These trophic interactions may have not been sufficiently considered in stock assessment models for this species.

Table 5.6. Habitat characteristics of Atlantic herring. (NEFSC 2005a)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Discrete, demersal, egg "beds" in coastal waters and on offshore banks and ledges in the Gulf of Maine and on Georges	Boulders, rocks, gravel, coarse sand, shell	Bottom temperatures over egg beds ranged from 7-15ºC; egg

	Bank with strong bottom currents and coarse substrate, depths of 5-90 m	fragments, macrophytes, and on a variety of benthic organisms and man-made structures (e.g., lobster traps); not on mud or fine sand.	development normal 1-22ºC; development rates/ incubation times inversely related to temperature
Larvae	Estuaries, coastal, and offshore waters between Bay of Fundy and New Jersey; remain on or near bottom for first few days after hatching, then rise to surface and are dispersed by currents. Depths from very shallow waters to 200 m; most 50-90 m	Pelagic	Lab study shows larvae tolerate wide temperature range (-1.8 to 24ºC).
Juveniles	One-year-olds in nearshore waters during summer and fall, overwinter in deeper, coastal waters; two-year-olds in inshore/offshore continental shelf waters of Gulf of Maine, deeper waters of Georges Bank in summer and fall, Cape Hatteras to deeper parts of Georges Bank in winter, widespread from Cape Hatteras to Bay of Fundy in spring. Mostly < 100 m in spring; migrate up in water column at dusk and down at dawn.	Pelagic	Prefer 8-12ºC
Adults	Pelagic, but spawn on bottom; inshore/offshore continental shelf waters of the Gulf of Maine and deeper parts of Georges Bank in summer and fall, Cape Hatteras to deeper parts of Georges Bank in winter, distributed across shelf in mid-Atlantic, southern New England, deeper waters of Georges Bank, and the southwest portion of the Gulf of Maine in spring.	Pre-spawning aggregations more abundant over gravel/sand.	Field observations suggest adults prefer 5-9ºC on Georges Bank in summer/ fall; most caught 4-7ºC in spring and 6-10ºC in fall NEFSC trawl surveys

510.2.5. Atlantic mackerel (*Scomber scombrus*)

1. The Atlantic mackerel is a pelagic fish found from the Gulf of St. Lawrence to Cape Hatteras. There are two separate stocks of mackerel, one of which spends winters between the Chesapeake Bay and Long Island, and moves northward along the New England coast in June and July, and the other which moves inshore to southern New England in late May, and migrates north toward Nova Scotia (Ross 1991). In the Ocean SAMP area, mackerel are targeted both by commercial and recreational fishermen.

Life History

2. Adult mackerel usually measure about fourteen to eighteen inches (35 to 46 cm) in length and weigh about a pound (0.5 kg). They are generally found in Rhode Island waters from

May through September, and migrate offshore to the edge of the continental shelf in winter. They spawn in the Mid-Atlantic Bight and in the Gulf of Maine in spring and early summer, once the water is warmer than 46 degrees Fahrenheit (8 degrees Celsius) (Collette and Klein-MacPhee 2002). The fish will form schools when they are about 40 days old, and are about two inches long (5 cm). The mortality rates of young mackerel are very high (Ross 1991). Mackerel grow to about eight inches (20 cm) by the end of their first year, and are sexually mature by their second year (Collette and Klein-MacPhee 2002).

Habitat

3. Mackerel are found in dense schools between 100 fathoms (183 meters) and the surface. They are an open-ocean fish often found over the edge of the continental shelf, but will also inhabit brackish coastal waters. They prefer to spawn near the surface. Mackerel are opportunistic feeders, and feed largely on zooplankters, including copepods, shrimps, and fish larvae. Larger mackerel will feed on larger prey such as squid, silver hake, sand lance, herring, and sculpins (Collette and Klein-MacPhee 2002). They are an important prey species for whales, porpoises, sharks, cod, tunas, bluefish, striped bass, birds, and squid, which eat small mackerel (Ross 1991).

Fishery

4. Mackerel are an important species for both commercial and recreational fisheries. The Atlantic mackerel stocks are currently managed by the Mid-Atlantic Fishery Management Council under the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. Spawning stock biomass for mackerel has increased steadily since 1976, and fishing mortality has been low since 1992 (NEFSC 2006a). Spawning biomass reached a record high in 2004, and population estimates put biomass of Atlantic mackerel at 257% above what is needed to support maximum sustainable yield (NMFS 2010b). Thus, the stock is not overfished and overfishing is not considered to be occurring (NEFSC 2006a).

Table 5.7. Habitat characteristics of Atlantic mackerel. (NEFSC 1999a)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Highest abundances in May/June in southern New England - Mid-Atlantic region. Eggs pelagic, distributed at depths ranging from 10-325 m, majority from 30-70 m.	Pelagic	Eggs collected at 5-23ºC, highest abundance from ~ 7-16ºC with range related to season.
Larvae	Highest abundance ranges from Hudson Canyon north to southern New England and north of Cape Cod. Most distributed at depths from 10-130 m, usually at < 50 m.	Pelagic	Larvae collected at 6-22ºC; highest abundance at 8-13ºC.
Juveniles	Late summer/fall primarily along western shores of Gulf of Maine, inshore areas of New England (includes estuaries in Rhode Island, Connecticut, eastern Long Island). Depth varies seasonally. Offshore in fall, most abundant at ~ 20-40 m, range from 0-320 m. In winter, 50-70 m.	Pelagic	Temperature distribution offshore changes seasonally as average temperature ranges increase: in Rhode Island, 19ºC in summer, 11 and 15ºC in fall.

	Spring, although dispersed through water column, concentrated 30-90 m. Move higher in summer to 20-50 m, range from 0-210 m.		
Adults	Fall: concentrated at 60-80 m. Winter: ~ 50% at 20-30 m. Spring: down to 380 m. Summer: > 60% at 50-70 m. Larger fish deeper than smaller ones. Distribution may also be correlated with downwelling events and onshore advection of warm surface water. Found on edge of continental shelf, but will also inhabit brackish waters. Most spawning in shoreward half of continental shelf, some on shelf edge and beyond.	Pelagic	Offshore distribution varies with seasonal temperature changes. Most found between 5-14ºC. Spawning begins when temperatures are ~ 7ºC (peak 9-14ºC) and progresses from southern to northern waters during adult migration.

510.2.6. Atlantic Sea Scallop (*Placopecten magellenicus*)

1. The Atlantic sea scallop is found from the Gulf of St. Lawrence to Cape Hatteras. In the Ocean SAMP area, sea scallop are harvested by commercial fishermen. The scallop fishery is presently the most lucrative fishery in New England.

Life History

2. Sea scallops become sexually mature at age two, but those less than four years of age probably contribute little to egg production. Fertilization takes place externally, and sea scallops usually spawn in late summer and early autumn. A single female may release hundreds of millions of eggs annually (NEFSC 2006a). Larvae remain in the water column as part of the plankton for over one month after hatching (Pogsay 1979), during which time eggs and larvae are subjected to currents. The spat, or juvenile larvae, eventually sink and seek out hard substrate, such as shell fragments, on which to settle. Young adults are exceptionally vulnerable to smothering by moving sands and loose bottom substrates (Mullen and Moring 1986). Sea scallops grow rapidly, increasing their shell height by 50 to 80 percent between ages three and five, and quadrupling their meat weight. They reach commercial size at about four or five years of age. Sea scallops can live up to 20 years. A combination of low mobility, rapid growth, and low natural mortality means sea scallop populations grow rapidly in areas which are closed to fishing activity (NEFSC 2006a).

Habitat

3. Sea scallops are found from mean low water to depths of several hundred feet. They are found on a variety of bottom types, including firm sand, gravel, shells, and rocks (NEFSC 2004b). They prefer sand and gravel sediments, and water temperatures below 68 degrees Fahrenheit (20 degrees Celsius). South of Cape Cod and on Georges Bank, sea scallops are usually found at depths between 25 and 200 meters (82 and 656 feet), with most commercial concentrations found between 35 and 100 meters (115 and 328 feet) of depth. Sea scallops are filter feeders, feeding mainly on phytoplankton, but also on microzooplankton and detritus (NEFSC 2006a). Large adults do not migrate, but can escape predators by clapping the two halves of their shells together in a rudimentary form of swimming.

Fishery

4. The fishery for sea scallops is conducted year-round, usually with scallop dredges. The sea scallop fishery is managed by the New England Fishery Management Council. Most sea scallop fishing in the United States is done by vessels with limited access permits, which provide them with days-at-sea and a limited number of trips to former closed areas. Some sea scallop vessels have open access general category permits, allowing them to take up to 400 pounds of meats per day; these are the vessels operating within the Ocean SAMP waters. The biomass of sea scallops on Georges Bank was low from 1982 through 1994, but then increased, and has been at a high, stable level since 2000. Surveys for Georges Bank and Mid-Atlantic sea scallops indicated the species was near its historical maximum biomass in 2005 (NEFSC 2006a). The biomass of Atlantic sea scallops in 2006 was estimated at 166,000 metric tons of meats, about 52% above the amount needed to produce maximum sustainable yield (NMFS 2010b). They are not considered to be overfished, nor is overfishing occurring (NEFSC 2006a).

Table 5.8. Habitat characteristics of Atlantic sea scallop. (NEFSC 2004b)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Remain on sea floor	N/A	N/A
Larvae	In mixed areas, larvae distributed evenly through water column; in stratified areas, larvae aggregated above pycnocline. Migrate vertically in response to tidal, solar cues.	Larvae settle in areas of gravelly sand, shell fragments or on hydroids, bryozoans and sponges; select substrates covered with a biofilm.	N/A
Juveniles	N/A	Mainly found on gravel, small rocks, shells, and among branching animals and plants that permit attachment of juveniles.	N/A
Adults	Wide distribution on offshore banks and coastal waters from Newfoundland to Cape Hatteras; from low tide level to ~100 m line; generally shallower in northern populations.	Generally found in seabed areas with firm sand, gravel, shells and cobble substrate. Typically abundant in areas with low levels of inorganic suspended particulates (fine clay size particles).	Prefer water temperatures below 20ºC

510.2.7. Black Sea Bass (*Centropristis striata*)

1. Black sea bass are concentrated from Cape Cod to Cape Canaveral, Florida. There are two distinct and overlapping stocks of black sea bass along the Atlantic coast. In the Ocean SAMP area, black sea bass are targeted by both commercial and recreational fishermen.

Life History

2. Black sea bass are protogynous hermaphroditic, beginning life as females and then changing to males when they reach about nine to thirteen inches (23 to 33 cm) in length. In the Mid-Atlantic, 38% of females will change sex between August and April, after most of the fish have already spawned. Most black sea bass will produce eggs when they

first mature, although some are already males at this stage, and then the ovaries eventually stop functioning as sperm production begins. Most fish will reverse sex before they reach the age of six (ASMFC 2008a). In populations where the larger, older males are heavily fished, females may change sex at an earlier age than they would in populations unaffected by fishing (Ross 1991).

3. The northern stock of black sea bass spawns off New England from mid-May until the end of June (Ross 1991), and an average sized fish will produce roughly 280,000 eggs. The eggs float in the water column, hatching a few days after fertilization. The larvae will drift offshore until they grow to a half an inch (one cm) in length, at which point the young sea bass will migrate inshore into estuaries, bays, and sounds (ASMFC 2008a).

Habitat

4. Black sea bass are a temperate reef fish, preferring water about 48 degrees Fahrenheit (9 degrees Celsius), and they prefer to inhabit rock bottoms near pilings, wrecks, and jetties. They are found in inshore waters at depths of less than 120 feet (37 meters) in the summer, and move offshore to deeper waters to the south during the winter (ASMFC 2008a). Larger adults are usually found in deeper waters than smaller individuals, and larger adults typically begin their migration earlier than the younger adults and juveniles, starting in August (Ross 1991). Juvenile sea bass migrate inshore and prefer sheltered habitats such as submerged aquatic vegetation, oyster reefs, and man-made structures. Juveniles feed primarily on benthic invertebrates such as shrimp, isopods, and amphipods, while adults feed on rock and hermit crabs, squid, fish, and mollusks (Ross 1991).

Fishery

5. In Rhode Island, black sea bass are important as both a commercial and recreational species. Both commercial and recreational landings are regulated under a quota system, managed jointly by the Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fishery Management Council under the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan, in which 51 percent of the quota is given to the recreational fishery, and 49 percent to the commercial fishery. The commercial quota is further divided up by state based on historical landings; Rhode Island fishermen are given eleven percent of the total quota for this species. By contrast the recreational quota is managed under a coastwide plan (ASMFC 2008a). Black sea bass is currently considered rebuilt by the Atlantic States Marine Fisheries Commission and overfishing is not occurring (ASMFC 2009b). Abundance of black sea bass had declined after 2003, but has since increased, and the stock was declared rebuilt in 2009 by NMFS. In 2008, biomass of black sea bass in the Mid-Atlantic was estimated to be 3% above the target level (NMFS 2010b).

Table 5.9. Habitat characteristics of black sea bass. (NEFSC 2007)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Mostly at shallow depths; majority around 30m	Pelagic	Mostly between temperatures of about 10-25ºC
Larvae	Reported in high salinity coastal areas of southern New England in August and September, but are rarely reported in	Pelagic	Between temperatures of 11-26ºC. Most larvae found at about 15-19ºC in July, at 15-

	estuaries. Most found at 30-50 m in July – September.		20ºC in August, and in 17-21ºC in September.
Juveniles	Most abundant in oceanic waters of estuaries. High numbers of juveniles in Rhode Island Sound, Buzzards Bay, and the tip of Long Island in the fall. Found in Narragansett Bay. Between 1-35 m, with the majority between 6-15 m. Most nurseries are located at depths < 20 m.	Shellfish beds, seagrass beds, rocky reefs, wrecks, cobble habitats, manmade structures	9-12°C in spring, 10-22°C in fall, with most between 17-21°C.
Adults	Structurally complex habitats with steep depth gradients. Use a variety of man-made habitats. Over wintering habitats in the Mid-Atlantic Bight appear to occur at depths between 60-150 m. Some fish may also over winter in deep water (> 80 m) off southern New England. Depth range in spring from 1 -65 m, with most between 6-25 m, and between depths of 6-20 m in fall. Larger fish found in deeper water.	Structurally complex habitats, including rocky reefs, cobble and rock fields, stone coral patches, exposed stiff clay, and mussel beds.	In spring, temperature range of 3-17°C, with the majority at 10-14°C. In fall, over a range of approximately 8-22°C, with the majority between 16-21°C. In Narragansett Bay, summer temperature range of 15-24ºC, with peaks at 91-20ºC. Potential over wintering habitat may be defined by bottom water temperatures > 7.5ºC.

510.2.8. Bluefish (*Potamomus saltatrix*)

1. Bluefish are a migratory, pelagic species found throughout much of the world's temperate, coastal regions. In the Ocean SAMP area, bluefish are pursued primarily by recreational fishermen.

Life History

2. Bluefish live up to fourteen years, and may weigh upwards of 31 pounds (14 kg) and measure at least 39 inches (one meter) in length. They reach sexual maturity at two years, and spawn offshore between Massachusetts and Florida. Different groups of bluefish spawn at different times of the year, with some spawning in spring, some in summer, and some in fall throughout their range (ASMFC 2008a). Once the larvae hatch, they live in surface waters and are carried by currents along the continental shelf. The survival of the young fish is highly variable from year to year, depending on whether the prevailing circulation patterns carry them inshore to suitable habitats (Ross 1991).

Habitat

3. Bluefish are found between Maine and Cape Hatteras, North Carolina during the summer months, and between Cape Hatteras and Florida in the winter (ASMFC 2008a). Larger fish will migrate further north than younger ones. The fish will begin arriving off the southern New England coast in April and May; smaller fish usually arrive first. Adults will leave the coastal areas again in October, when the water cools to 60 degrees Fahrenheit (16 degrees Celsius) (Ross 1991). They prefer warmer waters of at least 57 to 60 degrees Fahrenheit (14 to 16 degrees Celsius) in summer (Collette and Klein-MacPhee 2002). Bluefish migrate in large schools, each of which may cover tens of square miles of ocean (ASMFC 2008a). They inhabit both inshore and offshore habitats, with young-of-the-year fish often found in estuaries and river mouths (Ross 1991).

4. Bluefish are voracious predators, and will eat almost anything they can catch and swallow. Bigelow and Schroeder (1953) called the bluefish, "the most ferocious and bloodthirsty fish in the sea," although Ross (1991) notes this reputation is somewhat exaggerated. They have very sharp teeth and can take large bites, meaning they can eat larger prey (ASMFC 2008a). Common prey include schooling species such as squid, menhaden, mackerel, herring, alewives, and sand eels, as well as scup and butterfish. They usually feed in schools, pursuing fish into tidal rips or inshore shallows. They are known to force schools of menhaden and other fish up on shore, leading to fish kills. Juvenile bluefish will feed on polychaetes, shrimp, other small crustaceans, small mollusks, and small fish. Bluefish are prey for blue sharks, mako sharks, tuna, and billfish (Ross 1991).

Fishery

5. Bluefish are an important species for recreational fisheries, and are popular with anglers because of their aggressive feeding habits. Recreational harvest averages about 35 million pounds (16 million kilograms) per year. Bluefish are also targeted commercially with trawls, gillnets, haul seines, and pound nets. The species is managed jointly by the Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission. The Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fishery Management Council allocate 83 percent of the resource to recreational fisheries and 17 percent to commercial fisheries. The commercial fishery is managed through state-by-state quotas based on historic landings, and the recreational fishery is managed by a fifteen-fish bag limit. According to the Atlantic States Marine Fisheries Commission, bluefish are not overfished, nor is overfishing presently occurring. Recent data have shown a decreasing trend in fishing mortality and an increase in stock biomass and population numbers (ASMFC 2008a). Bluefish biomass in the Atlantic Ocean is estimated to be at 5% above the level needed to support maximum sustainable yield, and was estimated at 139,500 metric tons in 2006. A nine-year rebuilding plan was implemented in 2001, and the stock was declared rebuilt in 2009 (NMFS 2010b). Cycles of high and low abundance of bluefish have been observed to be the converse of striped bass abundance patterns, but no explanation for this phenomenon has been found (NEFSC 2006b).

Table 5.10. Habitat characteristics of bluefish. (NEFSC 2006b)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Occurs across continental shelf, southern New England to Cape Hatteras. Most in mid-shelf waters.	Pelagic	Most in 18-22ºC.
Larvae	Most 30-70 m depths, May-Sept, peak in July.	Strongly associated with the surface.	18-26ºC in Mid-Atlantic Bight
Juveniles	Mostly estuarine areas and river mouths, including Narragansett Bay. Also coast beaches and surf zones.	Mostly sand, particularly along coast, but some mud, silt, clay. Also uses vegetation beds.	In most studies, arrive > 20ºC, remain in temperatures up to 30ºC, emigrate when declines to 15ºC. Can not survive below 10ºC or above 34ºC. Fall migration in

			18-22ºC on inner continental shelf.
Adults	Generally oceanic, nearshore to well offshore over continental shelf. Not uncommon in bays, larger estuaries, as well as coastal waters.	Pelagic	Warm water, usually > 14-16ºC.

510.2.9. Butterfish (*Poronotus triacanthus*)

1. Butterfish are found from Newfoundland to Florida. In the Ocean SAMP area, butterfish are targeted by commercial fishermen.

Life History

2. Butterfish are pelagic fishes, forming loose schools (NEFSC 1999b). Butterfish are found in Narragansett Bay and in Rhode Island and Block Island Sounds from late spring through fall, appearing off Rhode Island in late April. They spawn usually within a few miles of the coast during the late spring and early summer, and migrate to the edge of the continental shelf during the winter (Collette and Klein-MacPhee 2002). Butterfish eggs are found within Narragansett Bay from June through August (NEFSC 1999b). The eggs of the butterfish are buoyant, and will hatch within two days in waters of around 65 degrees Fahrenheit (18 degrees Celsius). The juveniles will grow to about half their adult size within their first year (Collette and Klein-MacPhee 2002). Juvenile butterfish may associate with jellyfish during the summer to avoid predators (NEFSC 2006a). Butterfish mature in their second summer (Collette and Klein-MacPhee 2002). They can reach up to twelve inches (30 cm) in length, although most harvestable butterfish are between six and nine inches (15 and 23 cm). The maximum reported age for butterfish is six years, although most probably only live two to three years (Collette and Klein-MacPhee 2002).

Habitat

3. Butterfish feed primarily on tunicates and mollusks, as well as cnidarians, polychaetes, crustaceans, and other invertebrates (Collette and Klein-MacPhee 2002). Ctenophores have been found to make up an important component of the diet of juvenile butterfish in Narragansett Bay (Oviatt and Kremer 1977). They will often come close to shore into sheltered bays and estuaries, and they have a preference for sandy bottom as opposed to rocky or muddy bottom. They spend much of their time near the surface when they are near to shore, but spend the winter and early spring near the bottom at depths of up to 100-115 fathoms (183 to 210 m) (Collette and Klein-MacPhee 2002). Butterfish serve as prey to a number of species including hake, bluefish, weakfish, and swordfish, and are used commonly as bait in recreational tuna fisheries (Ross 1991).

Fishery

4. The butterfish stock is currently managed by the Mid-Atlantic Fishery Management Council under the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. There is considerable uncertainty in butterfish abundance estimates. Discards of butterfish in fisheries targeting other species, particularly in the squid fishery, is an important source of mortality (NEFSC 2006a).

Table 5.11. Habitat characteristics of butterfish. (NEFSC 1999b)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Surface waters from continental shelf into estuaries and bays; collected to about 60 m deep in shelf waters.	Pelagic	Most eggs collected between 11-17ºC.
Larvae	Surface waters from continental shelf into estuaries and bays; collected to about 60 m deep in shelf waters; common in high salinity zone of estuaries and bays; may spend day deeper in the water column and migrate to the surface at night.	Pelagic	4.4-27.9ºC
Juveniles	From surface waters to depth on continental shelf; into coastal bays and estuaries; common in inshore areas, including the surf zone, and in high salinity and mixed salinity zones of bays and estuaries. Most collected in < 120 m. Commonly occur in bays and estuaries from MA to VA from spring through fall.	Larger individuals found over sandy and muddy substrates.	4.4-29.7ºC
Adults	From near surface waters in summer to depths of 270-420 m on continental shelf in winter; into coastal bays and estuaries; common in inshore areas, including the surf zone, and in high salinity and mixed salinity zones of bays and estuaries. Most collected in < 180 m. Spawning occurs on continental shelf, inshore areas, and in bays and estuaries.	Schools found over sandy, sandy-silt, and muddy substrates.	4.4-26.0ºC; Spawning does not occur at < 15ºC.

510.2.10. False Albacore *(Euthynnus alletteratus)*

1. The false albacore is also referred to as the little tunny. These fish are found in the tropical and temperate waters of the Western Atlantic from New England south to Brazil. Unlike other tunas, the false albacore is mostly scaleless (Ross 1991). In the Ocean SAMP area, false albacore are one of the most prized fish pursued by recreational fishermen for catch and release.

Life History

2. False albacore are usually about 25 inches (63 cm) in length, although they can grow to 40 inches (101 cm). They reach sexual maturity at about 15 inches (38 cm). The fish spawn from April to November (NMFS 2007b). A female will produce as many as 1.8 million eggs, which are released in several large batches during the spawning season. They are usually found traveling in large schools with similar-sized individuals, and sometimes in mixed schools with Atlantic bonito (Ross 1991).

Habitat

3. The false albacore is usually found near the coast, or around offshore shoals or islands further out on the continental shelf. In the Atlantic, the false albacore is rarely found in waters beyond the continental shelf. The fish prefers areas with strong currents. False

albacore migrate northward along the Atlantic coast of the United States in spring and summer, moving from the North and South Carolina coasts in May and June to southern New England by August and September. The false albacore feeds during the daytime on schools of sand lance, herring, mackerel, and young false albacore, as well as squid, euphausiid shrimp, and other crustaceans. They are preyed upon by yellowfin tuna and various species of sharks (Ross 1991).

Fishery

4. False albacore are managed internationally through the International Commission for the Conservation of Atlantic Tunas. At present, there is no Fishery Management Plan in place for false albacore; recreational anglers are not required to have a permit to fish for this species. There are no size or bag limits for false albacore.

Table 5.12. Habitat characteristics of false albacore. (Ross 1991)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles/Adults	Near-coastal waters or around offshore shoals or islands. Usually on continental shelf, in areas with strong currents	Pelagic	N/A

510.2.11. Goosefish (monkfish) *(Lophius americanus)*

1. The goosefish, also commonly called monkfish, is found from Newfoundland to North Carolina, and in the Gulf of Mexico. In the Ocean SAMP area, monkfish are targeted by commercial fishermen.

Life History

2. Male monkfish become sexually mature at age four, and females at age five. They reproduce in shallow water from spring through early fall; typically from late June through mid-September in New England. They produce large masses of eggs in a single ribbon that can be up to 25-36 feet (7-11 m) in length that float within the water column, and can produce up to 2.8 million eggs at one time. By the time the fry reach about two inches (5 cm) in length, they become bottom-dwellers. They can reach four feet (1.2 m) in length and weigh up to 50 pounds (23 kg) (Ross 1991).

Habitat

3. Monkfish are found from the tideline out to depths of greater than 2,000 feet (610 m) on the continental slope. They live on various types of substrate, including sand, gravel, rocks, mud, and beds of broken shells. They have been found in a variety of temperatures, from 32 degrees to 70 degrees Fahrenheit (0 to 21 degrees Celsius), but prefer temperatures of 37-48 degrees Fahrenheit (3 to 9 degrees Celsius). Young monkfish fry will feed on copepods, crustacean larvae, and arrow worms (Ross 1991). Adult monkfish are voracious predators, feeding on skates, herring, mackerel, and silver hake, as well as lobsters and crabs. The most important prey species for monkfish in southern New England are little skate, red hake, sand lance, and other monkfish (Collette and Klein-MacPhee 2002). The monkfish often feeds by lying motionless in eelgrass, waving its “lure” to attract fish and then opening its enormous mouth to suck in the fish, earning it the nickname “angler”. The monkfish also eats seabirds, including cormorants,

herring gulls, loons, and other sea birds, the practice of which has given the fish the nickname "goosefish", although there have been no documented cases of a monkfish eating a goose. A monkfish can have up to half its own bodyweight in its stomach (Ross 1991), and can swallow a fish almost its own size (Collette and Klein-MacPhee 2002).

Fishery

4. Monkfish are currently managed under the Monkfish Fishery Management Plan by the New England and Mid-Atlantic Fishery Management Councils. Management measures include limited access, days-at-sea limitations, mesh size restrictions, minimum size limits, and trip limits. Monkfish are managed as two separate stocks; the monkfish in Rhode Island waters are considered part of the southern stock, which extends from the southern portions of Georges Bank to the Mid-Atlantic. Based on the 2007 stock assessment, monkfish biomass is 29% above that necessary to support maximum sustainable yield, and so monkfish are not considered overfished, nor is overfishing occurring (NMFS 2010b). Monkfish are caught throughout the Ocean SAMP area.

Table 5.13. Habitat characteristics of goosefish (monkfish). (NEFSC 1999c)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Upper water column, inner to mid-continental shelf, southern New England, and Mid-Atlantic Bight; not in estuaries. Contained in long mucus veils that float near or at surface.	Pelagic	4-18°C or higher
Larvae	Mainly mid-shelf in southern New England and Mid-Atlantic Bight. Upper to lower water column, at depths of 15 to > 1000 m; mostly 30-90 m.	Pelagic	6-20°C, most in 11-15°C
Juveniles	Southern New England: mostly mid to outer shelf. Seabed, > 20 m, peak abundance at 40-75 m.	Mud to gravelly sand, algae, and rocks.	2-24°C, most 3-13°C
Adults	Southern New England/Mid-Atlantic Bight: inshore in winter, offshore in summer fall. Seabed, 1- 800 m, most 50-99 m, sometimes at surface.	Mud to gravelly sand, algae, and rocks. Will hide in eelgrass to ambush prey.	Seasonally variable, 0-24°C; mostly 4-14°C.

510.2.12. Longfin Squid *(Loligo pealeii)*

1. Longfin squid are distributed from Cape Cod through Cape Hatteras. In the Ocean SAMP area, longfin squid are pursued by commercial fishermen.

Life History

2. The longfin squid grows to about eight to twelve inches long (20 to 30 cm), and is sexually dimorphic, with males growing faster than females. It moves by means of jet propulsion, taking in water through a siphon and then expelling it. The life span of the longfin squid is thought to be about six months (Macy and Brodziak 2001). Adult longfin squid are demersal during the day, coming to the surface at night to feed. Newly hatched squid are found at the surface, and move deeper in the water column as they grow, becoming demersal when they reach just under two inches (45 mm) in length (NEFSC 2005b). There is evidence that squid spawn throughout the year, with two main spawning periods in the summer and winter (Macy and Brodziak 2001).

Habitat

3. The greatest abundance of longfin squid are found in continental shelf and slope waters at depths between 55 and 92 fathoms (100 and 168 m). They generally migrate inshore to waters off Rhode Island and elsewhere in May or June, and by late November/early December they migrate to deeper waters along the edge of the continental shelf (Macy and Brodziak 2001). The adults feed on small fish, while juveniles feed on small crustaceans (Rathjen 1973). Squid are an important prey species to a number of other species including sharks, haddock, hakes, striped bass, black sea bass, bluefish, scup, mackerel, summer flounder, and tunas (Ross 1991).

Fishery

4. Two separate fisheries exist for longfin squid; an inshore fishery in summer and fall, and a larger offshore commercial fishery during the winter months, when the squid migrate to the edge of the continental shelf (Macy and Brodziak 2001). The longfin squid stock is currently managed by the Mid-Atlantic Fishery Management Council under the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. They are managed through the use of permits, quotas, and gear restrictions. Landings of longfin squid have declined, due in part to seasonal closures (NEFSC 2006a). The relative biomass measures of longfin squid were below average through 2005, but increased to slightly above average in 2007. Estimates of the level of biomass needed to support maximum sustainable yield for longfin squid are not currently available. Overfishing is not presently occurring on this species (NMFS 2010b).

Table 5.14. Habitat characteristics of longfin (*loligo)* squid. (NEFSC 2005b)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Shallow waters, <50m and near shore.	Egg masses are Commonly found on sandy/mud bottom; usually attached to rocks/boulders, pilings, or algae.	Eggs found in waters 10-23ºC; usually > 8ºC. Optimal development at 12ºC.
Larvae	Found in coastal, surface waters in spring, summer, and fall. Hatchlings found in surface waters day and night. Move deeper in water column as they grow larger.	Pelagic	Found at 10-26ºC (at lower temperatures found at higher salinities).
Juveniles	Inhabit upper 10 m at depths of 50-100 m on continental shelf. Found in coastal inshore waters in spring/fall, offshore in winter. Migrate to surface at night.	Pelagic	Found at 10-26ºC. Juveniles prefer warmer bottom temperatures and shallower depths in fall than adults.
Adults	March-October: inshore, shallow waters up to 180 m. Winter: offshore deeper waters, up to 400 m on shelf edge. Most abundant at bottom during the day; move upwards at night. Generally found at greater depths and cooler bottom	Mud or sandy mud	Found at surface temperatures ranging from 9-21ºC and bottom temperatures ranging from 8-16ºC.

	temperatures in the fall than juveniles.		

510.2.13. Menhaden *(Brevoortia tyrannus)*

1. Atlantic menhaden (*Brevoortia tyrannus*), also called pogies, bunkers, and fatbacks, are found in estuarine and coastal waters stretching from Nova Scotia to northern Florida. Menhaden are a prey species that provide food to many commercially and recreationally important species. In addition, menhaden are used as bait in the lobster fishery.

Life History

2. Adult and juvenile menhaden form large schools near the surface, mostly in estuaries and along the shore from early spring through early winter. During the summer, menhaden schools will stratify by age and size along the coast; older, larger menhaden are generally found further north. In the fall and early winter, menhaden of all ages and sizes will migrate south to spawn in the waters between New Jersey and North Carolina, usually about twenty to thirty miles offshore. The eggs that are released float offshore; when the juveniles hatch, they will be carried into estuarine nursery areas by ocean currents where they will spend the first year of their lives, migrating south in the winter (ASMFC 2008a). Adults average about 7- 12 inches (20-30 cm) in length and weigh 0.5 – 1.3 pounds (0.25-0.6 kg) (Collette and Klein-MacPhee 2002).

Habitat

3. Menhaden spawn offshore in the waters between New Jersey and North Carolina during the fall and early winter, and spend the rest of the year in estuaries, migrating further north. Menhaden feed on plankton, most commonly diatoms and small crustaceans, by straining it from the water using their gill rakers. They themselves serve as an important food source for many larger fish, including striped bass and bluefish (ASMFC 2008a). This is highlighted by the 2006 menhaden stock assessment, which found that predation mortality is most likely the highest cause of natural mortality (Atlantic Menhaden Technical Committee 2006).

Management

4. Menhaden are managed by the Atlantic States Marine Fisheries Commission, and are managed through the use of seasonal restrictions and management areas in Rhode Island. Commercial fishing for menhaden typically includes both a bait fishery and a reduction fishery, where the fish are processed into fishmeal and oil. Rhode Island does not allow a reduction fishery to occur in state waters, but there is a bait fishery taking place here. They are of commercial importance largely because of their use as bait for the lobster fishery, though they are also used by recreational fishermen as bait in the striped bass and bluefish fisheries. Although they are typically fished from Narragansett Bay rather than from the Ocean SAMP area, menhaden pass through the Ocean SAMP area. However, due to current restrictions placed on the bait fishery in Narragansett Bay, fishing pressure may transfer in to the Ocean SAMP area in the future. Menhaden were historically a major fishery in Rhode Island (see Section 530). Some have argued that local stocks have been depleted due to fishing pressure off mid-Atlantic states, which has prevented menhaden from migrating northward (Oviatt et al. 2003). According to the Atlantic

States Marine Fisheries Commission, menhaden are not overfished, and overfishing is not occurring (ASMFC 2008a).

Table 5.15. Habitat characteristics of menhaden (ASMFC 2008a; Collette and Klein-MacPhee 2002).

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Buoyant; hatch at sea.	Pelagic	N/A
Larvae	Estuarine nursery areas with salinity < 10 ppt.	N/A	N/A
Juveniles	Live in estuaries for first year of life.	Unconsolidated bottom with sand, mud, organic material; rocky coves with cobble, rock, and sand bottoms in northern part of range.	N/A
Adults	Nearshore and inland tidal waters.	Ranges from a bottom composition of sand, mud and organic material to marine sand and mud with increasing amounts of rocks in the more northerly areas.	Prefer water temperatures near 18° C.

510.2.14. Scup *(Stenotomus chrysops)*

1. Scup, also known as porgy, are a migratory species found from Cape Cod to Cape Hatteras. Scup are pursued by both recreational and commercial fishermen in the Ocean SAMP area.

Life History

2. Scup spawn in inshore waters during the summer, with spawning reaching its peak in June off southern New England. The eggs will hatch about 40 hours after fertilization. Larval scup are pelagic and are found in coastal waters during the warmer months. Scup become sexually mature at age two or three (ASMFC 2008a). They form into schools of similarly-sized individuals. They can grow up to six pounds, but rarely exceed two pounds (one kg) in weight and fourteen inches (36 cm) in length. They can reach fifteen years of age, although it appears this is rare because of high mortality rates due to predation and fishing (Ross 1991).

Habitat

3. Scup are most commonly found in waters between 55 and 77 degrees Fahrenheit (13 and 25 degrees Celsius). They spend the winters in offshore waters from southern New Jersey to Cape Hatteras, and spawn in the summer in inshore waters from southern New

England to Long Island, moving to New England waters in May until leaving in October. Juvenile scup inhabit coastal habitats, and will sometimes dominate the fish population of estuarine areas during the summer months (ASMFC 2008a). They prefer areas with smooth or rocky bottoms, and are often found around piers, rocks, offshore ledges, jetties, and mussel beds. During the winter, they prefer depths of 240 to 600 feet (73 to 183 m), where the water temperature is at least 45 degrees Fahrenheit (7 degrees Celsius). Adult scup feed on bottom invertebrates, including small crabs, squid, worms, clams, mussels, amphipods, jellyfish, and others. They are eaten by a variety of different fishes; as many as 80% of all juvenile scup annually are eaten by fish such as cod, bluefish, striped bass, and weakfish (Ross 1991).

Fishery

4. Scup is important as both a recreational and commercial species. Rhode Island has the largest share of scup landings in state waters along with New Jersey. The species is jointly managed by the Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission through the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (ASMFC 2008a). Scup spawning stock biomass had declined greatly in the mid-1990s, but has steadily increased since then. Overfishing is not occurring, and the stock is not overfished. Scup biomass for 2008 was estimated to be 104% above that required for maximum sustainable yield. Spawning stock biomass was estimated to be around 188,000 metric tons in 2008 (NMFS 2010b).

Table 5.16. Habitat characteristics of scup. (NEFSC 1999d)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Water column, < 30 m in depth, Coastal Virginia – Southern New England.	Buoyant in water column.	11-23°C; most common 12-14°C
Larvae	Water column, < 20 m until juvenile transition.	Water column	14-22°C; peak densities at 15-20°C
Juveniles	Young-of-year: Estuarine and coastal; from intertidal to about 38 m. Winter juveniles: Mostly > 38 m depth; mid and outer continental shelf; sometime in deep estuaries.	Sand, mud, mussel, and eel grass beds.	Greater than ~9-27°C; mostly 16-22°C
Adults	2-38 m in summer. Mostly 38-185 m depths; mid/outer continental shelf in winter.	Fine to silty sand, mud, mussel beds, rock, artificial reefs, wrecks, and other structures in summer. Weedy and sandy habitats when spawning.	~7-25°C

510.2.15. Shark, Blue *(Prionace glauca)*

1. Sharks are pursued by recreational fishermen in the Ocean SAMP area. Whereas a number of different shark species may be pursued by fishermen, the most commonly targeted ones are blue, shortfin mako, and thresher. Compared with other marine fishes,

sharks have a very low reproduction potential because of a combination of factors including slow growth, late sexual maturity, infrequent reproductive cycles, a small number of young produced, and requirements for nursery areas. These factors make sharks highly vulnerable to overfishing (ASMFC 2008a). The blue shark is widely distributed in both inshore and offshore areas throughout the North Atlantic, and is one of the most commonly encountered shark species.

Life History

2. Male blue sharks grow to between five and six feet long at maturity. Like other shark species, the eggs are fertilized internally. Females will often not give birth until up to two years after mating, storing the sperm for up to a year after the first time they mate, and then incubating the embryo for up to one year. The young are between fourteen and eighteen inches (46 cm) at birth. Females may bear up to 82 young, although the average number is much lower. The largest blue sharks measure eleven or twelve feet (more than 3.5 m) in length (Ross 1991).

Habitat

3. Blue sharks are found in the Northwest Atlantic from May through October, often in waters of depths between 100 and 130 feet (30 and 40 m) off southern New England. Large females will typically migrate northward and inshore during the spring, and smaller females and males will follow later in the year. During the fall, blue sharks will migrate southward along the continental shelf to the margins of the Gulf Stream. They appear to prefer temperatures between 55 and 64 degrees Fahrenheit (13 and 18 degrees Celsius). They are often found near the surface in temperate areas, but frequent deeper, cooler waters in tropical regions. Blue sharks feed on squid and octopus, as well as bluefish, red and silver hakes, mackerel, menhaden, and herring (Ross 1991).

Table 5.17. Habitat characteristics of blue shark. (Ross 1991)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles/Adults	Often found in waters of 30 to 40 meters of depth off southern New England coastline.	Pelagic	From 8 to 27ºC, prefer waters from 13 to 18ºC

Shark Fishery

4. Fishing efforts for most shark species are controlled by means of possession limits. Sharks are managed jointly by NMFS, through the Consolidated Atlantic Highly Migratory Species Fishery Management Plan (NMFS 2006), and by the Atlantic States Marine Fisheries Commission, under the Interstate Fishery Management Plan for Atlantic Coastal Sharks (ASMFC 2008d). The Atlantic States Marine Fisheries Commission's plan complements federal shark management actions and places special attention on the protection of pregnant females and juveniles in inshore nursery areas.

510.2.16. Shark, Shortfin Mako *(Isurus oxyrinchus)*

1. Mako sharks are one of the three shark species most commonly targeted by recreational fishermen in the Ocean SAMP area.

Life History

2. Mako sharks spend the summer months at northern latitudes, and migrate south along the continental shelf to winter in the Caribbean during the winter. Males are sexually mature at three to four years of age, and females at seven years of age. Like other sharks, fertilization of egg cells occurs internally within mako sharks. After one year of embryonic development, the female mako shark will give birth to from one to several young, each measuring more than two feet long at birth. Internal incubation allows newly born sharks to be more highly developed than species hatched through external fertilization, and provides them with a higher probability of survival than for larval fish (Ross 1991). Most adult mako sharks are between five and eight feet (1.5 to 2.5 m) in length.

Habitat

3. The mako shark is a pelagic shark not found in waters less than thirty feet (9 m) deep. They are usually found offshore either at or near the surface (Ross 1991). Mako sharks prefer tropical and warm temperate waters; southern New England is the northern part of their range. In southern New England waters, bluefish may make up to 80% of a mako shark's diet. Mako sharks also eat small schooling fish such as mackerel and herring, squid, and larger species including swordfish, bonito, and tuna species (Ross 1991). The current status of the shortfin mako shark is uncertain, but it may be approaching an overfished condition (NMFS 2010b).

Table 5.18. Habitat characteristics of mako shark. (Ross 1991)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles/Adults	Oceanic, never within waters less than 9 m deep. Found at or near the surface.	Pelagic	N/A

4. Fishing efforts for most shark species are controlled by means of possession limits. Mako sharks are managed by NMFS, under the Consolidated Atlantic Highly Migratory Species Fishery Management Plan (NMFS 2006), and by the Atlantic States Marine Fisheries Commission under the Interstate Fishery Management Plan for Atlantic Coastal Sharks (ASMFC 2008d). There is a great deal of uncertainty over stock levels of mako sharks in the North Atlantic; the current stock levels may be below the biomass required to support maximum sustainable yield, suggesting the stock may be approaching an overfished condition (NMFS 2010b).

510.2.17. Shark, Thresher *(Alopias vulpinus)*

1. Thresher sharks are sometimes targeted by recreational fishermen in the Ocean SAMP area.

Life History

2. Thresher sharks are ovoviviparous; they develop *in utero* without a placental attachment. Females usually give birth to two to four pups at a time, and they are typically longer than 150 cm (59 inches) at birth. It is thought thresher sharks reproduce annually, as most mature female sharks caught are pregnant. Thresher sharks may attain a length of up to 300 cm (118 inches) (Collette and Klein-MacPhee 2002). It is estimated they may live anywhere from 19 to 50 years (NMFS 2010b).

Habitat

3. Thresher sharks are an epipelagic species, found in both coastal and oceanic waters. They are found from Nova Scotia to Argentina, and are common off southern New England during the summer months. Juveniles are more likely to be found in inshore waters, and may also be found in coastal bays. Adults are often found over the continental shelf (Collette and Klein-MacPhee 2002). They are most common in temperate waters, but can also be found in cold-temperate and tropical waters (NMFS 2010b). Most young sharks are seen in southeast U.S. waters, so it has been suggested that the sharks may have a pupping ground in the south, but it is not known whether this is the case. Thresher sharks use their long caudal fins to stun their prey. They feed primarily on small schooling fishes including herring, menhaden, bluefish, sand lance, and mackerel, as well as on bonito and squids. Thresher sharks will often feed in groups, herding schools of fish into a tight group, and then whipping them with their tails (Collette and Klein-MacPhee 2002).

Table 5.19. Habitat characteristics for thresher shark. (Collette and Klein-MacPhee 2002)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles	Inshore waters, coastal bays.	Pelagic	N/A
Adults	Oceanic; over the continental shelf.	Pelagic	N/A

Fishery

4. The status of Atlantic thresher sharks is unknown; it is not known if they are overfished or if overfishing is occurring. They are often caught as by-catch in longline fisheries targeting tuna and swordfish, and are taken recreationally in rod and reel fisheries (NMFS 2010b). Atlantic thresher sharks are managed by NMFS, under the Consolidated Atlantic Highly Migratory Species Fishery Management Plan (NMFS 2006), and by the Atlantic States Marine Fisheries Commission under the Interstate Fishery Management Plan for Atlantic Coastal Sharks (ASMFC 2008d).

510.2.18. Silver Hake *(Merluccius bilinearis)*

1. Silver hake, or whiting, are found along the continental shelf of North America, from Canada to the Bahamas, and are most abundant between Newfoundland and South Carolina (Collette and Klein-MacPhee 2002). There are two stocks of silver hake; one in the Gulf of Maine and northern Georges Bank, and the other on southern Georges Bank and the Mid-Atlantic Bight. In the Ocean SAMP area, silver hake are targeted by commercial fishermen.

Life History

2. Silver hake can reach a length of two and a half feet (76 cm) and weigh up to five pounds (2.3 kg), but usually are only around fourteen inches in length (36 cm). They do not form definitive schools, but will swim together in groups (Collette and Klein-MacPhee 2002). Silver hake spawn throughout the year, peaking from May through November, and with a peak in May to June in the southern stock (NEFSC 2004c). They reach sexual maturity at two to three years of age. The eggs are pelagic, and hatch within two days (Ross 1991). The larvae are just one-tenth of an inch (2.8 mm) in length after hatching. During their first summer or fall, when they are still less than an inch (17-22 mm), the silver hake

larvae will descend to the bottom as juveniles (NEFSC 2004c). Females live longer and grow faster than males; males usually don't live past six years, while females may occasionally live to between twelve and fifteen years in age (Ross 1991).

Habitat

3. Silver hake are wanderers, unconcerned with the depth or with the sea floor. They are sometimes found near the bottom, and sometimes close to the surface, as they chase prey throughout the water column. They are found as deep as 2400 feet (122 m) as well as just below the tide line. When they are found near the bottom, they are usually on sandy or pebbly ground, or mud (Collette and Klein-MacPhee 2002). There are two major stocks of silver hake, one north and one south of Georges Bank. The stock of silver hake found off Rhode Island spend their winters along the continental slope south of Georges Bank, and migrate to shallower waters in southern New England for the spring and summer. They spawn on the southern slopes of Georges Bank and Nantucket Shoals, and south of Martha's Vineyard (Ross 1991). The area between Cape Cod and Montauk Point, which includes the Ocean SAMP area, is a primary spawning ground for silver hake (NEFSC 2004c). Silver hake will move south and to offshore waters during the winter (NEFSC 2004c). Voracious predators, silver hake prey on many different schooling fish including herring, young mackerel, sand lance, and smaller silver hake (Collette and Klein-MacPhee 2002). They themselves are food for cod, mackerel, swordfish, spiny dogfish, flounders, and larger silver hake (Ross 1991).

Fishery

4. Silver hake and red hake were the two primary species targeted by Rhode Island's industrial fishery in the 1950s (Olsen and Stevenson 1975). Silver hake are managed by the New England Fishery Management Council as part of the "small mesh multispecies" management unit of the Northeast Multispecies Fishery Management Plan. The southern stock of silver hake is not currently considered to be overfished, nor is overfishing occurring, but there are concerns about the age structure of the stock; specifically that there are very few fish over the age of four within the population. Significant numbers of juvenile silver hake are discarded in otter trawl fisheries, which may limit opportunities to rebuild this stock (NEFSC 2006a).

Table 5.20. Habitat characteristics of silver hake. (NEFSC 2004c)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Most abundant in deep parts of Georges Bank and bank off southern New England; in southern New England waters July-October; most from 50-150 m.	N/A	Peak abundance from 11-17ºC.
Larvae	Present in Block Island Sound in June through November; abundant in southern New England July-September; most at depths from 50-130 m.	N/A	Temperature preference varies based on annual warming and cooling cycle.
Juveniles	Migrate to deeper waters of the continental shelf as water temperatures decline in the autumn and return to shallow waters in spring and summer. Large concentrations south of RI in fall.	Prefer mud bottoms, also transitional and sand bottoms.	Wide temperature ranges.
Adults	Migrate to deeper waters of the continental	Prefer mud	Prefer temperatures

	shelf as water temperatures decline in the autumn and return to shallow waters in spring and summer to spawn. Frequent spawning in October south of Martha's Vineyard. Older hake prefer the warmer waters of the shelf slope and deep-water shelf area. Found as deep as 122 m as well as in shallow waters.	bottoms, also transitional and sand bottoms.	greater than 9ºC in Southern New England. Found at wide temperature ranges. Spawning peaks between 7 and 13ºC.

510.2.19. Skates

1. Common skates to Rhode Island waters targeted in commercial fisheries are the little skate (*Leucoraja erinacea*), also known as the summer or common skate, and the winter skate (*Leucoraja ocellata*), also called the big skate. The two species are very similar in appearance, and difficult for many people to tell apart. Skates are listed and discussed here together as this is how most skate fishery landings are reported to NMFS (NMFS 2009a).

Life History

2. Winter skates mature at a length of 24 inches (61 cm), and little skates at a length of sixteen inches (41 cm). The eggs are fertilized inside the female's reproductive tract, and then released into the water where much of the embryo's development will take place. It is believed the winter skate spawns in southern New England waters in summer and fall. The little skate spawns throughout the year, with spawning activity in southern New England peaking in June and July. Female skates produce egg cases two at a time, and may produce between 60 and 150 per year. The young hatch between six and nine months after fertilization, and are about three and a half inches (9 cm) long once hatched. The little skate will grow to about 21 inches (53 cm), and the winter skate to 42 inches (107 cm) (Ross 1991).

Habitat

3. Skates are most abundant from shallow waters to depths of up to 360 feet (110 m). The winter skate prefers temperatures between 34 to 70 degrees Fahrenheit (1 and 21 degrees Celsius), and little skates between 34 to 66 degrees Fahrenheit (1 and 19 degrees Celsius). The little skate is distributed along the coast from Chesapeake Bay to Georges Bank in winter and spring, with large numbers along the Long Island coast. They are most abundant between Georges Bank and Long Island in summer and fall. The winter skate is concentrated on Georges Bank throughout the year, and along the eastern shore of Long Island in the winter and spring. Both species of skate feed largely on rock crabs, shrimp, and squid, but also frequently eat amphipods, polychaetes, razor clams, and small fishes. In one study in Block Island Sound, skates fed almost exclusively on digger amphipods. Skates are commonly eaten by monkfish (Ross 1991).

Fishery

4. A market for skate as bait developed in southern New England in the 1980s, and landings have increased substantially. Prior to this, skate was mostly taken as bycatch or targeted as an industrial fish. The little skate is the species primarily targeted in the bait fishery, whereas the winter skate is sometimes also targeted as food fish for its wings, which are sold in a growing export market. Skates are frequently taken as bycatch in groundfishing

operations. Skates are federally managed as a group under the Skate Fishery Management Plan through the New England Fishery Management Council. Little skate is not currently overfished, nor is overfishing occurring. Winter skate is not considered to be overfished at present, but overfishing is occurring for this species (NEFSC 2006a).

Table 5.21. Habitat characteristics of little skate. (NEFSC 2003a)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Egg capsule is deposited on the bottom, perhaps in water < 27 m deep.	May be partially buried in sand.	Embryonic growth takes place when temperatures are > 7-8ºC and increases with increasing temperature.
Juveniles/Adults	Generally move into shallow water during spring, deeper water in winter. May leave some estuaries for deeper water during warmer months. Generally caught at depths <111 m, but occasionally at depths > 183 m.	Sandy or gravelly bottoms, but also on mud. Southern New England at 55 m. Skates are known to remain buried in depressions during the day and are more active at night.	Overall temperature range is 1-21ºC, although most are found between 2-15ºC.

Table 5.22. Habitat characteristics of winter skate. (NEFSC 2003b)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles/Adults	Generally caught at depths from shoreline to 371 m, although most abundant <111 m.	Prefer sand and gravel bottoms.	Recorded over a temperature range of -1.2ºC to 19ºC.

510.2.20. Spiny Dogfish *(Squalus acanthias)*

1. The spiny dogfish (*Squalus acanthias*) is a coastal shark, and is the most abundant shark in the Northwest Atlantic, ranging from Labrador to Florida.

Life History and Habitat

2. Spiny dogfish have a long life, low fecundity, late maturation, and a long gestation period, making it highly vulnerable to population collapse. Spiny dogfish are born in the fall or winter, and are about 26-27 cm (10 inches) in length at birth. They do not reach maturity for ten or more years. Mating occurs in the winter months, and pups are delivered on the offshore wintering grounds (ASMFC 2008a). Females will produce a litter of between 1-15 pups, usually averaging 6-7 pups, and give birth every two years.

Habitat

3. Spiny dogfish are an important predator in the Ocean SAMP area, and eat fish of many sizes, including herring and hakes, squid, and ctenophores. They also eat bivalves, especially scallops, off southern New England. Dogfish diets have changed in response to changes in abundance of certain fish species due to fishing pressures. They migrate north during the spring and summer, and south in the fall and winter. Juvenile and adult spiny dogfish are abundant in the Mid-Atlantic waters extending to the southern part of Georges Bank in winter. During the summer months, they are found farther north in

Canadian waters, and will move inshore into bays and estuaries (ASMFC 2008a). In the fall they are commonly found closer to shore, and are abundant off Martha's Vineyard and Nantucket (NEFSC 2006a).

Management

4. The spiny dogfish is managed jointly by the Mid-Atlantic and New England Fishery Management Councils and the Atlantic States Marine Fisheries Commission. The fishery is managed primarily through trip limits and seasonal closures. Some Rhode Island fishermen participate in the spiny dogfish harvest, and they are commonly found within the Ocean SAMP area. Dogfish are frequently taken as bycatch with otter trawls and other gear targeting groundfish, and were heavily targeted by foreign fleets before the enactment of the EEZ. Management measures have been highly effective in reducing landings and bycatch mortality, and the stock is not currently considered overfished, nor is overfishing occurring. The biomass of spiny dogfish exceeded target levels in 2008 and was considered rebuilt; in 2009 biomass was estimated to be 163,256 metric tons (Rago and Sosebee 2010). In 2010, there was a proposal to list spiny dogfish in Appendix II of the Convention on the International Trade in Endangered Species, though this proposal was rejected (CITES 2010).

Table 5.23. Habitat characteristics of spiny dogfish. (NMFS 2010b; ASMFC 2008a)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles	Most at depths below 50m.	Pelagic	7-15°C
Adults	Inshore in bays and estuaries in summer; offshore in winter. Large females may prefer nearshore shelf and lower salinities. Found at depths from 1-500 m.	Pelagic; demersal at times, found over soft sediment such as mud, sand, and silt where food is available.	7-15°C

510.2.21. Striped Bass *(Morone saxatilis)*

1. Atlantic striped bass range from the St. Lawrence River in Canada south to the St. John's River in Florida. They are an anadromous species, spending their life in estuaries and in the ocean. They are sometimes referred to as the striper or rockfish. Striped bass are usually found in Rhode Island waters from April through November. In the Ocean SAMP area, striped bass are one of the most important and popular fish pursued by recreational fishermen, and are also targeted in commercial fisheries.

Life History

2. Striped bass can live at least thirty years. They may grow up to 150 cm (59 inches) in length, and between 55 and 77 pounds (25 to 35 kg) (Collette and Klein-MacPhee 2002), although the largest striped bass ever caught weighed 125 pounds (57 kg). Females typically grow much larger than males. They are a migratory species, migrating north in the summers and south in the winters, and migrating into rivers during the spring to spawn. Females mature at age four, and males at age two; females will produce millions of eggs which they release into riverine spawning areas where they are fertilized by males. The eggs will drift downstream and eventually form into larvae. The larvae will

mature into juveniles in nursery areas, which are usually located in river deltas, and inland portions of coastal sounds and estuaries. After two years in these estuarine habitats, they will join the migratory coastal population in the Atlantic Ocean. Once mature, the fish will migrate to spawning areas in the spring (ASMFC 2008a). Frequently, male striped bass remain along the coast near the area where they were hatched, even after they mature, while females migrate much greater distances; Collette and Klein-MacPhee (2002) note that only about 10% of the striped bass found in northern waters are male. Young striped bass less than three years of age (sometimes referred to as "schoolies" by anglers) are found in small groups, while larger striped bass are found in large schools. Occasionally large females will be solitary (Ross 1991). Mycobacteriosis is a disease affecting striped bass that may be having an influence on mortality levels of this species; see Section 550.8 for more information on mycobacteriosis.

Habitat

3. Striped bass spawn in riverine areas, usually in fresh or nearly fresh waters, and the larvae will travel downstream to river deltas or the inland portions of coastal sounds and estuaries, where they will mature. The majority of striped bass found off Rhode Island will spawn within the Chesapeake Bay (ASMFC 2008a); some will also be fish born in the Hudson River, which rarely migrate beyond Cape Cod (Ross 1991). Typically, the fish spend their winters offshore between New Jersey and North Carolina. Striped bass rarely stray from within six or eight kilometers (three to five miles) of the shore, and are typically found along sandy beaches, in shallow bays, around rocks and boulders, and at the mouths of estuaries (Collette and Klein-MacPhee 2002). Striped bass feed on a wide variety of invertebrates, especially crustaceans, and on small fish.

Fishery

5. The striped bass fishery has been one of the most important Atlantic coast fisheries for centuries and is one of the most popular recreational fisheries in the Ocean SAMP area. Recreational fishermen take striped bass with hook-and-line, whereas in commercial fisheries they are also taken with gillnets, pound nets, haul seines, and trawls. In Rhode Island, commercial fishermen also use floating fish traps to catch striped bass, but are prohibited from using gillnets for harvest in state waters. In 2006, commercial harvest accounted for 17% of fish removals, while commercial discards of dead fish accounted for 3%. Recreational harvest accounted for 45% of removals of striped bass, and recreational discards of dead fish accounted for an additional 34%. In Rhode Island, recreational vastly outweighs commercial harvest: in 2008, 732,564 pounds (332,285 kg) were harvested by recreational fishermen whereas 245,988 pounds (111,578 kg) were harvested by commercial fishermen (ASMFC 2008b). The striped bass populations declined sharply in the 1970s and 1980s, causing many states to close their striped bass fisheries. At present, the species is not overfished and overfishing is not occurring (ASMFC 2008a). The amount of female striped bass capable of reproduction, known as female spawning stock biomass, was estimated at 55 million pounds (25,000 metric tons) for 2004, which is well above the recommended biomass threshold of 30.9 million pounds (NMFS 2010b). Spawning stock biomass in 2004 was 42% greater than the target level (NEFSC 2006a). Striped bass are managed by the Atlantic States Marine Fisheries Commission through the Interstate Fishery Management Plan for Atlantic Striped Bass.

Commercial fisheries are managed through effort restrictions such as size limits and quotas, while recreational fisheries are managed through size limits, bag limits, and fishing seasons (ASMFC 2008a).

Table 5.24. Habitat characteristics of striped bass. (Ross 1991; Collette and Klein-MacPhee 2002)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Released into riverine areas, drift downstream.	Pelagic	Hatch from 14 to 22ºC.
Larvae/Juveniles	River deltas, inland portions of estuaries. Remain in natal estuary during first two years of their lives.	Sandy beaches, rocky areas, among rocks and boulders.	N/A
Adults	Found within several miles of shoreline, often in river mouths, estuaries, or along rocky shorelines and sandy beaches. Reproduce in rivers or brackish areas of estuaries.	Sandy beaches, rocky areas, among rocks and boulders, mussel beds.	Spawning takes place when water is about 18ºC. Migrate south when water temperatures reach 7ºC.

510.2.22. Summer Flounder (*Paralichthys dentatus*)

1. Summer flounder, also called fluke, are found in both inshore and offshore waters from Nova Scotia to Florida, although they are most abundant from Cape Cod south to Cape Fear, North Carolina. They are left-eyed flatfish, meaning the eyes are on the left side when viewed from above, with the top fin facing up, distinguishing them from winter flounder, which are right-eyed (ASMFC 2008a). In the Ocean SAMP area, summer flounder are targeted by both commercial and recreational fishermen.

Life History

2. Summer flounder reach sexual maturity at age two or three, when they are about ten inches (25 cm) in length. The fish spawn offshore in the fall; the oldest, largest fish migrate, and thus spawn, first, followed by the smaller fish. The larvae will migrate inshore to coastal and estuarine areas from October through May. Upon reaching the coast, the larvae will move to the bottom, and spend the first year of their lives in bays and other inshore areas. Summer flounder are born with eyes on both sides of their body, but the right eye will migrate to the left side within 20-32 days (ASMFC 2008a). Females are typically much larger than males and can grow up to three feet (0.9 m) in length and weigh up to 29 pounds (13 kg) (Collette and Klein-MacPhee 2002). Females can live for up to twenty years, although males rarely live more than seven years (Ross 1991).

Habitat

3. Summer flounder are concentrated in bays and estuaries from late spring through early fall, when they migrate offshore to the continental shelf to waters between 120 to 600 feet (37 to 183 meters) in depth, spending their fall and winters offshore. The summer flounder found off New England spend the winters east of the Hudson Canyon off New York and New Jersey (Ross 1991). Adult summer flounder spend most of their lives near the bottom, and prefer to bury themselves in sand substrate. During the summer, they are often found on hard sand, and prefer mud during the fall. They are often found hiding

motionless in eelgrass or among the pilings of docks, but swim very quickly if disturbed (Collette and Klein-MacPhee 2002).

4. Summer flounder feed by waiting for their prey and then ambushing them. Summer flounder have well-developed teeth that allow them to capture such prey as small fish, squid, sea worms, shrimp, and other crustaceans (ASMFC 2008a). They are fierce predators, pursuing prey up to the surface and sometimes jumping out of the water while chasing prey, although they also feed on the bottom (Collette and Klein-MacPhee 2002).

Fishery

5. Summer flounder are one of the most sought-after species for both commercial and recreational fishing along the East Coast. The species is currently managed under a joint management plan between the Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fisheries Management Council as part of the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan. The current plan by the Atlantic States Marine Fisheries Commission allocates 60% of the quota to commercial fishing and 40% to recreational fishing (ASMFC 2008c). Fishing mortality of summer flounder has been declining and spawning stock biomass has been increasing since the 1990s. According to the Atlantic States Marine Fisheries Commission, summer flounder is not currently overfished, and overfishing is not occurring, although the stock is not yet rebuilt (ASMFC 2008c). Summer flounder has been under a rebuilding plan since 1993, which was recently extended to 2013. Biomass was estimated at about 77% of the target level in 2008, or about 46,029 metric tons (NMFS 2010b).

Table 5.25. Habitat characteristics of summer flounder. (NEFSC 1999e)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Eggs are pelagic and buoyant, mostly at depths of 30-70 m in the fall, as far down as 110 m in the winter, and from 10-30 m in the spring.	Pelagic	Most abundant in the water column where bottom temperatures are between 12 and 19ºC.
Larvae	Planktonic; most abundant 19-83 km from shore at depths of around 10-70 m. From October to May larvae and postlarvae migrate inshore to coastal and estuarine nursery areas.	Dominant in sandy substrates or where there was a transition from fine sand to silt and clay.	Larvae have been found in temperatures ranging from 0-23ºC, but are most abundant between 9 and 18ºC.
Juveniles	Juveniles are distributed inshore and in many estuaries throughout their range during spring, summer, and fall.	Dominant in sandy substrates or in transition areas from fine sand to silt and clay. Juvenile and adult summer flounder will hide in vegetation to ambush prey.	Most juveniles are caught over a range of temperatures from 10-27ºC in the fall, from 3-13ºC in the winter, from 3-17ºC in the spring, and from 10-27ºC in the summer.
Adults	During spring distributed widely over the continental shelf, from 0-360 m depth. Found in depths of less than 100 m in summer	Prefer sandy habitats; can be found in a variety of habitats with both mud and sand	Most adults are caught over a range of temperatures from 9-26ºC in the fall, from 4-

	and fall. Generally are found at depths greater than 70 m in winter.	substrates, including marsh creeks, seagrass beds, sand flats, among dock pilings. Summer flounder will hide in vegetation to ambush prey.	13ºC in the winter, from 2-20ºC in the spring, and from 9-27ºC in the summer.

510.2.23. Tautog *(Tautoga onitis)*

1. Tautog, also called blackfish, are distributed along the coast of the Northwest Atlantic from Nova Scotia through Georgia, with the greatest abundance found between Cape Cod and the Chesapeake Bay. In the Ocean SAMP area, tautog are pursued primarily by recreational fishermen, with a small commercial fishery in the area as well.

Life History

2. Both male and female tautog reach sexual maturity at three or four years of age, and fecundity increases with size. Spawning takes place from May though August. Once they have reached sexual maturity, many fish will return to the same spawning area throughout their lives. Fertilized eggs will float for about two days before hatching. Within four days of hatching, larvae will begin to feed on microscopic plankton. Tautog are very slow growing. They can live up to 34 years and weigh up to 22 pounds (10 kg), although the average fish is usually between six and ten years old, and weighs between two and four pounds (one and two kilograms). Males grow larger and generally live longer than females (Ross 1991). Tautog have been observed to leave a home area during the daytime to feed, and then return to that home area throughout the night (Collette and Klein-MacPhee 2002).

Habitat

3. Tautog usually spend their summers in shallow, coastal waters, and move offshore to deeper waters in the fall. The fish migrate inshore to coastal waters and estuaries in the spring when the water temperatures reach around 48 degrees Fahrenheit (9 degrees Celsius). In the northern parts of their range, tautog remain inshore during the summer, and are frequently found in waters less than 60 feet (18 m) deep south of Cape Cod, although they may be found as far as 40 miles (64 km) from shore. They move offshore to deeper waters during the fall, generally to between 80 and 150 feet (24 to 46 meters) in depth, to spend the winter. Tautog spawn in the summer months, usually in water temperatures between 62 and 70 degrees Fahrenheit (17 and 21 degrees Celsius), and in areas dominated by eelgrass beds. Small juveniles seek out vegetated estuaries and other inshore areas, while larger juveniles and adults are found in deeper offshore waters, often preferring rocks and boulders, as well as piers, jetties, and mussel and oyster beds. Inshore they are often found around the mouths of estuaries and other inlets (ASMFC 2008a). The fish will often follow flood tides inshore to feed in the intertidal zone, moving to deeper water with the ebb tides (Ross 1991). Tautog will have a home site which they will remain close to, moving away during the day to feed, and returning to at night (ASMFC 2008a). They feed largely on invertebrates, including mussels, clams, crabs, amphipods, shrimp, sand dollars, small lobsters, and barnacles. Some individuals living near the shore feed largely on blue mussels, using their large teeth to tear the

mussels from the substrate, and then grinding the mussels in their teeth before swallowing them (Ross 1991).

Fishery

4. The fishery for tautog is primarily recreational, accounting for about 90% of the fishery, although there is also a commercial fishery for this species in Rhode Island waters and elsewhere. Slow growth and reproduction rates, along with their tendencies to be found around rock piles, make tautog susceptible to overfishing. The species is managed by the Atlantic States Marine Fisheries Commission through the Interstate Fishery Management Plan for Tautog, which employs a minimum size limit. In addition, Rhode Island employs a self-imposed commercial quota which is managed in three seasons; the recreational fishery is managed by seasons and bag limits (RIDEM 2009). According to the Atlantic States Marine Fisheries Commission, the stock is currently considered overfished, but overfishing is not occurring (ASMFC 2008a). However it should be noted that Rhode Island and Massachusetts assess tautog on a regional basis and are therefore not bound to the coastwide assessment stock status. The most recent regional stock assessment update indicates that the regional stock is overfished and overfishing is occurring in RI and MA state waters (RIDEM 2010a).

Table 5.26. Habitat characteristics of tautog. (Ross 1991)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Eggs are buoyant.	Pelagic	17 - 21ºC
Larvae	N/A	Pelagic	N/A
Juveniles	Young tautog rarely stray from their home sites. Small juveniles seek out vegetated estuaries.	Steep, rocky shorelines, wrecks, mussel and oyster beds, boulders, vegetated estuaries.	N/A
Adults	Usually within 16 to 19 km of shore and in water depths of 18 to 24 m. Found in association with cover. Spawn inshore over eelgrass beds.	Steep, rocky shorelines, wrecks, mussel and oyster beds, boulders.	Peak spawning from 17 to 21ºC. Migrate inshore when water approaches 9ºC.

510.2.24. Tuna, Bluefin *(Thunnus thynnus)*

1. In the Ocean SAMP area, tuna are targeted primarily by recreational fishermen and were historically a major focus of Rhode Island sportfishing tournaments. The tuna species targeted recreationally in Rhode Island waters include the yellowfin tuna and bluefin tuna. Both species are important in commercial fisheries elsewhere around the globe.

Life History

2. The bluefin tuna is the largest species of bony fish in the world. Bluefin tuna are found both in schools and individually. They are generally classified into three size groups: juvenile or school tuna (5 to 70 pounds / 2 to 32 kg); medium tuna (70 to 270 pounds / 32 to 122 kg); and giant tuna (greater than 270 pounds / 122 kg). While bluefin tuna are found in both the Atlantic and Pacific Oceans, as well as the Mediterranean, Atlantic

bluefin tunas grow to the largest size, reaching lengths of ten feet or greater and sometimes weighing more than 1,000 pounds (454 kg). A bluefin tuna reaches sexual maturity at about six years of age, and they can live up to 38 years of age. Giant bluefin tunas will spawn in the Caribbean and Gulf of Mexico from April through June before heading north, while mid-sized tuna spawn later in the year, and may spawn as far north as the New York Bight. Like yellowfin tuna, bluefin tuna are warm-blooded, permitting them to withstand large fluctuations in temperature, and to maintain very high swimming speeds over a long period (Ross 1991). This fish is known for making long migrations, and fish tagged off North America have been found off Europe and Africa.

Habitat

3. Bluefin tuna, a pelagic species, are rarely found at depths greater than 300 feet (91 m) and are sometimes seen at the surface of the water. The species migrates along the Atlantic coast, moving northward and inshore during the spring and summer, and then offshore and to the south during the fall. Large bluefin tunas will sometimes be found in waters as cold as 50 to 54 degrees Fahrenheit (10 to 12 degrees Celsuis), but smaller fish prefer temperatures above 60 degrees Fahrenheit (16 degrees Celsius). Giant bluefin tunas appear in New England waters before smaller individuals, mostly in June and July. Small bluefin tunas will appear in southern New England later in July (Ross 1991). The fish can be found in Rhode Island waters through November, although they are most common in July. Small school tunas are relatively common off Rhode Island during the summer, although giant bluefin tuna are rare (Collette and Klein-MacPhee 2002). The bluefin tuna is a noted predator, feeding on schooling species such as herring, mackerel, squid, and silver hake (Ross 1991).

Table 5.27. Habitat characteristics of bluefin tuna. (Ross 1991)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles	Both inshore and offshore areas, rarely found more than 90 meters below the surface.	Pelagic	Stay in waters above 16ºC
Adults	Both inshore and offshore areas, rarely found more than 90 meters below the surface. Follow the Gulf Stream.	Pelagic	Waters as cold as 10 to 12ºC

Fishery

4. In the Ocean SAMP area, bluefin tuna are targeted primarily by recreational fishermen. Bluefin tuna are managed domestically by the NMFS Consolidated Atlantic Highly Migratory Species Management Plan and internationally through the International Commission for the Conservation of Atlantic Tunas. The allocation of bluefin tuna in the United States is divided into five categories: a purse seine fishery, a harpoon fishery, a general category fishery (including hook-and-line, handline, and harpoon vessels), an incidental-catch fishery for vessels targeting other species or bluefin tuna of another size from one of the other categories, and an angling fishery for smaller bluefin tunas (Ross 1991). At one time, Galilee was known as the Tuna Capital of the World, and was home to the Atlantic Tuna Tournament, until the tournament was moved to Gloucester in 1973 (Olsen and Stevenson 1975). Bluefin tuna is considered overfished, and overfishing is occurring. Two different stock assessment scenarios place the spawning stock biomass of

bluefin tuna at either 14% or 57% of target levels (NMFS 2010b). In 2010, there was a proposal to list bluefin tuna in Appendix 1 of the international Convention for the International Trade of Endangered Species (CITES), which would indicate the species was threatened with extinction and international commercial trade would be restricted. This proposal was not accepted at the most recent CITES convention, but there is growing international concern over the stock status of bluefin tuna (CITES 2009, CITES 2010).

510.2.25. Tuna, Yellowfin *(Thunnus albacares)*

1. Yellowfin tuna is another tuna species targeted in the Ocean SAMP area by recreational fishermen. Like bluefin tuna, it is important in commercial fisheries elsewhere around the globe.

Life History

2. Yellowfin tunas, like other tunas, are warm-blooded, maintaining an internal body temperature that may be much higher than the external water temperature, permitting them to swim at higher speeds and for longer periods than other fish. Yellowfin tuna form schools with other individuals of a similar size, sometimes with similarly-sized tuna of other species. Tunas spawn throughout the year, with peaks during the summer months in the northern parts of their range. Some yellowfin tuna will mature at twelve to fifteen months of age, when they are between 20 and 24 inches (50 and 60 cm) in length, while others may not mature until they are at least 47 inches (145 cm) in length. The fish grow quickly, to about 21 inches (53 cm) by their first year, and reaching lengths of over six feet (1.8 m) (Ross 1991).

Habitat

3. The yellowfin tuna occurs along the edge of the continental shelf from Nova Scotia south through both temperate and tropical waters. The yellowfin is an open-ocean, schooling tuna found throughout the water column, usually in temperatures between 65 and 88 degrees Fahrenheit (18 and 31 degrees Celsius). They prefer waters of at least 68 degrees (20 degrees Celsius), and water temperature determines where this fish is found both geographically and also within the water column. Schooling usually occurs near the surface, and large schools are often found in major upwelling areas. After they hatch, larvae will remain in the upper 200 feet (61 meters) of the water column. Yellowfin usually feed during the daylight hours close to the surface. They eat a variety of finfishes, cephalopods, and crustaceans (Ross 1991).

Table 5.28. Habitat characteristics of yellowfin tuna. (Ross 1991)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Juveniles/Adults	Open-ocean species, found throughout upper water column. Temperature determines where it is found in water column. Often found in areas of upwelling.	Pelagic	Between 18 to 31ºC

Fishery

4. Yellowfin tuna are managed domestically by the NMFS Consolidated Atlantic Highly Migratory Species Management Plan and internationally through the International Commission for the Conservation of Atlantic Tunas. Management measures include a recreational retention limit (NMFS 2010b). Both yellowfin and bluefin tuna have historically been important to recreational fisheries in Rhode Island and were once the focus of multiple Rhode Island-based fishing tournaments. Recreational fishermen target yellowfin tuna using longline, handline, and rod and reel gear. The biomass level of Atlantic yellowfin tuna is currently considered to be at 96% of the level needed for maximum sustainable yield, and overfishing is not occurring (NMFS 2010b).

510.2.26. Winter Flounder *(Pseudopleuronectes americanus)*

1. Winter flounder, also called blackback flounder or lemon sole, are a right-handed flat fish found in shallow, estuarine habitats along the Northwest Atlantic coast. In the Ocean SAMP area, winter flounder are targeted by both commercial and recreational fishermen.

Life History

2. Winter flounder spawn in the winter and early spring, producing both demersal eggs and adhesive eggs (ASMFC 2008a). The eggs hatch about fifteen to eighteen days after being released (Ross 1991). Larvae will be found in the upper reaches of estuaries in early spring, and will move to the lower estuary as they grow (ASMFC 2008a). Studies of the genetic population structure of winter flounder larvae and juveniles in Narragansett Bay found that juvenile flounder tend to remain near their natal nursery grounds (Buckley et al. 2008). Winter flounder generally reach sexual maturity by age three (Ross 1991). Winter flounder depend on sight to feed, and therefore feed only during the day. At night they lie flat on the bottom and retract their eye turrets (ASMFC 2008a). They typically lie buried in the mud with only their eyes showing, but can dash quickly for a few yards when feeding. Adults are typically between twelve and fifteen inches long (30 to 38 cm), and weigh between a pound and a half and two pounds (0.6 and 0.9 kg), although fish as long as 25 inches (63 cm) have been recorded (Collette and Klein-MacPhee 2002). Winter flounder can live for about twelve years (Ross 1991).

Habitat

3. Winter flounder get their name because they migrate into nearshore waters in the winter months. They prefer muddy sand habitat inshore, particularly eelgrass habitat. Many winter flounder move into estuarine habitats in the fall prior to spawning, typically spawning on shallow, sandy bottom, and move either offshore or to deeper, cooler portions of estuaries during the spring and summer (ASMFC 2008a). They are rarely found deeper than 180 feet (55 m), although have been found as deep as 420 feet (128 m) on Georges Bank (Ross 1991). Important nursery habitats for larvae and juveniles include saltwater coves, coastal salt ponds, embayments, and estuaries, although some larvae and juveniles have been found in the open ocean (ASMFC 2008a). Winter flounder are known to return to the same pond or portion of the Bay where they were hatched (Collette and Klein-MacPhee 2002). They are found in both Narragansett Bay and the Sounds off Rhode Island.

4. Winter flounder have a small mouth, and feed on small invertebrates, shrimp, clams, and worms. Larval flounder eat primarily diatoms (Collette and Klein-MacPhee 2002). In turn, adult winter flounder are prey for a number of species including cod, dogfish, monkfish, skates, hakes, striped bass, bluefish, and other fish. The larvae and juveniles are preyed upon by striped bass, bluefish, and summer flounder, as well as birds, invertebrates, and marine mammals (ASMFC 2008a).

Fishery

5. Winter flounder are targeted in both commercial and recreational fisheries; recreational harvest has traditionally made up a significant percentage of total harvest levels for this species (Ross 1991). However, in the most recent decade the recreational harvest has been severely limited by regulation, and at present there is a two-fish bag limit for winter flounder. For management purposes, there are considered to be three stocks of winter flounder: the Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic Bight stocks. The Southern New England/Mid-Atlantic Bight stock of winter flounder is currently considered overfished and experiencing overfishing. The stock of winter flounder has declined considerably from a combination of overfishing and habitat degradation, a threat to which winter flounder are particularly susceptible given the fact that they spawn in vulnerable near-shore habitats. According to the Atlantic States Marine Fisheries Commission, winter flounder is currently overfished, and overfishing is occurring. In 2007, the Southern New England/Mid-Atlantic Bight spawning stock biomass (SSB) was estimated at 7.4 million pounds (3.4 million kg), or 9% of the target SSB for this species. Fishing mortality in 2007 was at 262% of the plan target; presently, even if fishing mortality were reduced to zero, the stock would not be rebuilt by the current 2014 target (ASMFC 2008a). The stock is jointly managed by the Atlantic States Marine Fisheries Commission and the New England Fishery Management Council, employing fishing effort controls including seasonal closures, gear restrictions, size limits, trip limits, and days-at-sea restrictions. In addition, NMFS has recently implemented new groundfish rules which prohibit vessels from keeping southern New England winter flounder (NMFS 2010b). Because the area winter flounder seem to be made up of several local, genetically distinct populations, each of which returns to its own spawning ground, this puts the species at greater risk for localized losses. In the event that a spawning aggregation is lost to fishing or other factors, this localized population is unlikely to be able to rebuild (Buckley et al. 2008).

Table 5.29. Habitat characteristics of winter flounder. (NEFSC 1999f)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Found at 0.3-4.5 m (inshore); 90 m or less on Georges Bank.	Mud to sand or gravel.	Spawning initiated at about 3ºC; highest percent hatch at 3-5ºC; 18ºC lethal.
Larvae	1-4.5 m inshore. Salt water coves, salt ponds, estuaries, embayments.	Fine sand, gravel.	Hatch from 1-12ºC; larvae most abundant at 2- 15ºC.
Juveniles	Peak abundance of flounder less than 200 mm occurs in 18-27 m of water in Long Island Sound in April and May. Less than 100 m offshore.	Equally abundant on mud or sand shell.	Commonly found at 10-25ºC during summer and fall.
Adults	Most 1-30 m inshore, shallowest during spawning; less than 100 m offshore. Rarely	Mud, sand, cobble, rocks,	0.6-23ºC; 12-15ºC suggested as preferred.

	deeper than 60m.	boulders, eel grass.	

510.2.27. Yellowtail Flounder *(Limanda ferruginea)*

1. The yellowtail flounder is distributed from Labrador to the Chesapeake Bay. There are three stocks of yellowtail flounder for management purposes – the Cape Cod/Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic stocks (NEFSC 2006a). Within the Ocean SAMP area, yellowtail flounder have traditionally been pursued by commercial fishermen.

Life History

2. Yellowtail flounder grow to about twenty-two inches (56 cm) and weigh up to 2.2 pounds (1 kg). Yellowtail flounder are sexually dimorphic, with females growing faster than males. Female fish reach sexual maturity at a median of 1.6 years of age off southern New England (NEFSC 1999g). Spawning occurs in spring and summer, peaking in May. Eggs are deposited on or near the bottom, and then float to the surface once fertilized. The larvae drift for about two months before settling to the bottom (NEFSC 2006a). Fish from the southern New England stock of yellowtail flounder typically remain within their fishing grounds, but migrate eastward during spring and summer, and then westward during fall and winter as water temperatures change (NEFSC 1999g).

Habitat and prey

3. Yellowtail flounder are found south of Block Island all year long, and in shallower waters during the winter. They prefer sand and sand-mud bottoms between 33 and 330 feet (10 and 100 m), and are most abundant at temperatures between 46 and 57 degrees Fahrenheit (8 and 14 degrees Celsius) (NEFSC 1999g). They generally avoid rocky areas or soft mud (Collette and Klein-MacPhee 2002). Yellowtail flounder eat small crustaceans, polychaetes, and sand dollars (NEFSC 1999g).

Fishery

4. Yellowtail flounder are managed under the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan, along with fourteen other groundfish species. They are managed through fishing effort limitations which include gear restrictions, time/area closures, minimum size limits, a moratorium on permits, and days-at-sea. The fishery for yellowtail flounder off southern New England developed in the 1930s, and the stock collapsed in the early 1990s. Spawning biomass has remained low since then. Discards constitute about twenty percent of the catch. At present, the stock is considered overfished, and overfishing is presently occurring. The biomass of the southern New England/Mid-Atlantic stock of yellowtail flounder is estimated to be at 13% of targeted levels, or about 3,500 metric tons in 2007 (NMFS 2010b).

Table 5.30. Habitat characteristics of yellowtail flounder. (NEFSC 1999g)

Life Stage	*Habitat*	*Substrate*	*Temperature*
Eggs	Pelagic, near surface, along continental shelf waters of Georges Bank, northwest of Cape Cod, southern New England and nearshore	Pelagic	Range 2.0-15°C

	along NJ and southern Long Island.		
Larvae	Pelagic, movement limited to water current. Peak during May-July in southern New England and southeastern Georges Bank.	Pelagic	Range 5.0-17°C
Juveniles	Spring and Fall: In Gulf of Maine concentrations occur between Mass. Bay, Cape Cod, and along the outer perimeter of Cape Cod. Southern edge of Georges Bank in spring.	Sand or sand and mud.	2.0-16°C in Spring, 5.0-18°C in Fall.
Adults	High concentrations around Cape Cod for both spring and autumn seasons. Concentrations pull away from coastal southern New England, Long Island, and the NY Bight during autumn months. Spawning along continental shelf waters of Georges Bank, northwest of Cape Cod, southern New England and nearshore along NJ and southern Long Island, peaks in April to June in southern New England. Prefer depths between 9 to 110 m.	Sand or sand and mud. Avoid rocky areas or soft mud.	2.0-16°C in Spring, 5.0-18°C in Fall. Spawning: estimated range 2.0-17°C

510.3. Stocks of Concern

1. Several of the above-mentioned finfish species include regional stocks that are of particular management concern within the vicinity of the Ocean SAMP area and adjacent waters. Those stocks include the Georges Bank and southward stock of cod (which includes cod found in Ocean SAMP waters) and the Southern New England/Mid-Atlantic winter flounder and yellowtail flounder stocks, all managed by the New England Fishery Management Council. These also include butterfish, which is managed by the Mid-Atlantic Fishery Management Council. Each of these stocks has additional management measures in place. Incidental catch quotas are in place for each of the New England Fishery Management Council-managed stocks, meaning that in addition to other multispecies regulations, there is a limit to how many fishermen can catch while targeting other species. Management of butterfish by the Mid-Atlantic Fishery Management Council has recently changed significantly to address butterfish bycatch. These stocks are further discussed below.

510.3.1. Georges Bank and Southward Cod[6]

1. The Georges Bank and southward stock of cod, which includes cod found in southern New England, is managed by the New England Fishery Management Council. Both the Georges Bank and Gulf of Maine stocks of cod have declined since the 1960s and are in the process of being rebuilt. Currently, the Georges Bank and southward cod stock is at 10% of the level needed to achieve maximum sustainable yield. According to the most recent stock assessment, biomass levels for the Gulf of Maine stock have increased

[6] NMFS assesses and manages Atlantic cod as two distinct stocks, the "Gulf of Maine" stock and the "Georges Bank and Southward" stock (NMFS 2010b). It should be noted that cod found in southern New England, including the Ocean SAMP area, are part of the Georges Bank and Southward stock.

substantially such that this stock is no longer considered overfished, whereas biomass levels for the Georges Bank stock have not changed much since an earlier stock assessment in 2004. In 2007, spawning stock biomass was estimated at 17,672 metric tons, a relatively small increase over 2004 estimates (NEFSC 2008).

2. Cod are managed under the Northeast Multispecies Fishery Management Plan, which encompasses most species in the groundfish complex. Through the Fishery Management Plan, area closures, gear restrictions, and minimum size limits have been employed as the primary management tools. In 2004, the controversial Amendment 13 to the Fishery Management Plan was implemented, with tighter regulations on catch in an attempt to reduce mortality on this species. The Georges Bank stock of cod is a transboundary resource shared with Canada, which is responsible for managing a portion of the stock as well. Generally about 25% of the annual catch is taken by Canadian vessels, with the rest taken by American vessels (Mayo and O'Brien 2006). As of May 1, 2010, NMFS implemented additional catch limits and other management measures to further protect cod and other groundfish stocks (NMFS 2010b).

510.3.2. Southern New England/Mid-Atlantic Winter Flounder

1. The Southern New England/Mid-Atlantic stock of winter flounder is managed by the New England Fishery Management Council. According to the 2008 stock assessment, winter flounder stocks have severely declined. In 2007, the spawning stock biomass of Southern New England/Mid-Atlantic winter flounder was approximately 3,368 metric tons, or 9% of the target level. This was an increase from 2005 levels, which were a record low of 2,098 metric tons. Commercial landings of Southern New England winter flounder peaked in 1966 and again in 1981, then falling to a record low of 1,320 metric tons in 2005. Landings had increased somewhat by 2007, reaching 1,622 metric tons (NMFS 2010b).

2. Winter flounder are managed under the Northeast Multispecies Fishery Management Plan, which encompasses most species in the groundfish complex. Through the Fishery Management Plan, effort controls (days at sea), area closures, gear restrictions, and minimum size limits have been employed as the primary management tools. In 2004, the controversial Amendment 13 to the FMP was implemented, with tighter regulations on catch in an attempt to reduce mortality on this and other groundfish species (NMFS 2010b). In state waters, they are managed through the Atlantic States Marine Fisheries Commission's Fishery Management Plan for Inshore Stocks of Winter Flounder. Management measures under the Atlantic States Marine Fisheries Commission plan include a two-fish bag limit for recreational fishermen, and a 50 pound possession limit for non-federally permitted commercial fishermen (ASMFC 2008a). Recently, NMFS has also implemented new groundfish rules which include additional protections for winter flounder, including a prohibition against keeping winter flounder (NMFS 2010b).

510.3.3. Southern New England/Mid-Atlantic Yellowtail Flounder

1. The Southern New England/Mid-Atlantic stock of yellowtail flounder is managed by the New England Fishery Management Council. The spawning stock biomass of Southern

New England/Mid-Atlantic yellowtail flounder is currently at 13% of the target levels needed to support maximum sustainable yield (NMFS 2010b). The fishery for yellowtail flounder in Southern New England began in the 1930s, and landings peaked in the 1960s; by the mid-1990s the fishery had collapsed. Between 1994 and 2005, spawning stock biomass generally averaged around 1,100 metric tons, but increased to 3,500 metric tons in 2007. Landings of Southern New England yellowtail flounder reached a record low of 200 metric tons in 1995, increased to over 1,000 metric tons in 2000 and 2001, and declined again to 200 metric tons in 2006 and 2007 (NMFS 2010b).

2. Yellowtail flounder are managed under the Northeast Multispecies Fishery Management Plan, which encompasses most species in the groundfish complex. Through the Fishery Management Plan, effort controls (days at sea), area closures, gear restrictions, and minimum size limits have been employed as the primary management tools. In 2004, the controversial Amendment 13 to the FMP was implemented, with tighter regulations on catch in an attempt to reduce mortality on this and other groundfish species. Yellowtail flounder are also directly managed through days-at-sea restrictions and a moratorium on permits. As of May 1, 2010, NMFS implemented additional catch limits and other management measures to further protect yellowtail flounder and other groundfish stocks (NMFS 2010b).

510.3.4. Butterfish

4. Butterfish are managed by the Mid-Atlantic Fishery Management Council. Butterfish biomass estimates vary considerably from year to year. From 1968 to 2002, the spawning stock biomass ranged from 7,800 to 62,900 metric tons, although it has consistently declined since 1980. U.S. commercial landings of butterfish peaked in 1984, and have declined since then, reaching a low of 432 metric tons in 2005. Discards of butterfish in other fisheries can be substantial, ranging from an estimated 1,000 to 9,200 metric tons in recent years. From 1965 to 2002, commercial landings averaged 3,200 metric tons per year, while discards averaged 5,300 metric tons per year (NEFSC 2006a).

2. Butterfish are managed by the Mid-Atlantic Fishery Management Council as part of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. In 2005, butterfish was listed as overfished. As a result the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan was amended to address butterfish mortality resulting from bycatch and discarding through a variety of management measures (MAFMC 2009).

510.4. Forage Fish

1. Commercial and recreationally targeted species rely on the availability of forage fish to survive. The northern sand lance is an important forage fish found in Ocean SAMP waters, and serves as an important prey species in southern New England for smooth dogfish, winter skate, silver hake, Atlantic cod, summer flounder, windowpane, striped bass, and yellowtail flounder (Bowman et al. 2000), as well as silversides and smelt. Other important forage fish in the Ocean SAMP area were mentioned above in the descriptions of commercially and recreationally important species, and include Atlantic herring, squid (both long- and short-fin), and butterfish. Menhaden is another important

forage fish in this area (see above), as are alewife and blueback herring (see below under "river herring"). Herring and menhaden in particular have been the subject of fisheries management debates in recent years over how to consider their importance as a source of food within the ecosystem for fish, seabird, and marine mammal species, while trying to set catch targets to permit commercial fisheries.

510.5. Threatened and Endangered Species and Species of Concern

1. Several finfish species that may occur within the Ocean SAMP area are not targeted through commercial or recreational fisheries, but may be managed by the NMFS Office of Protected Resources. The NMFS Office of Protected Resources has jurisdiction over most marine and anadromous species listed as endangered or threatened under the federal Endangered Species Act (ESA). In addition, NMFS has identified "Species of Concern" as species about which NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA (NMFS 20l0a. However, "Species of Concern" status does not carry any procedural or substantive protections under the ESA. For further discussion of non-finfish species protected under the Endangered Species Act, see Chapter 2, Ecology of the Ocean SAMP Region.

2. According to the NMFS Northeast Regional Office Protected Resources Division, based on the best available information, no finfish currently listed as threatened or endangered are likely to occur within the Ocean SAMP area (Crocker, pers. comm. a). However, according to the NMFS Northeast Regional Offices Protected Resources Division (Crocker, pers. comm., b), the following species currently listed as "Species of Concern" (NMFS 2010a) could be present in the Ocean SAMP area: Atlantic halibut (*Hippoglossus hippoglossus)*; Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*); Atlantic wolffish (*Anarhichas lupus)*; Dusky shark (*Carcharhinus obscurus)*; Porbeagle shark (*Lamna nasus)*; Rainbow smelt (*Osmerus mordax)*; River herring (which includes two species: Alewife (*Alosa pseudoharengus)* and Blueback herring (*Alosa aestivalis*)); Sand tiger shark *(Carcharias taurus)*; and Thorny skate (*Amblyraja radiate).*

510.5.1. Atlantic Halibut *(Hippoglossus hippoglossus)*

1. The Atlantic halibut is distributed from Labrador to southern New England and is one of the largest fish found in the Gulf of Maine. There is currently no directed fishery for halibut, but there was a major commercial halibut fishery in the Gulf of Maine throughout the 19th century (NEFSC 2006a).

Life History and Habitat

2. Halibut are large, long-lived, right-eyed flounders. Females are typically larger than males, growing to an average of 100-150 pounds (45.5-68 kg). Halibut mature at approximately 10 years yet are prolific, with females spawning several batches of eggs each year. Period of spawning varies by region, and the depth at which halibut spawn is not known. Halibut eggs drift within the water column and hatch at a very immature stage. Halibut are bottom-dwelling flat fish typically found on sand, gravel, or clay bottom. They move into shallower waters in the summer and deeper waters in the winter,

and have been found in U.S. waters in trawls at temperatures ranging from 4-13°C (39-55°F). Halibut prey for the most part on other fish, but also eat shellfish, crustaceans, and even seabirds (Collette and Klein-MacPhee 2002).

Management

3. Atlantic halibut are managed by the New England Fishery Management Council under their Multispecies Fishery Management Plan, which includes a moratorium on direct harvests as well as bycatch limits and minimum fish sizes (NEFSC 2006a). Atlantic halibut were heavily fished throughout the 19th century and have not recovered since, and for this reason NMFS attributes the species' decline to overfishing (NMFS 2009b). According to NMFS, Atlantic halibut are listed as a species of concern because of demographic and genetic diversity concerns (NMFS 2009b).

510.5.2. Atlantic Sturgeon *(Acipenser oxyrinchus oxyrinchus)*

1. Atlantic sturgeon is an anadromous finfish found from Labrador to Florida. They are ancient fish, dating back at least 70 million years (ASMFC 2009c). In addition to its status as a species of concern, Atlantic sturgeon is a candidate for listing under the Endangered Species Act (NMFS 2010c).

Life History and Habitat

2. The average Atlantic sturgeon ranges in size from 2.9-6.6 feet (88 – 200 cm) (Collette and Klein-MacPhee 2002), although sturgeon have been known to grow up to 14 feet (425 cm) with weights of more than 800 pounds (363 kg) (NMFS 2010c). Sturgeon may live up to 60 years. There is significant variation in the age of sexual maturity, with fish at the northern end of their range maturing later. Atlantic sturgeon are anadromous fish, with adults migrating upriver in the spring to spawn. Spawning does not necessarily occur every year, and sturgeon eggs adhere to benthic substrate (Collette and Klein-MacPhee 2002). Sturgeon are bottom dwellers and prey upon shellfish, crustaceans, and small fish (ASMFC 2009c).

Management

3. Historically, Atlantic sturgeon were harvested commercially for a wide range of commercial uses of both the fish and its eggs. ASMFC instituted a coast-wide moratorium prohibiting the harvest and retention of Atlantic sturgeon in 1998, and NMFS followed with a moratorium in Federal waters. According to NMFS, Atlantic sturgeon were first identified as a species of concern in 1988; however, they were formally retained on the list in 1998. According to NMFS, Atlantic sturgeon numbers have declined because of fishing pressure as well as incidental mortality through bycatch, habitat degradation, and dams that have interrupted spawning behavior. In October 2009, the Natural Resources Defense Council petitioned NMFS to list the Atlantic sturgeon under the Endangered Species Act. At the time of this writing, NMFS is in the process of developing a listing determination indicating whether listing Atlantic sturgeon as an endangered or threatened species is warranted (NMFS 2010c). This decision must be published in the Federal Register on or before October 6, 2010 (12 months after receipt of the NRDC petition).

510.5.3. Atlantic Wolffish *(Anarhichas lupus)*

1. Atlantic wolffish are sedentary, solitary fish that are primarily taken as bycatch in other fisheries. They are known for their canine-like teeth and biting ability.

Life History and Habitat

2. Atlantic wolffish are large, slow growing fish known for their large teeth. They may grow up to 59 inches (150 cm) long and 40 pounds (18 kg) and live up to 20 years. Males and females form pairs before spawning, and females lay egg masses of varying sizes in clusters in protected areas which are then protected by the males. Spawning period varies by region (Collette and Klein-MacPhee 2002). Females may produce between 5,000 and 12,000 eggs, with larger females producing larger egg masses (NMFS 2009c). Atlantic wolffish are benthic dwellers with a preference for complex habitats such as rocky areas. They can be found in depths up to 1640 feet (500 meters) and in waters as cold as 1.3°C (34°F). They feed on a diverse diet of benthic fauna as well as a variety of shellfish, crustaceans, and echinoderms (Collette and Klein-MacPhee 2002).

Management

3. Wolffish are frequently taken as incidental catch in otter trawl fisheries, and small quantities of wolffish have been landed by commercial fishermen since the 1970s, though catches have declined to a recent low (NEFSC 2006a). According to NMFS, the decline of the wolffish can be attributed to incidental catch, as well as commercial fishing, and habitat degradation caused by fishing gear. NMFS designated the Atlantic wolffish a species of concern in 2004 due to demographic and genetic diversity concerns. In 2008, NMFS was petitioned to list the Atlantic wolffish under the Endangered Species Act, and in 2009, NMFS found that listing was not warranted at that time (NMFS 2009c). In 2010, Atlantic wolffish were added to the Northeast Multispecies Fisheries Management Plan (FMP) in Amendment 16 to the plan. Inclusion of Atlantic wolffish in Amendment 16 provides for the prohibition of landing Atlantic wolffish in commercial and recreational fisheries.

501.5.4. Dusky Shark *(Carcharhinus obscurus)*

1. The dusky shark is a highly migratory large coastal shark that occurs from southern New England to the Caribbean and South America.

Life History and Habitat

2. Dusky sharks reach an average size of 11.8 feet (360 cm) long and 400 pounds (180 kg) and can live up to 40 years. Like many sharks, dusky sharks bear live young. They reproduce every three years, bearing litters ranging from 6 to 14 young, which may range in size from 33 to 39 inches (85-100 cm) (NMFS 2009d). The dusky shark is a highly migratory species, migrating north in the summer and south in the fall and winter, following warmer waters. Dusky sharks seem to avoid estuaries and other areas of lower salinity (Collette and Klein-MacPhee 2002), and may be found from the surf zone to offshore and from the surface to depths up to 1300 feet (400 m) (NMFS 2009d).

Management

3. Dusky sharks are managed as a highly migratory species by NMFS under the Consolidated Atlantic Highly Migratory Species Fishery Management Plan and by the Atlantic States Marine Fisheries Commission under the Interstate Fishery Management Plan for Atlantic Coastal Sharks. According to NMFS, dusky sharks are currently overfished. They have been a popular target for recreational fishermen, though they have been harvested commercially and have also been taken as bycatch in directed fisheries. Commercial and recreational fishing for dusky sharks has been prohibited since 1998. NMFS attributes their decline to recreational fishing pressure and incidental mortality as bycatch, and listed them as a species of concern in 1997 due to a range of demographic and genetic diversity concerns (NMFS 2009d).

501.5.5. Porbeagle Shark *(Lamna nasus)*

1. The porbeagle shark is a large coastal and oceanic shark found from Newfoundland to New Jersey.

Life History and Habitat

2. The average porbeagle shark grows to between 4 and 6 feet (120-180 cm) in length, though may reach a maximum size near 10 feet (300 cm) and may live up to 46 years (Collette and Klein-MacPhee 2002). Porbeagle sharks give birth to live young, though prior to birth the young are nourished in utero with egg yolk for roughly 8-9 months (NMFS 2010d). Porbeagle shark are pelagic and infrequently enter shallow, coastal waters (Collette and Klein-MacPhee 2002). Porbeagle sharks in the northwest Atlantic are believed to make extensive annual migrations. They feed on small fish, other shark species, and squid (NMFS 2010d).

Management

3. Porbeagle sharks were harvested commercially in the Northwest Atlantic starting in the early 19th century (Collette and Klein-MacPhee 2002). Catch records indicate that the fishery collapsed in the early 1960s and dropped off through the 1970s and 1980s, allowing the population to rebuild. In the early 1990s a new fishery developed and catch rates increased dramatically, only to drop off again. Porbeagle sharks are managed by NMFS under the Consolidated Atlantic Highly Migratory Species Fishery Management Plan and by the Atlantic States Marine Fisheries Commission under the Interstate Fishery Management Plan for Atlantic Coastal Sharks. According to NMFS, porbeagle shark are overfished, although overfishing is not currently occurring. NMFS attributes the decline of porbeagle sharks to fishing pressure, and designated them a species of concern in 2006 (NMFS 2010d). In early 2010, NMFS received two petitions to list porbeagle sharks under the ESA. After reviewing the petitions and available information, including the most recent stock assessment from the International Commission for the Conservation of Atlantic Tunas (ICCAT) and International Council for the Exploration of the Seas (ICES), it was determined that the petitions did not present substantial scientific information indicating that listing the species under the ESA may be warranted at this time (75 Fed. Reg. 39656, 12 July 2010). In 2010, there was a proposal to list porbeagle sharks in Appendix II of the Convention on the International Trade in Endangered Species, though this proposal did not receive the votes that are needed to be passed (CITES 2010).

510.5.6. Rainbow Smelt *(Osmerus mordax)*

1. Rainbow smelt are small, pelagic, anadromous fish found from Labrador to New Jersey.

Life History and Habitat

2. Rainbow smelt are small, slender fish, averaging 7 - 9 inches (18 – 23 cm) in length. Rainbow smelt are anadromous and make their migrations upriver to spawn in the early spring; they typically do not migrate far upstream and many spend most of their lives in relatively shallow estuarine or coastal waters. Rainbow smelt typically begin spawning at age two and a female can produce 7,000 to over 75,000 eggs depending on her size. Smelt often school during migrations, though little is known about smelt behavior while at sea. Smelt feed on amphipods, shrimps, euphausiids, mysids, and marine worms, as well as small fishes, and are themselves a major food source for larger fish as well as aquatic birds (Collette and Klein-MacPhee 2002).

Management

3. Historically, rainbow smelt have been targeted by both commercial and recreational fishermen, particularly in northern New England and Canada, and are still popular among sport fishermen (Collette and Klein-MacPhee 2002). According to NMFS, rainbow smelt populations have declined due to a variety of factors including fishing, dams and other habitat degradation that impacts spawning behavior, and acid precipitation. Citing a variety of demographic and genetic diversity concerns for this species in the northeastern U.S., NMFS listed rainbow smelt as a species of concern in 2004 (NMFS 2007a).

510.5.7. River Herring

1. River herring collectively refers to Alewife (*Alosa pseudoharengus)* and Blueback herring (*Alosa aestivalis*). Because of difficulties in distinguishing between alewife and blueback herring, these two species are managed together under this collective term and are discussed here together. Both species are designated as species of concern.

Life History and Habitat

2. Alewife are currently distributed from Newfoundland to North Carolina, whereas blueback herring are distributed from Nova Scotia to Florida. Alewife reach lengths of between 14 and 15 inches (36-38 cm) and live up to 10 years, whereas blueback herring grow to approximately 15 inches (40 cm) and live 8 years. Both are small, anadromous fish. Alewife initiate spawning when water temperatures reach 41 to 50° F (5-10 C°), and are prolific, producing between 60,000 and 467,000 eggs each year. Blueback herring spawn in slightly warmer water and therefore follow alewife spawning by 3 to 4 weeks; egg production varies based on age and size. Both alewife and blueback herring feed on plankton as well as small fish while at sea. Both alewife and blueback herring are schooling fish while at sea and make seasonal migrations (Collette and Klein-MacPhee 2002).

Management

3. Alewife and blueback herring are managed together with shad, another anadromous fish, by the Atlantic States Marine Fisheries Commission. Both species were historically the target of both commercial and recreational fisheries, and in New England, landings declined dramatically between the 1970s and the 1990s. According to NMFS, river herring have declined due to a variety of factors including fishing pressure and mortality due to bycatch, habitat degradation, and dams that impede spawning (NMFS 2009e). Rhode Island and other adjacent states currently prohibit the harvest of river herring (ASMFC 2007). NMFS (2009e) designated both alewife and blueback herring as species of concern in 2006, citing a variety of demographic and genetic diversity concerns. Currently, there are several restoration initiatives taking place in upper Narragansett Bay that will restore fish passage and enhance depleted spawning populations of anadromous species including river herring (RI Coastal Resources Management Council 2010). These initiatives may result in an increase of river herring in the Ocean SAMP area in future years.

510.5.8. Sand Tiger Shark *(Carcharias Taurus)*

1. Sand tiger sharks can be found throughout the western Atlantic, and in southern New England are common in shoal waters near Woods Hole and Nantucket, MA (Collette and Klein-MacPhee 2002).

Life History and Habitat

2. Sand tiger sharks may grow up to 10.4 feet (318 cm) and live up to 17 years. Like many sharks, sand tiger sharks bear live young, nourishing them in utero with egg yolk prior to birth. Reproduction takes place every other year and a litter typically includes just one or two pups (NMFS 2009f). Sand tiger sharks have been described as relatively sluggish (Collette and Klein-MacPhee 2002). They are more active at night and are primarily coastal. They usually live near the bottom. Sand tiger sharks are voracious predators and feed on fish, small sharks and rays, squid, and some crustaceans (NMFS 2009f).

Management

3. Sand tiger sharks were historically harvested commercially in southern New England during the early 20th century (Collette and Klein-MacPhee 2002), though they are more commonly targeted in Japan for food. Increased exploitation in the 1980s and 1990s resulted in notable abundance declines. Sand tiger sharks are managed by NMFS under the Consolidated Atlantic Highly Migratory Species Fishery Management Plan, which currently prohibits the landing of sand tiger shark for commercial and recreational purposes, and by the Atlantic States Marine Fisheries Commission under the Interstate Fishery Management Plan for Atlantic Coastal Sharks. According to NMFS, sand tiger shark populations have declined because of fishing pressure and bycatch, because of their low reproduction rates, and because of estuarine pollution. For these reasons the sand tiger shark was listed as a species of concern throughout its entire range in 1997 (NMFS 2009f).

510.5.9. Thorny Skate *(Amblyraja radiate)*

1. Thorny skate is one of several skate species that occurs from Labrador to South Carolina. They are more abundant in the Gulf of Maine and only infrequently found in shallow, inshore areas.

Life History and Habitat

2. Thorny skate grow to lengths of over 39 inches (1 m) (NMFS 2009g) and live up to 20 years (Collette and Klein-MacPhee 2002). Thorny skate reproduce by depositing a single, fertilized egg in a rectangular, thorned egg capsule approximately 2-4 inches (48 to 96 mm) long. Thorny skate feed on benthic fish and invertebrates. They appear to be sedentary creatures with a preference for a range of bottom types and water temperatures ranging from 29 to 57° F (-1.4 to 14° C) (Collette and Klein-MacPhee 2002).

Management

3. Thorny skate are one of several skates historically harvested in New England. Skate species are not specified in NMFS commercial fisheries landings data; unspecified skate landings have increased markedly since the late 1970s/early 1980s. Northeast Fisheries Science Center trawl survey data indicates that thorny skate biomass has declined since the 1960s and is now historically low (NEFSC 2006a). The New England Fishery Management Council manages thorny skate as part of the Northeast Skate Complex Fishery Management Plan. At present the species is overfished and overfishing is occurring. In addition to direct harvest by commercial fishermen, NMFS sites bycatch, predation of skate embryos, and competition for prey resources as the reasons for thorny skate's decline. NMFS listed thorny skate as a species of concern in 2004 in response to a series of demographic and genetic diversity concerns (NMFS 2009g).

510.6. Baseline Characterization

1. This section presents baseline data characterizing fisheries resources within and around the Ocean SAMP area. The purpose of the baseline characterization is to provide baseline information on the current state of fisheries resources in the area based on existing survey data. It is not an assessment of individual fish stocks, nor is it an analysis of longer-term trends in Rhode Island's offshore fisheries resources. Ten years of fisheries-independent bottom trawl survey data were used in this analysis as this provides enough data to smooth out interannual variability while still allowing an assessment of the current state of Ocean SAMP area fisheries resources. In addition, a ten-year period, rather than a longer time period, was chosen for this analysis because the goal was to assess the current, baseline conditions of fishery resources within the Ocean SAMP area, not to analyze longer-term trends in abundance. This ten-year time period does not represent an idealized state or a targeted abundance level; rather it is intended to provide current abundance data in order to inform decision-making. For a more detailed discussion of data sources, methods, and data products for the baseline characterization, see Bohaboy et al. 2010, included in Appendix A. See Chapter 2, Ecology of the Ocean SAMP Region, for discussion of the interactions of fisheries resources with other aspects of the ecosystem, and for data on longer-term trends in stock abundance.

2. There is no one fisheries-independent survey or dataset that provides insight into the abundance and biomass of finfish, shellfish, and crustacean species throughout the entire

Ocean SAMP area. Accordingly, data from four different bottom trawl surveys that are regularly conducted in or around the Ocean SAMP area were aggregated and analyzed to provide this baseline characterization. Data used in this analysis were obtained from the RI Department of Environmental Management (RIDEM) trawl survey (1999-2008); the URI Graduate School of Oceanography (GSO) trawl survey (1999-2008); the Northeast Area Monitoring and Assessment Program (NEAMAP) trawl survey (2007-2008); and the National Marine Fisheries Service (NMFS) trawl survey (1999-2008). Data included in this analysis were collected at survey stations within a polygon delineated by the following coordinates:

41° 30’ N, 071° 50.5’W
40° 50’ N, 071° 50.5’W
41° 30’ N, 070° 50’W
40° 50’ N, 070° 50’W

Survey stations that occur adjacent to but just outside the Ocean SAMP area were included in this analysis in order to allow for a comprehensive analysis of fisheries resources in and around the planning area. See Figure 5.1 for a map showing the location of each of the survey stations included in this analysis, and see Appendix A for further discussion of data sources and methodology.

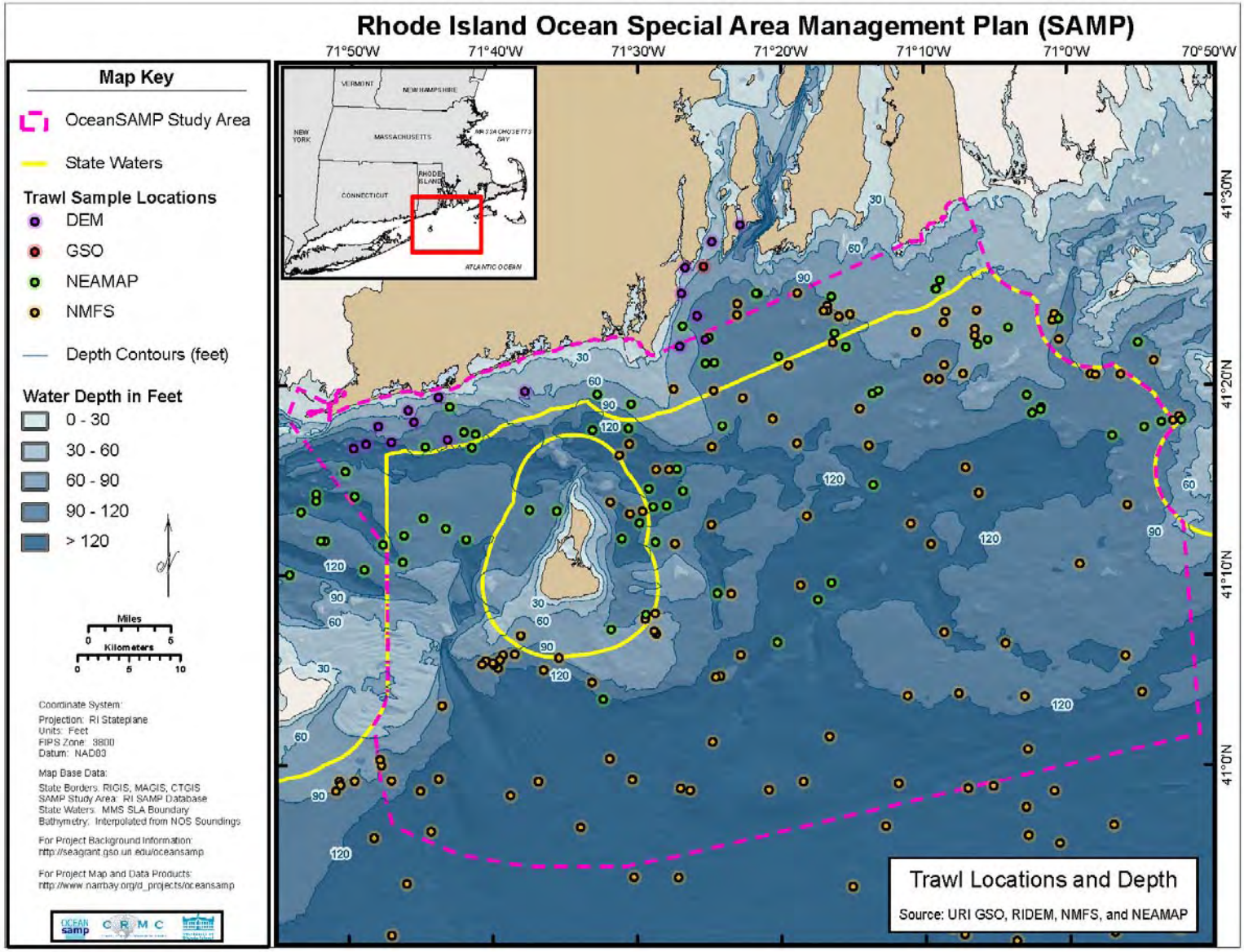


Figure 5.1. Locations of survey stations used in baseline characterization.

3. The RIDEM, GSO, NEAMAP, and NMFS bottom trawl surveys are all conducted for research purposes and are also used to inform stock assessments and other fisheries management decisions. The RIDEM survey is conducted in Rhode Island state waters but does not include survey stations within the state waters surrounding Block Island. The GSO survey has been run by URI since 1959, and is the longest continuous record of fish and invertebrate relative abundance in Rhode Island.[7] The NEAMAP survey is also unique in that a fisherman conducts the survey, using gear designed by fishermen and drawing upon advice from local fishermen about which of the randomly-selected survey stations in a given area are towable.[8] In all cases, the purpose of these surveys is to assess the overall occurrence of fisheries resources in the area, not to compare relative occurrence or abundance at specific sites.

4. Bottom trawl surveys, which employ the use of otter trawls, are used for this baseline characterization because they provide the only consistent record of fish abundance. However, while bottom trawl surveys are appropriate for sampling demersal and some pelagic species, they may not accurately characterize the occurrence of some pelagics, shellfish and crustaceans. Moreover, bottom trawl surveys do not sample untrawlable bottom types of high habitat complexity, which may include moraines and other rocky areas. For these reasons, this baseline characterization does not provide insight into all habitats of importance as well as several recreational species of importance (see list above). It should also be noted that site-specific surveys employing multiple gear types will be required as part of the permitting process for future developments within the Ocean SAMP area; see Section 560, Policies and Standards, for further discussion.

5. The baseline characterization focused on 29 finfish, shellfish, and crustacean species and assessed species abundance and biomass. Baseline characterization species included the above-mentioned commercially and recreationally targeted species, with the exception of some pelagics (e.g. tunas) which are not adequately sampled in bottom trawl surveys. This analysis also included several "Species of Concern" (see Section 510.5) which are present in the Ocean SAMP area and adequately sampled through bottom trawl surveys. Abundance and biomass for these species were assessed for the spring and fall seasons in aggregate and for each individual species. Survey data were aggregated by calculating the survey catch weight (biomass) for each survey by dividing the catch per tow (weight) by the area of each tow. Survey biomass units are milligrams per square meter (mg / m2). The purpose of these calculations was to allow for comparison between the surveys. However, these calculations do not account for all differences between the surveys, and results show that relative biomass estimates nonetheless vary significantly between the surveys (Bohaboy et al. 2010). See Appendix A for further details on data sources and methodology.

[7] For further information on the URI GSO Fish Trawl Survey, see http://www.gso.uri.edu/fishtrawl/.
[8] For further information on the NEAMAP Mid-Atlantic Nearshore Trawl Survey, see http://www.neamap.net/.

Table 5.31. Species assessed in the baseline characterization**.**
See Bohaboy et al 2010, included in Appendix A.

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
American lobster	*Homarus americanus*
American shad	*Alosa sapidissima*
Atlantic cod	*Gadus morhua*
Atlantic herring	*Clupea harengus*
Atlantic mackerel	*Scomber scombrus*
Atlantic sea scallop	*Placopectin magellanicus*
Barndoor skate	*Dipturus laevis*
Black sea bass	*Centropristis striata*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Butterfish	*Peprilus triacanthus*
Cusk	*Brosme brosme*
Dusky shark	*Carcharhinus obscurus*
Goosefish	*Lophius americanus*
Little skate	*Leucoraja erinacea*
Longfin squid	*Loligo pealeii*
Rainbow smelt	*Osmerus mordax*
Scup	*Stenotomus chrysops*
Silver hake	*Merluccius bilinearis*
Smooth dogfish	*Mustelus canis*
Spiny dogfish	*Squalus acanthias*
Striped bass	*Morone saxatilis*
Summer flounder	*Paralichthys dentatus*
Tautog	*Tautoga onitis*
Thorny skate	*Amblyraja radiate*
Winter flounder	*Pseudopleuronectes americanus*
Winter skate	*Leucoraja ocellata*
Yellowtail flounder	*Limanda ferruginea*

510.6.1. Analysis of Total Catch Biomass

1. Analysis of total catch biomass was conducted to determine the sources of variability in the data by assessing the effects of season (fall or spring), survey (RIDEM, GSO, NEAMAP, or NMFS), water depth, and part of the Ocean SAMP area (east or west). Multiple-way analysis of variance based on natural log transformed data indicates that season, survey, and depth are all significant factors affecting total survey biomass (actual p-value < 0.001). Region, as defined by survey stations east or west of -71.38° (West) longitude, does not have a significant effect on total catch biomass. As is illustrated by Figure 5.2, total catch biomass is higher in the fall and lower in the spring. This difference may be due to the fact that young of the year (YOY) are recruited to the fishery in the fall and thus reflected in fall trawl surveys. Figure 5.2 also illustrates that deep depth strata (60 to 90 ft and 90+ ft) have higher total catch biomass than shallow depth strata (20 to 40 ft and 40 to 60 ft) (Bohaboy et al. 2010).

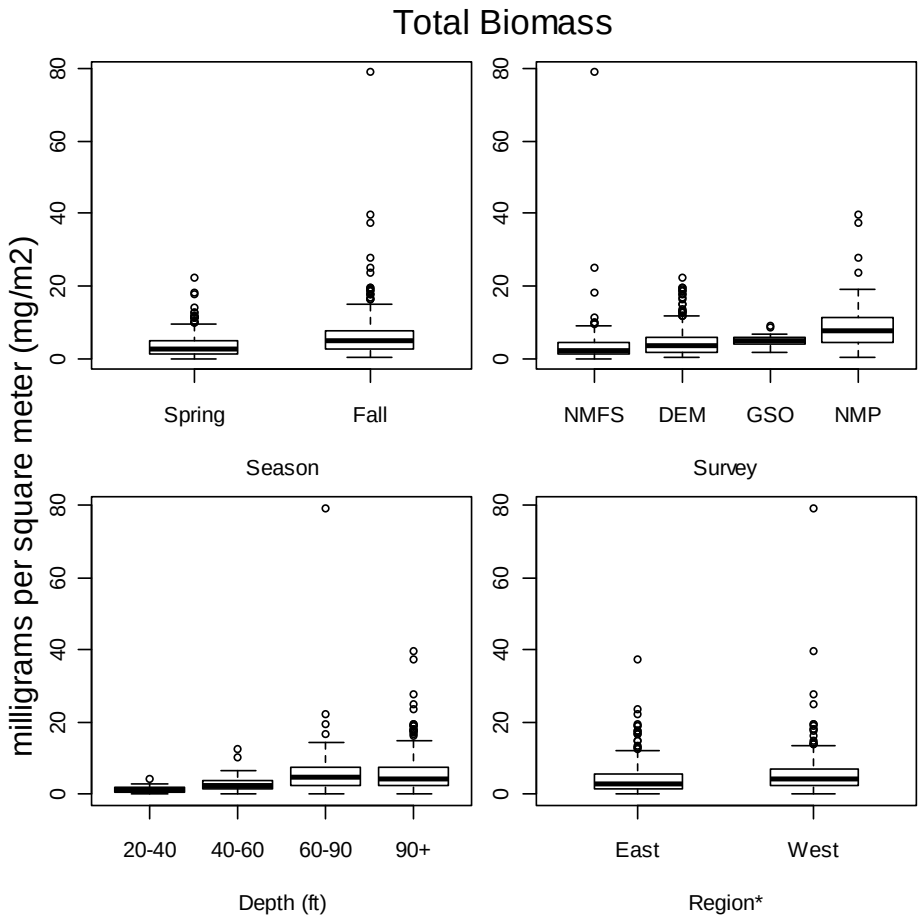


Figure 5.2. Results of multi-way ANOVA of total biomass. (Bohaboy et al. 2010)
**Region defined as survey stations east or west of -71.38° (west) longitude. See Appendix A for data sources and methods, including sample sizes for each analysis.*

2. The spatial distribution of total catch biomass during the spring and fall seasons is shown below in Figure 5.3 and Figure 5.4. A comparison of these figures indicates that there is a depth/season interaction in the spatial distribution of total catch biomass. Figure 5.3 illustrates that in the spring, higher biomass is largely located inshore in shallower, protected waters. By contrast, Figure 5.4 illustrates that in the fall, higher biomass is distributed further offshore in deeper, open waters. It should be noted that these maps reflect a synthesis of data from the four different fisheries-independent trawl surveys; however, there are differences between the vessel types, gear types, and methods used in these different surveys. It should also be noted that the absence of biomass, or relatively low biomass, in a given area does not necessarily mean that there are no fish there. Rather, it may mean that the area was not sampled through any of the survey programs. See Appendix A for maps showing the spatial distribution of individual species biomass and for further discussion of data sources and methodology.

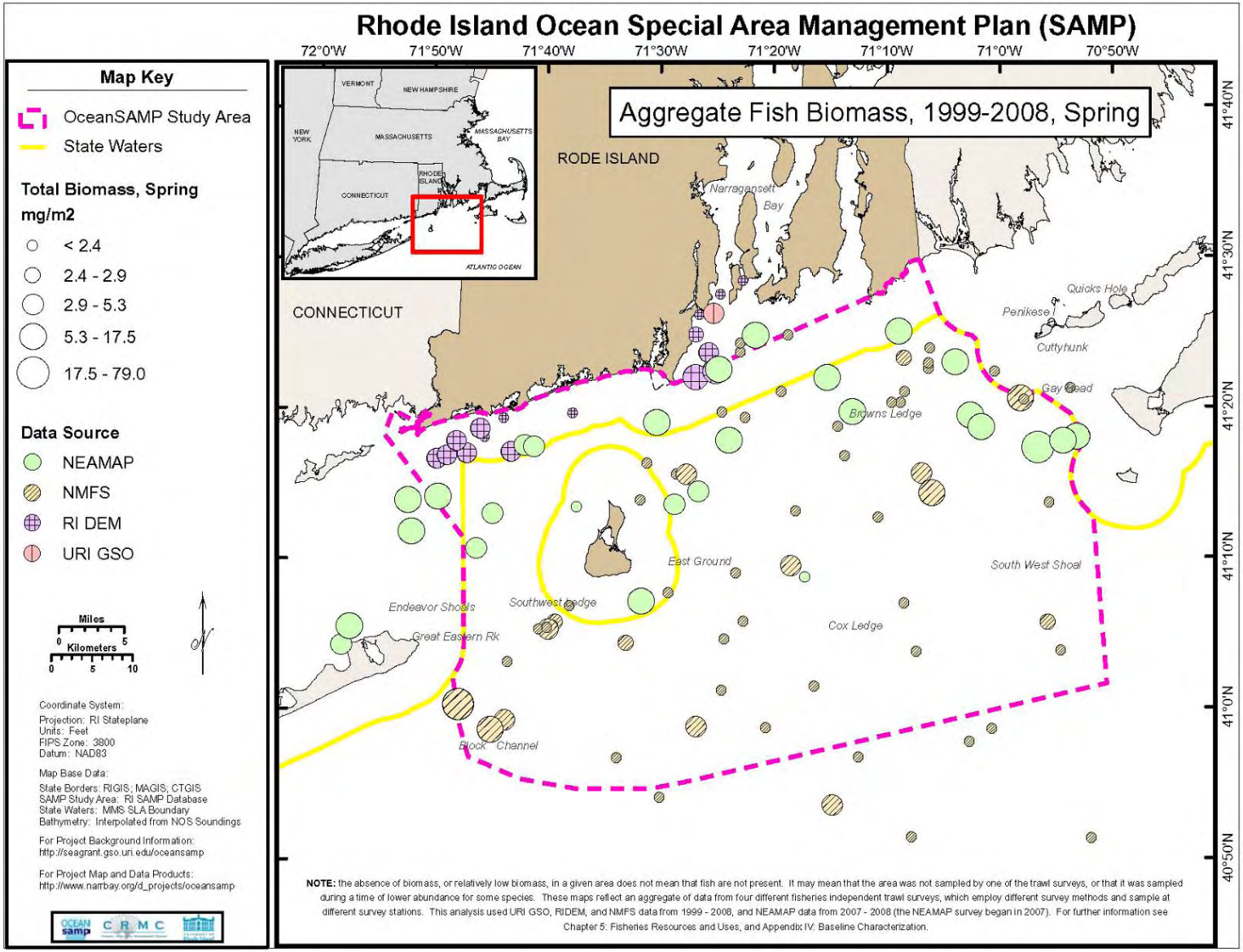


Figure 5.3. Aggregate fish biomass, 1999-2008, spring.

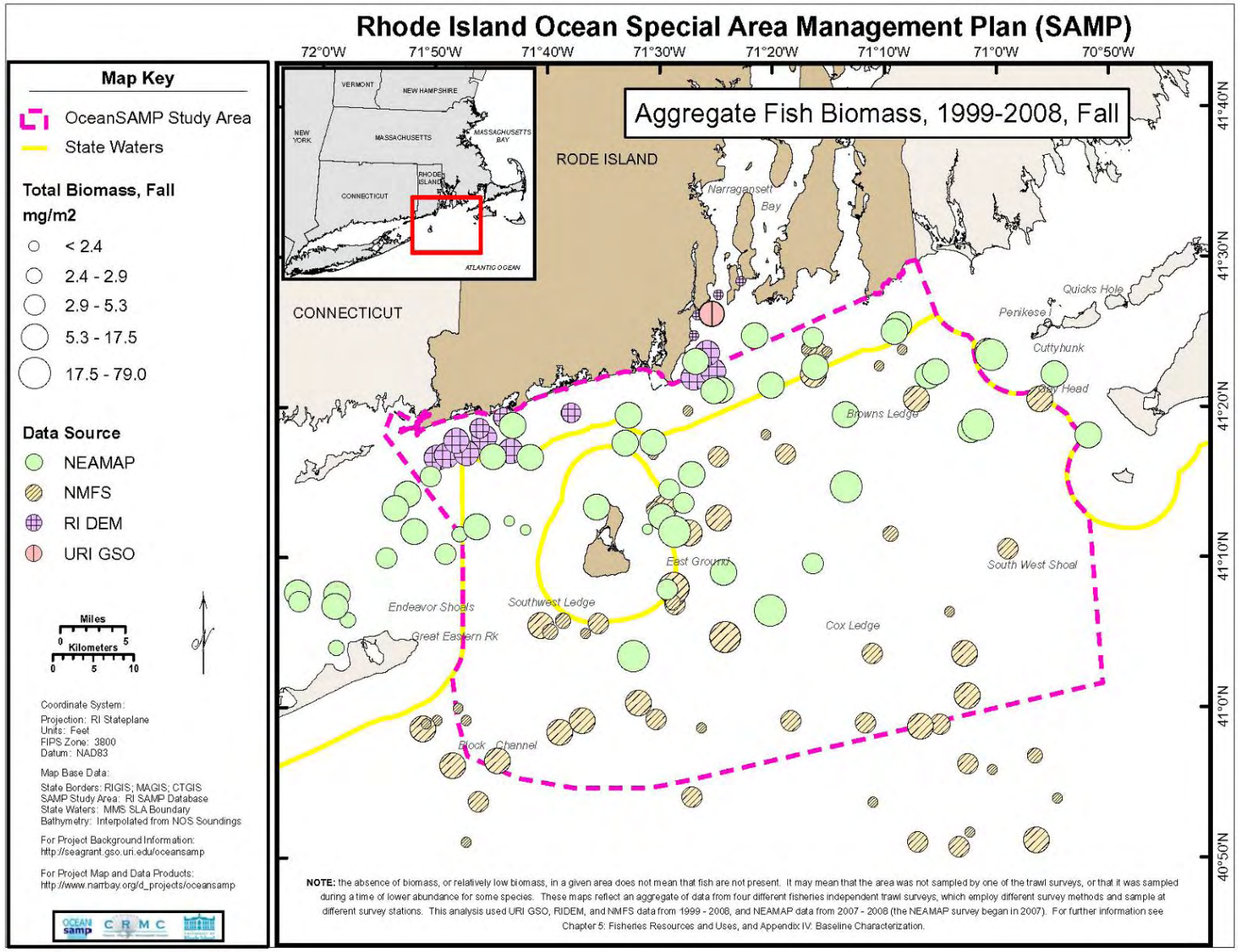


Figure 5.4. Aggregate fish biomass, 1999-2008, fall.

510.6.2. Analysis of Catch by Individual Species

1. Catch biomass data from the four trawl surveys were also used to assess the relative biomass of key species for which data were available. Figure 5.5 below shows the relative biomass of individual species within the study area based on a simple sum of RIDEM, GSO, and NMFS survey data from 1999-2008. NEAMAP data were not included in this figure as only two years of data are available. This figure illustrates that in the fall surveys, little skate, scup, and longfin squid were among the species with the highest relative biomass in the study area, whereas in the spring surveys, little skate, scup, and winter flounder were among the species with the highest relative biomass in the study area. Figures 5.6 to 5.9 below show the relative biomass of individual species based on each seasonal survey. Note that all figures represent the relative biomass on a logarithmic scale to allow for comparison between the figures (Bohaboy et al. 2010).

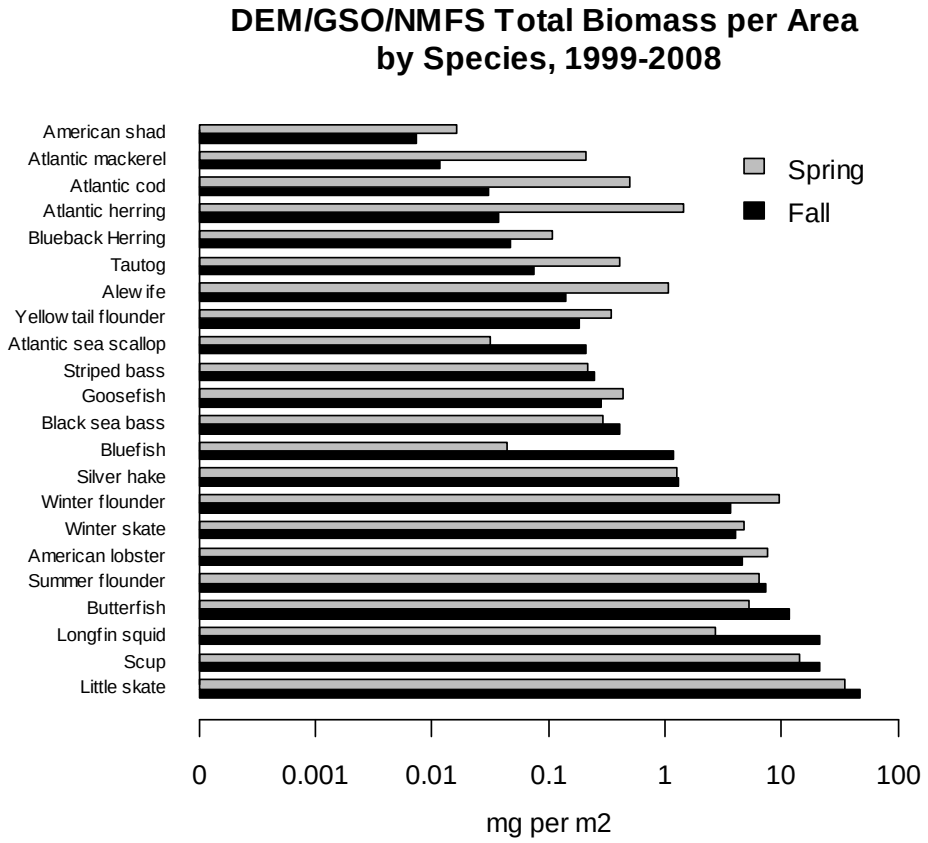


Figure 5.5. Total biomass per area by species, 1999-2008. (Bohaboy et al. 2010).\
**Based on RIDEM, URI GSO, and NMFS trawl surveys*

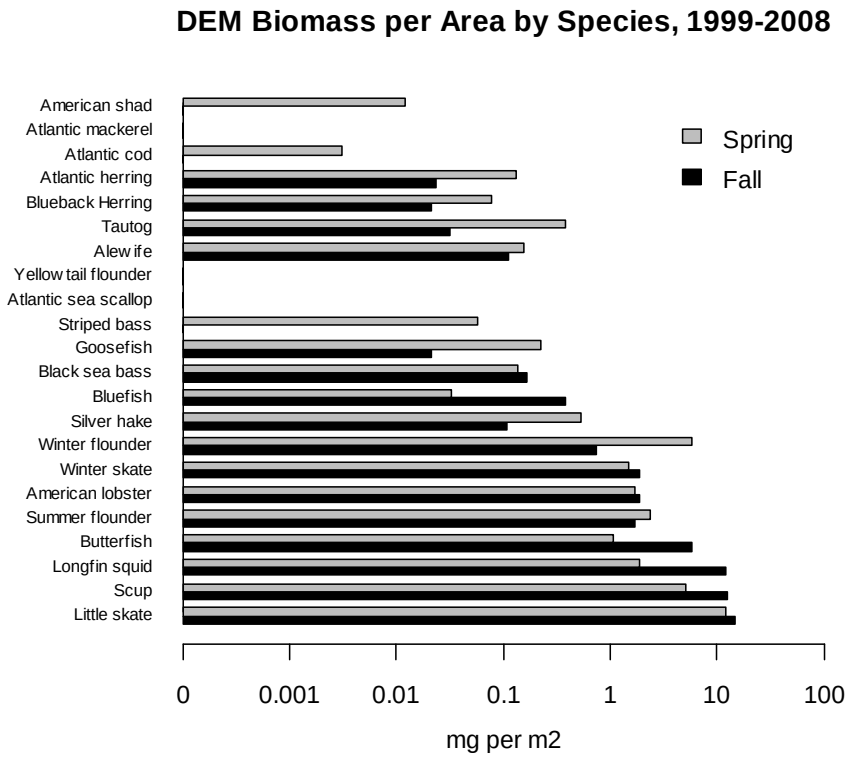


Figure 5.6. DEM trawl survey biomass per area by species. (Bohaboy et al. 2010)

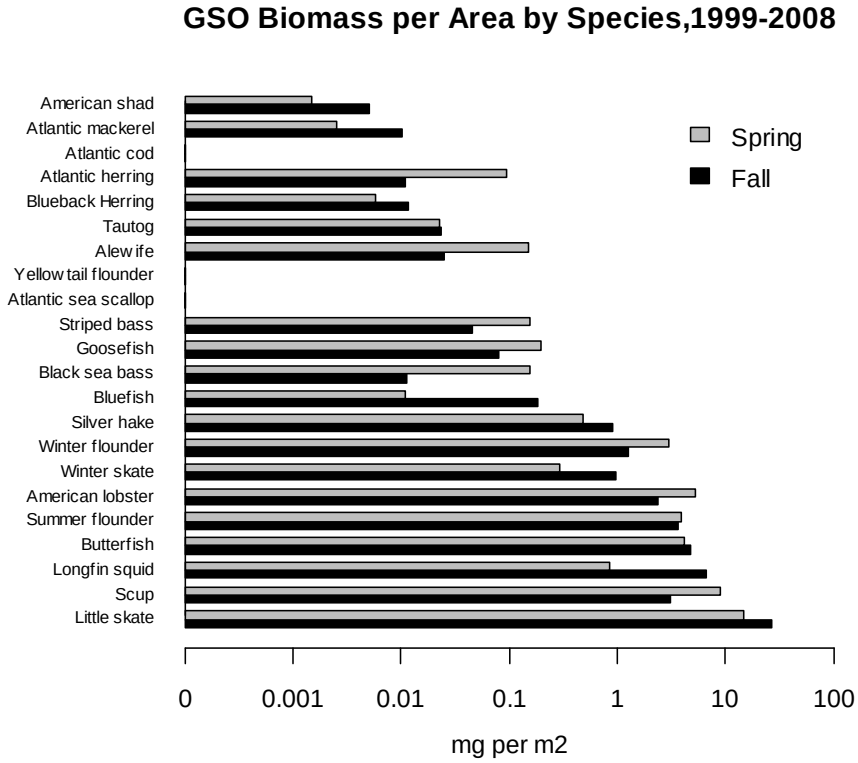


Figure 5.7. GSO trawl survey biomass per area by species. (Bohaboy et al. 2010)

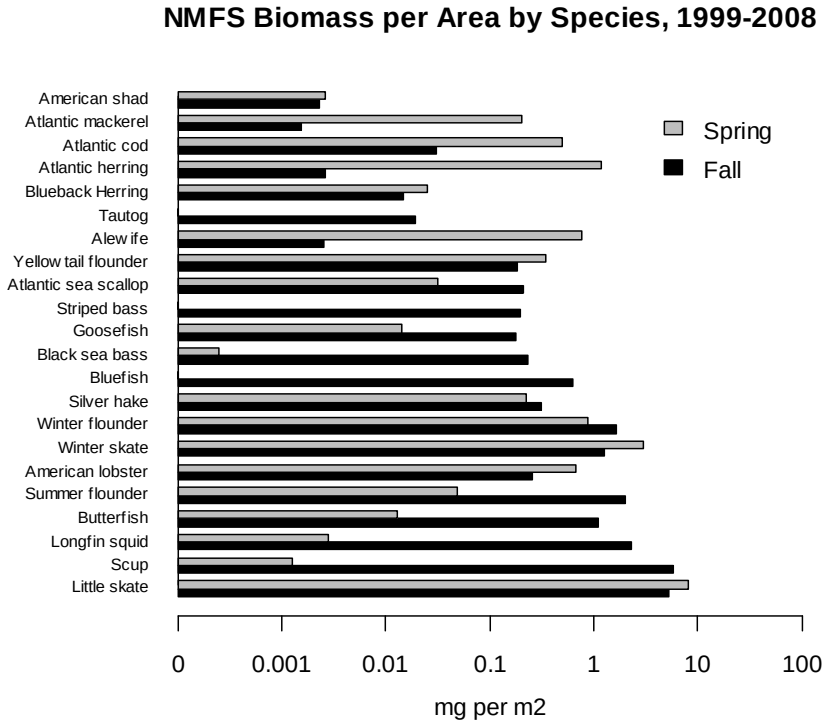


Figure 5.8. NMFS trawl survey biomass per area by species. (Bohaboy et al. 2010)

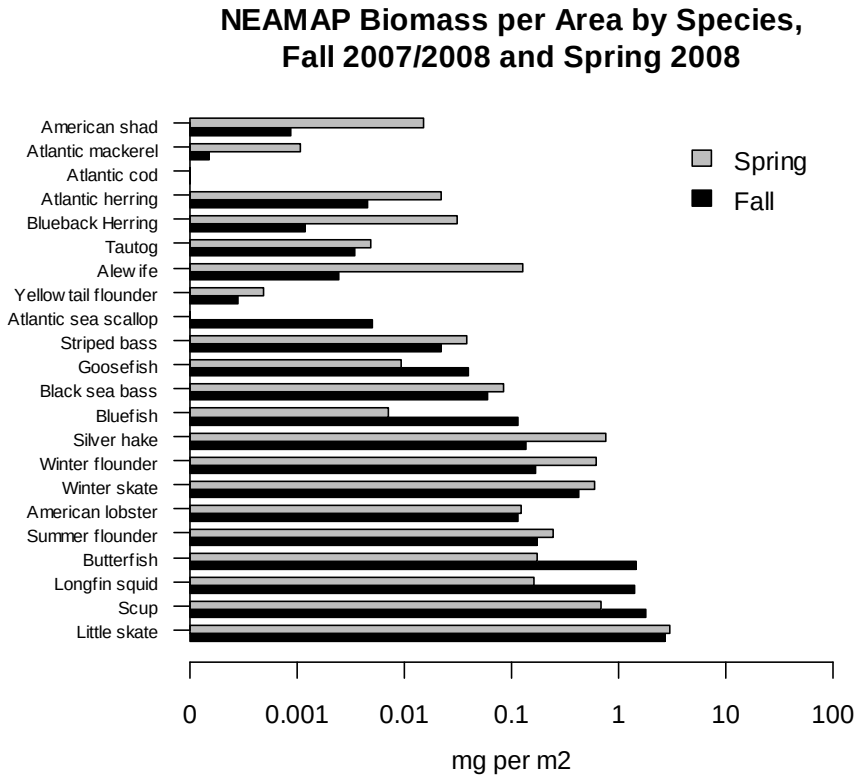


Figure 5.9. NEAMAP trawl survey biomass per area by species. (Bohaboy et al. 2010)

2. Individual species catch biomass data also provide insight into trends in biomass over the past decade. Data from the DEM, GSO, and NMFS trawl surveys were used to assess trends in biomass for the Ocean SAMP area from 1999 to 2008; spring and fall trends figures for each of the key species for which data were available are included in Appendix A. NEAMAP data were not used in these figures as only two years of data were available.

3. Multivariate analyses identified 17 species that effectively control the demersal fish and invertebrate community composition within the Ocean SAMP area (see Figure 5.10 below). Although these species may not be the most abundant within the Ocean SAMP area, they are of immense ecological importance to the stability and resiliency of the local marine community. When attempting to predict the effects of development and exploitation on the demersal fish community within the Ocean SAMP area, it is essential to consider these community-shaping species. As illustrated by this figure, many of these species vary in abundance from fall to spring. Such seasonal community dynamics should also be considered when planning offshore construction and directed exploitation (Bohaboy et al. 2010).

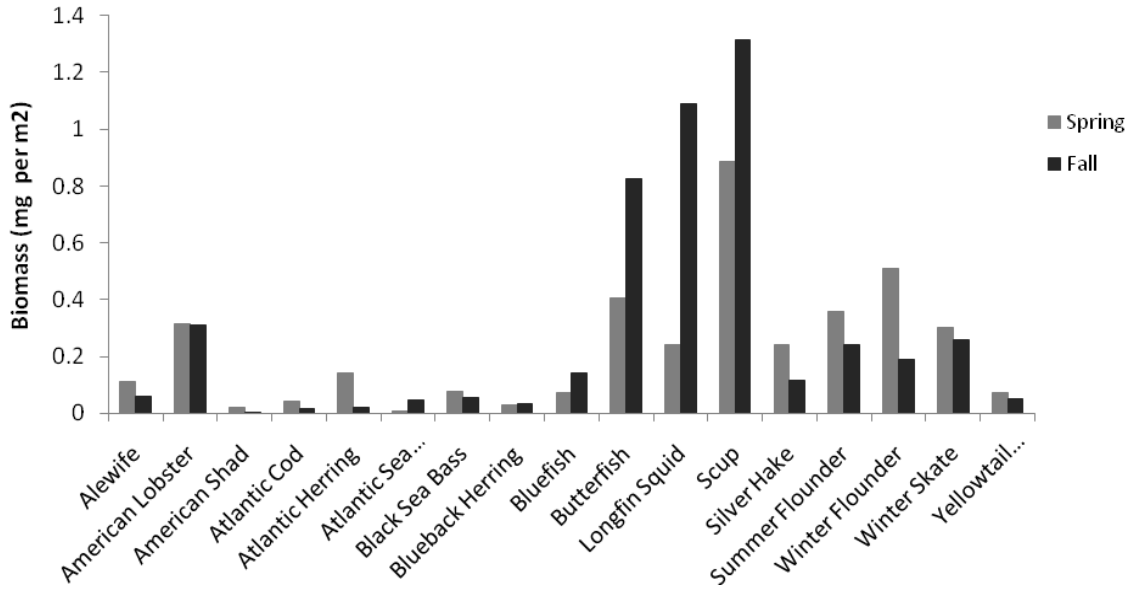


Figure 5.10. Spring and fall biomass of species identified as a driver of demersal fish and invertebrate community composition (Primer 6.0, BVStep, R=0.940). (Bohaboy et al. 2010)

4. The spatial distribution of individual species catch biomass during the spring and fall seasons is shown in a series of maps that are included in Appendix A. Maps are included for all of the species identified in Figure 5.10, as well as the remaining species of commercial and recreational importance for which bottom trawl survey data were available.

Section 520. Fish Habitat in the Ocean SAMP area

520.1. Benthic Habitat

1. Fish populations in the Ocean SAMP area and elsewhere require access to suitable habitats at all stages of the life cycle in order to thrive. Habitat requirements vary widely by species. Suitable habitat for a given species may include specific chemical and physical properties of the water column as well as specific geological or biological bottom characteristics. For an extensive discussion of habitat in the Ocean SAMP area, as well as other ecosystem characteristics, see Chapter 2, Ecology of the Ocean SAMP Region.

2. This section focuses on the current status of fish habitat in the Ocean SAMP area. Potential impacts to habitat from existing activities are discussed below in Section 550. It should be noted that future uses of the Ocean SAMP area may result in habitat disturbances. Conversely, future uses of the Ocean SAMP area may result in habitat enhancements through the creation of artificial reefs or other factors. See Chapter 8, Renewable Energy and Other Offshore Development for discussion of the potential effects of renewable energy on fish habitat, and Chapter 9, Other Future Uses for discussion of artificial reefs and other potential future uses of the Ocean SAMP area.

3. Very little mapping of geological and biological habitats has been done to date in the Ocean SAMP area. At the time of this writing, URI Graduate School of Oceanography researchers are conducting research on benthic habitat and have mapped approximately 15% of the total Ocean SAMP area. Future efforts by these researchers and by the NOAA hydrographic mapping program will result in approximately 40% of the area being mapped by 2011. This work will provide maps of geological and biological habitats, including fish habitat, for those areas being studied (J. King and J. Collie pers. comm.). Results of this study are forthcoming in 2010 and will be incorporated into subsequent revisions of the Ocean SAMP document. Preliminary results are summarized in Chapter 2, Ecology of the SAMP Region. A technical report detailing these preliminary results (Malek et al. 2010) may be found in the Ocean SAMP Appendices.

520.2 Habitat Requirements for Species of Importance

1. As noted above, habitat requirements vary widely by species. Table 5.32 below is a summary of the habitat requirements for the commercial and recreational species of importance found within the Ocean SAMP area, summarized from Section 510.3; this table also includes a column summarizing the presence of designated Essential Fish Habitat (EFH) in the area. See Section 520.3 below for further discussion. For more information on specific habitat preferences, please refer to the individual species descriptions and tables in Section 510.3.

Table 5.32. Habitat requirements for species of importance found within the Ocean SAMP area.
This table is a summary of Tables 5.3-5.28 included above in the individual species descriptions; for references, see those individual tables.

Species	Life Stage	Pelagic	Rocky	Cobble	Sand	Mud	Clay	Gravel	Boulder	Algae/ Vegetation	Shell fragments/ shellfish beds	Man-made structures /wrecks	EFH Designated in Ocean SAMP Area
American Lobster	Eggs	X											N/A
	Larvae	X											
	Juveniles		X										
	Adults			X	X	X							
Atlantic bonito	Juveniles	X											N/A
	Adults	X											
Atlantic cod	Eggs	X											X
	Larvae	X											X
	Juveniles			X						X			X
	Adults		X					X					X
Atlantic herring	Eggs		X	X	X			X	X		X	X	
	Larvae	X											X
	Juveniles	X											X
	Adults				X			X					X
Atlantic mackerel	Eggs	X											X
	Larvae	X											X
	Juveniles	X											X
	Adults	X											X
Atlantic sea scallop	Eggs												X
	Larvae				X						X		X
	Juveniles		X					X		X	X		X
	Adults			X	X			X			X		X
Black sea bass	Eggs	X											
	Larvae	X											X
	Juveniles		X	X						X	X	X	X
	Adults		X	X			X				X	X	X
Bluefish	Eggs	X											X
	Larvae	X											X
	Juveniles	X			X	X	X			X			X
	Adults	X											X
Butterfish	Eggs	X											X
	Larvae	X											X
	Juveniles					X							X
	Adults				X	X							X
False albacore	Juveniles	X											N/A
	Adults	X											
Monkfish	Eggs	X											X
	Larvae	X											X
	Juveniles		X		X	X		X		X			X
	Adults		X		X	X		X		X			X
Loligo squid	Eggs		X		X	X			X	X		X	
	Larvae	X											
	Juveniles	X											X
	Adults	X			X	X							X
Menhaden	Eggs	X											N/A
	Larvae	X											
	Juveniles	X	X	X	X	X							
	Adults	X	X		X	X							
Scup	Eggs	X											X
	Larvae	X											X
	Juveniles				X	X				X	X		X
	Adults		X		X	X				X	X	X	X
Sharks (all)	Juveniles	X											N/A
	Adults	X											
Silver hake	Eggs	X											X
	Larvae	X											X
	Juveniles	X			X	X							X
	Adults	X			X	X							X

Skate, little	Eggs				X								
	Juveniles				X	X		X					X
	Adults				X	X		X					X
Skate, winter	Juveniles				X			X					X
	Adults				X			X					X
Spiny dogfish	Juveniles	X											N/A
	Adults	X			X	X							
Striped bass	Eggs	X											N/A
	Larvae		X		X				X				
	Juveniles		X		X				X				
	Adults		X		X				X		X		
Summer flounder	Eggs	X											X
	Larvae				X		X						X
	Juveniles				X		X			X			X
	Adults				X	X				X		X	X
Tautog	Eggs	X											N/A
	Larvae	X											
	Juveniles		X						X	X	X	X	
	Adults		X						X		X	X	
Tunas (all)	Juveniles	X											N/A
	Adults	X											
Winter flounder	Eggs				X	X		X					X
	Larvae				X			X					X
	Juveniles				X	X							X
	Adults		X	X	X	X			X	X			X
Yellowtail flounder	Eggs	X											X
	Larvae	X											X
	Juveniles				X	X							X
	Adults				X	X							X

520.3 Essential Fish Habitat

1. Under the Magnuson-Stevens Act, Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH is designated by the respective regional fishery management councils through their fishery management plans. EFH designation requires NMFS and federal agencies to work to protect these areas from actions which may have an adverse effect on EFH (NMFS n.d.). The New England Fishery Management Council is in the process of developing an Omnibus Habitat Amendment that will address the effects of fishing on Essential Fish habitat.

2. Within the Ocean SAMP area, EFH has been designated for 24 finfish, shellfish, and crustacean species for at least part of their life cycle (see Table 5.33 below). Figure 5.11 below shows the total number of EFH species per ten minute square; Figures 5.12 to 5.15 below show the number of EFH species per ten minute square by life stage.

Table 5.33. Species for which Essential Fish Habitat has been designated within the Ocean SAMP area. (NMFS Office of Habitat Conservation, 2010)

American plaice	Scup
Atlantic cod	Silver hake
Atlantic herring	Skate, little
Atlantic mackerel	Skate, winter
Atlantic sea scallop	Spiny dogfish
Black sea bass	Squid, *Illex*
Bluefish	Squid, *Loligo*
Butterfish	Surf clams
Haddock	Summer flounder
Monkfish	Windowpane flounder

Ocean pout	Winter flounder
Ocean quahog	Witch flounder
Red hake	Yellowtail flounder

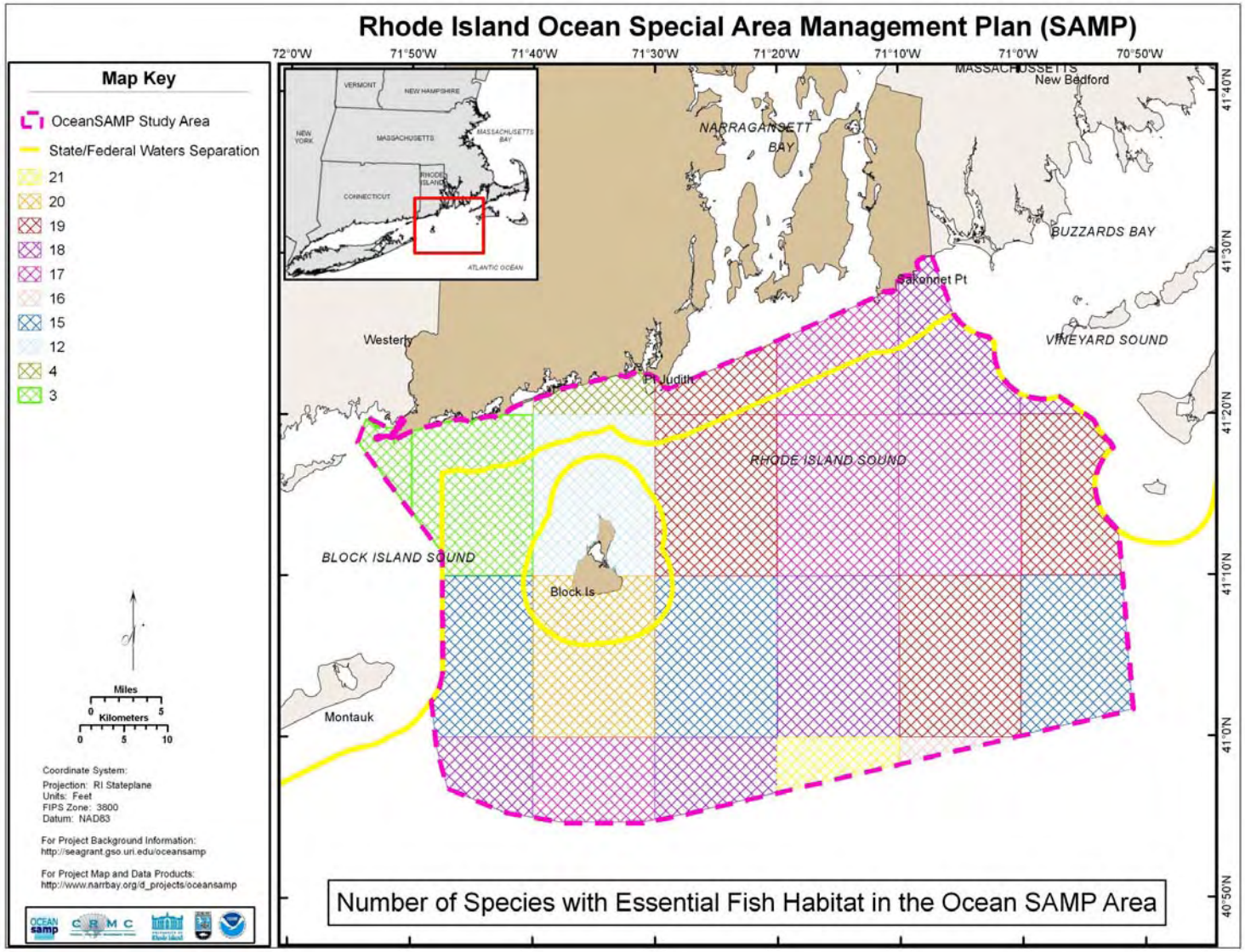


Figure 5.11. Number of species per ten minute square with Essential Fish Habitat, all life **s**tages. (Data: NMFS; Map prepared by RIDEM Div. Fish and Wildlife, 2010)

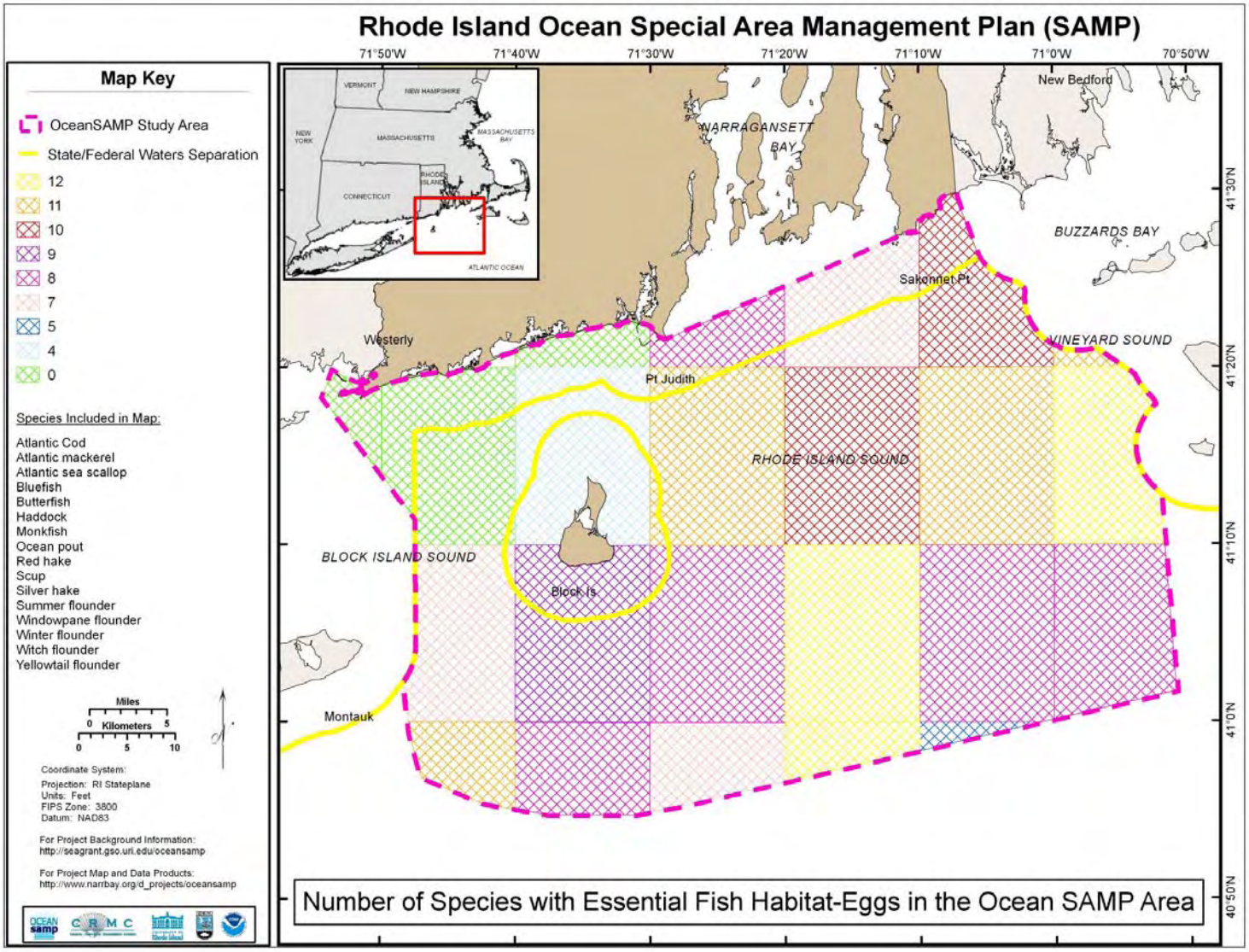


Figure 5.12. Number of species per ten minute square with Essential Fish Habitat, egg life stage. (Data: NMFS; Map prepared by RIDEM Div. Fish and Wildlife, 2010)

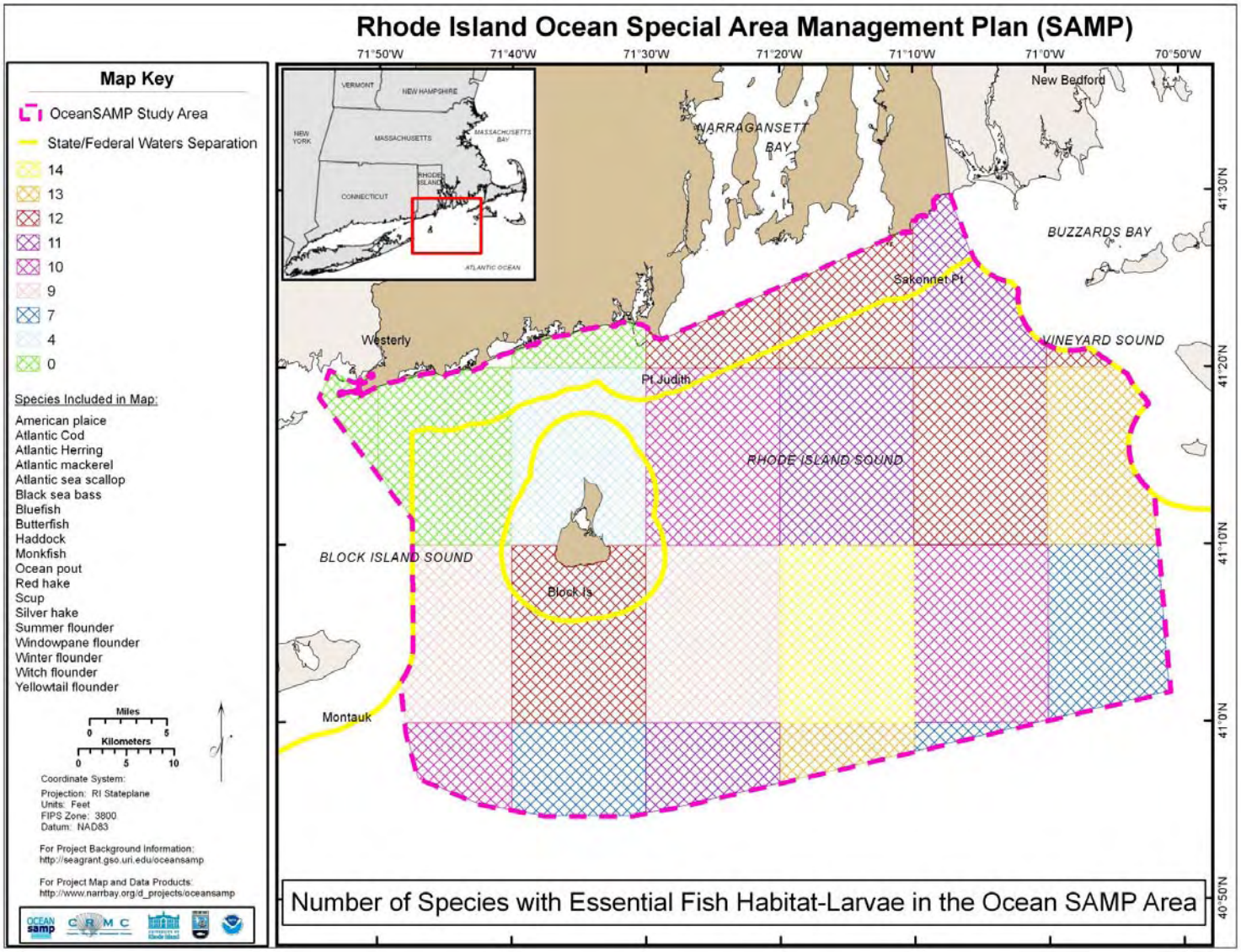


Figure 5.13. Number of species per ten minute square with Essential Fish Habitat, larval life stage. (Data: NMFS; Map prepared by RIDEM Div. Fish and Wildlife, 2010)

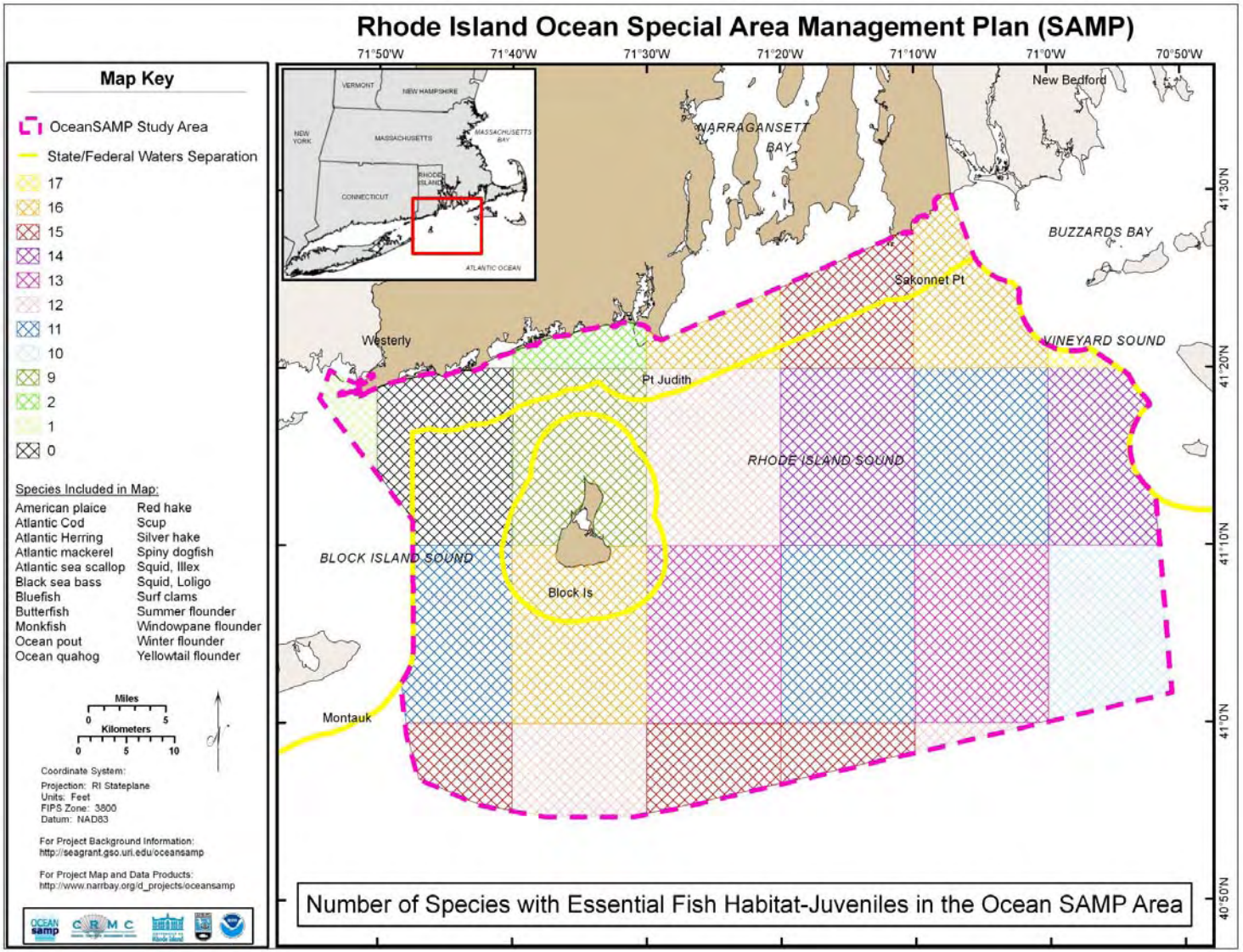


Figure 5.14. Number of species per ten minute square with Essential Fish Habitat, juvenile life stage. (Data: NMFS; Map prepared by RIDEM Div. Fish and Wildlife, 2010)

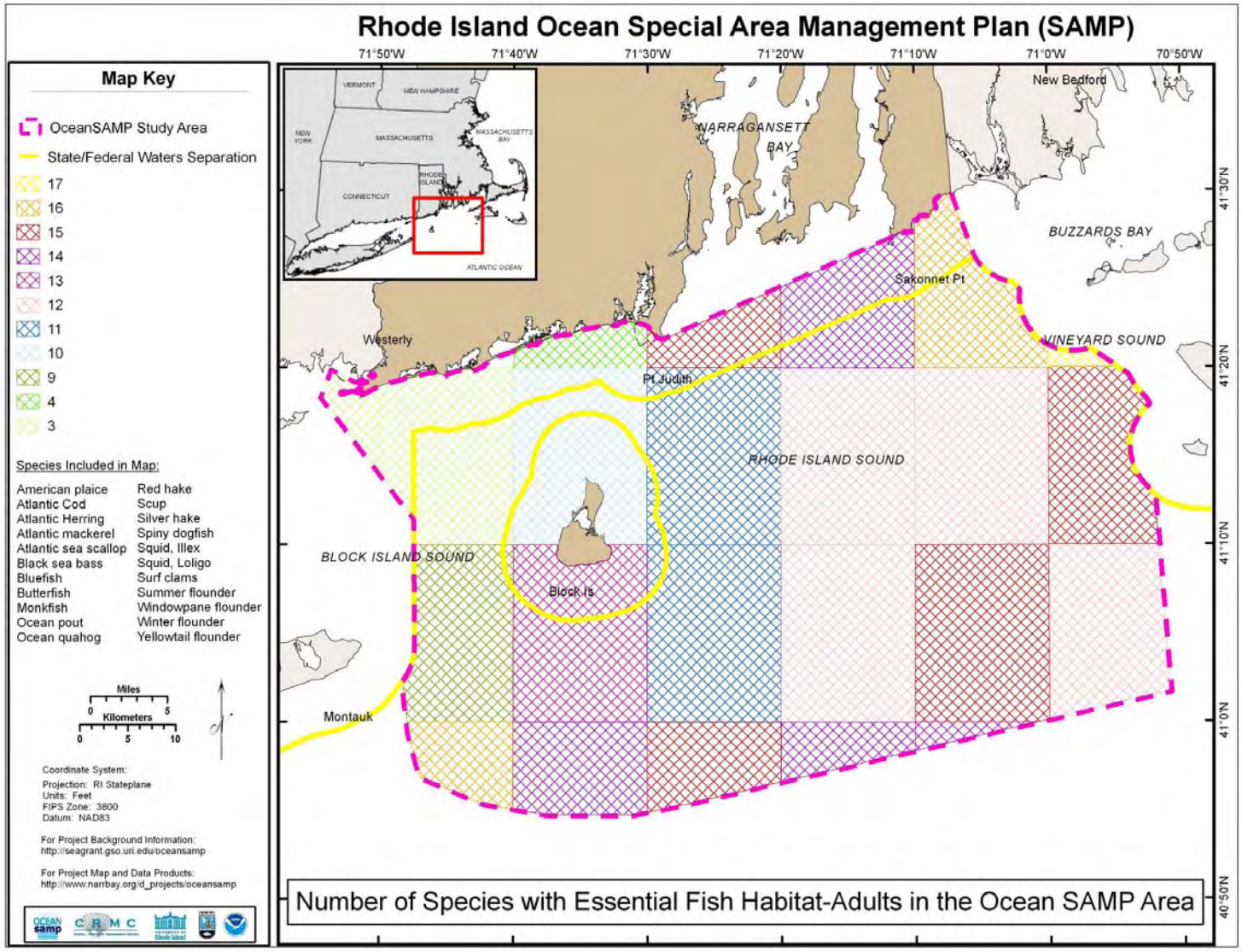


Figure 5.15. Number of species per ten minute square with Essential Fish Habitat, adult life stage. (Data: NMFS; Map prepared by RIDEM Div. Fish and Wildlife, 2010)

3. Under the Magnuson-Stevens Act, federal agencies must consult with NMFS on actions that adversely affect EFH. Part of an EFH consultation is an EFH assessment, which is a site- and project-specific analysis of the potential impacts of an action on EFH.

520.4. Critical Habitat

1. Under the Endangered Species Act, Critical Habitat is designated for species listed under the Act as threatened or endangered. The ESA describes Critical Habitat as those areas that are "essential to the conservation of the species and which may require special management considerations or protection." According to the NOAA Northeast Regional Office Protected Resources Division, there is no Critical Habitat for any listed finfish species within the Ocean SAMP area (Crocker, pers. comm. a.).

Section 530. Commercial and Recreational Fisheries in the Ocean SAMP Area

530.1. History of Fisheries in Rhode Island

530.1.1. Commercial Fishing History

1. The commercial fisheries of Newport and Sakonnet Point have origins dating back to the 17th century (Hall-Arber et al. 2001). Colonial fishermen in Rhode Island used a hook and line and fished from a small skiff, or set seine nets along the shore. The small fish caught with seines were used primarily as manure in the fields (Olsen et al. 1980). Seining usually involved leaving a net in the water for an hour or so, and returning to pull up the net and whatever it had caught. Poggie and Gersuny (1974) describe the fishing gangs in South Kingstown who would have fish houses along the beach equipped with bunks, where they would stay while fishing for striped bass. Each fishing gang typically used two boats and a seine.

2. The historically important food species of fish in Rhode Island have been striped bass, scup, tautog, bluefish, and mackerel (Sedgwick et al. 1980). During the mid-1800s, the use of staked and floating fish traps, set close to shore, came into prominence as a fishing technique, eclipsing the hook and line method. This new method of fishing was much more efficient (Olsen et al. 1980). At the time, traditional hook and line fishermen claimed that the waters of Rhode Island were being overfished by these new technologies. In 1870, the Rhode Island General Assembly appointed a special committee to investigate these claims (Poggie and Gersuny 1974). By 1910 there were 400 fish traps in use throughout Rhode Island. Eventually, because they were so numerous, the state placed restrictions on where and when they could be used (Olsen et al. 1980).

3. Fishermen also seined for menhaden using larger nets, usually requiring a more substantial operation with four men rowing the boat, two men to throw the net overboard, and about sixteen men on shore to haul the net ashore. Typically, neighbors would assist in the process in exchange for a share of the catch. Menhaden were generally used for rendering fertilizer and fish oil rather than food, and as many as 100,000 were sometimes taken in a single catch (Poggie and Gersuny 1974). Menhaden became a highly important industrial fishery in Rhode Island and throughout New England in the late 1800s and early 1900s. In 1889, there were a reported 127 million pounds of fish landed in Rhode Island, of which 89 percent were menhaden (Olsen and Stevenson, 1975). Menhaden plants, which rendered the fish for oil, were common along the New England coastline around the turn of the century. Scup and alewives were also important species to commercial fisheries in this period (Poggie and Pollnac, eds. 1981).

4. The development of the fishing industry coincided with the development of markets for fish and with the ability to store and transport fish. Around the turn of the last century, fish could be shipped by steamship from Newport to New York, or via railroad. There is evidence that ice was used in keeping fish as early as 1900, but its early use was limited because of cost (Poggie and Gersuny 1974). Other methods of shipping fish included boxing them or placing them in barrels (Sedgwick et al. 1980).

5. During the 1920s and 1930s, menhaden began to disappear off the coast of New England as stocks were overfished, and many of the menhaden plants were forced to close. Fishermen were pushed to pursue other species (Poggie and Pollnac, eds. 1981). In the 1930s, the first otter trawls were used off Rhode Island (Olsen and Stevenson 1975). Marine diesel engines were also introduced around this time, allowing fishermen to travel further offshore in pursuit of fish (Poggie and Pollnac, eds. 1981). Trawling quickly became the dominant method of fishing, and trap fishermen soon began criticizing trawlers for a decline in stocks. Whiting (silver hake) and red hake, both used for industrial purposes, usually in the form of fertilizer or protein, were the two species initially targeted by otter trawls (Poggie and Pollnac, eds. 1981). As trawling became more commonplace, the species caught as well as people's preferences for food fish both changed, and flounder, which had previously been considered "trash" fish, eclipsed scup, bluefish, and mackerel in the marketplace (Sedgwick et al. 1980). See Figure 5.16 for offshore areas used by trawlers during the 1970s.

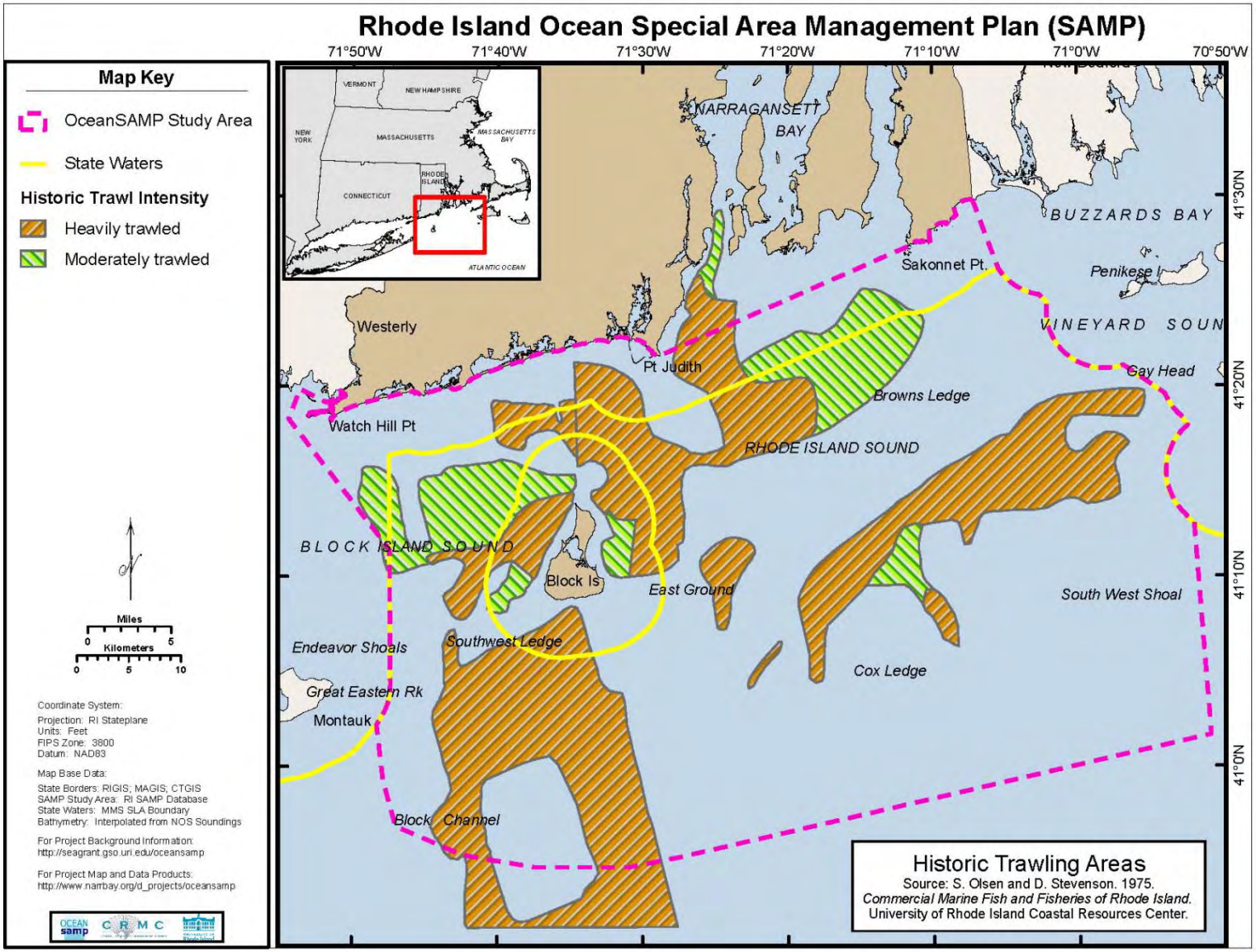


Figure 5.16. Historic trawling areas of the 1970s.

6. During the 1960s, significant stocks of lobsters that had not previously been fished were discovered offshore, providing a large boost to landings and value in the state's lobster fishery (Sedgwick et al. 1980). Around this time, traps replaced trawling as the dominant method for catching lobsters offshore, and this also significantly boosted lobster landings and revenues (Poggie and Pollnac, eds. 1981).

7. As in other states around the country, the presence of foreign fishing fleets was a contentious issue in Rhode Island in the 1960s through the mid-1970s, until the passage of the Magnuson Stevens Fishery Conservation and Management Act in 1976, which declared a 200-mile limit on U.S. waters. Rhode Island offshore fisheries continued to grow even during the time of massive fishing efforts by foreign fleets, as some of the offshore stocks were not heavily exploited by foreign fleets, and were thus targeted by Rhode Island vessels. A significant period of development in fisheries followed the passage of the Act, in which Rhode Island fishermen, more so than other New England fishermen, diversified their targeted species to include butterfish, whiting (silver hake), and squid, based both on the abundance of these species in Rhode Island waters compared with northern New England, where their geographic range does not extend, and also on a willingness of Rhode Island fishermen to target non-traditional species (Sedgwick et al. 1980). This led to rapid expansion of Rhode Island fisheries in the late 1970s and early 1980s. In 1979, there were a record 264 offshore vessels landing at Rhode Island ports, although some of these vessels were home ported elsewhere. As the number of vessels grew in this period, so did vessel length, tonnage, and horsepower, and the traditional wooden eastern rigged side trawler was replaced by new steel-hulled stern trawlers (Sedgwick et al. 1980).

8. Rhode Island's important squid fishery began in the late 1800s as a bait fishery, and a market for human consumption developed during the 1960s. Whereas longfin squid have been harvested since the late 1800s, harvesting of shortfin (*illex*) squid as a bait fishery began somewhat more recently. From the late 1960s through early 1980s, longfin squid were heavily exploited in Rhode Island waters by foreign fishing fleets. After the departure of foreign vessels from U.S. waters, Rhode Island vessels were among the first to target squid in large numbers; Rhode Island commercial landings for longfin squid increased by an order of magnitude from 1981 through 1992 (DeAlteris et al. 2000).

9. During the 1980s, the commercial fishing industry in Rhode Island was growing, increasing by 24 percent in total landings from 1980 through 1987, while landings in the other New England states declined by 37 percent. This increase was due in part to an increase in fish consumption nationwide, to the increased harvesting of what at the time were underutilized species (such as squid, butterfish, and silver hake), and also to a significant increase in international exports from Rhode Island, particularly to Japan. This growth was also aided by public investment into the fishing industry during the late 1970s and 1980s, including the development of piers at both Newport and Galilee (Intergovernmental Policy Analysis Program, University of Rhode Island, 1989).

530.1.2. Recreational Fishing History

1. Recreational fishing, also known as sport fishing, also has a long and important history in Rhode Island. However, as with many other types of recreation, there is very little documentation of recreational fishing history, both in Rhode Island and throughout the U.S. In the late 19th-century, recreational boating became a popular pastime, and Newport and other Rhode Island coastal communities became destinations for wealthy people seeking leisure time and recreational activities. Coastal recreation and tourism activities, including boating and beach-going, became increasingly popular with the emergent middle class during the early- to mid-20th century. Recreational fishing also emerged as a popular activity during this time.

2. Rhode Island's many fishing clubs and organizations are a testament to the presence of recreational fishing within the state's history. The Narragansett Salt Water Fishing Club, for example, has been in existence since 1936, and the club had as many as 800 members in the 1940s and 50s. Historically, there were tuna clubs in coastal communities such as Block Island, where the Atlantic Tuna Club had a club house in 1915 (Allen 2010). The RI Party and Charter Boat Association was established by 15 party and charter boat operators in 1962 in order to promote their industry; today, membership has grown to 70 members from throughout the state with vessels ranging in size from 18 to 100 feet long (Bellavance, pers. comm.). The RI Saltwater Anglers Association was established more recently, in 1999, as a forum and advocacy organization for recreational fishermen, and currently has approximately 1,800 members (Hittinger, pers. comm. a).

3. Rhode Island has a long history of recreational fishing tournaments, many of which are focused on species found in the Ocean SAMP area. The Atlantic Tuna Tournament, alternately known as the Point Judith Tuna Tournament, is one of the better known of these tournaments. This tournament began in the 1940s (Conley 1986) and became especially popular in the 1950s and 1960s, drawing large crowds to Galilee. Galilee was known as the Tuna Capital of the World until the tournament was moved to Gloucester in 1973 (Olsen and Stevenson 1975). Other large recreational fishing tournaments described in a 1986 history of Rhode Island include the Rhode Island Tuna Tournament, the Point Judith Masters Invitational, the Snug Harbor Shark Tourney, the Block Island Bluefish Tournament, and the Block Island Striper Tournament (Conley 1986).

4. Recreational fishing in Rhode Island has also expanded in recent years through the growth of the party and charter boat industry. RI Department of Environmental Management licensing data indicates that 240 party and charter boats are currently licensed; this is more than twice the number than were licensed in 1999 when the licensing program first took effect (RIDEM 2010b).

530.2. Rhode Island's Commercial and Recreational Fishing Ports

1. Rhode Island today has two major commercial fishing ports, Point Judith and Newport, as well as several smaller fishing ports used by both commercial and recreational fishermen. These ports have seen significant changes over the years, as the fishing industry has given way to tourism and other waterfront development. However, Rhode

Island's ports still serve as the physical and social nexus of fishing activity within the state, and have an important place in the state's history and culture.

2. Rhode Island's commercial fishing ports serve commercial fishermen and fishing vessels both from within the state of Rhode Island and from other states along the East Coast. The nature of fishing regulations and markets is such that at various times of the year, fishermen from as far away as North Carolina and Florida may be fishing in the Ocean SAMP area, and may make use of the infrastructure present in the state to unload and sell their catch. Likewise, Rhode Island fishermen may land their catch in other states at times.

3. Because of the importance of recreational fishing to Rhode Island, recreational fishermen, and boats used either occasionally or frequently for recreational fishing, can be found in every port and harbor in the state. Point Judith and Newport, critical to the state's commercial fishing industries, also host much of the state's recreational fishing activity, particularly for vessels fishing within the Ocean SAMP area.

530.2.1. Point Judith/Galilee

1. Commercial fishing did not become a prominent industry at Point Judith until the 1930s. During the 17th and most of the 18th centuries, farming was the primary activity in the South Kingstown/Narragansett area (Narragansett was part of the town of South Kingstown until splitting off in 1888). A textile industry developed in 1802, and was a prominent industry here throughout the 19th century (Poggie and Gersuny 1974).

2. The development of the Point Judith commercial fishing industry coincided with the development of the Harbor of Refuge. Between 1892 and 1915, the US Army Corps of Engineers built three breakwaters at Point Judith to create the Harbor of Refuge (Olsen and Stevenson 1975). Previously, Point Judith had presented a hazard to navigation between Boston and New York, and the shifting sands of the pond had made it impossible for use as a harbor. In 1934 and 1935, the state and the Public Works Administration built two state piers and dredged a 35-acre anchorage basin – these improvements allowed the commercial fishing industry to prosper here. Landings of commercial fish at Point Judith grew exponentially from 300 tons in 1895 to 3,000 tons in 1935, and then from 17,000 tons in 1945 to 30,000 tons in 1970 (Poggie and Gersuny 1974). The fishery during the 1950s was primarily an industrial fishery, largely for whiting and red hake used as industrial feeds. This fishery had a rapid decline after peaking in 1956, but other fisheries continued to be robust (Olsen and Stevenson 1975).

3. One major force in the development of the commercial fishing industry at Point Judith was the creation of a cooperative. The Point Judith Fishermen's Cooperative was founded in 1948 by returning World War II veterans, and served as a marketing cooperative for local fishermen, rather than as a fishing cooperative. At its start, it had 65 members and 20 fishing vessels (Poggie and Gersuny 1974). The coop provided its members with organized marketing and with lumpers (fish handlers). They provided low-cost insurance and unemployment compensation to members. The coop also had a store where they sold equipment and supplies such as line, boots, gloves, and replacement

parts, saving the coop members valuable time and money by not having to go elsewhere. The coop also provided fuel and ice. By 1973, the coop had 129 members and employed 82 people. There were approximately 120 trawlers and lobster boats landing regularly at the coop, and most of the fish was sold to Fulton Fish Market in New York (Olsen and Stevenson 1975).

4. During the 1970s, as commercial fisheries expanded due to the creation of the 200 mile limit, membership in the coop increased to the point where a moratorium was placed on membership. In the 1980s, the coop increased its processing capacity by moving into a larger building. During the moratorium, other companies developed to fill this gap, and after its expansion there were few incentives to join the coop. The combination of increased competition and growing operating costs (which were not accompanied by growth in membership) contributed to the coop's ultimate demise, and it shut its doors in 1994 (Griffith and Dyer 1996). Declining fish stocks and low prices also contributed to the coop's closure. The coop exists today as an independent fish marketing organization (Clay et al. 2008).

5. Point Judith did not become a significant commercial fishing port until the 1930s, so it lacks the long tradition of fishing of some other New England towns, including Newport. Many of the fishermen do not come from fishing families with a long fishing history, but became fishermen during the 1960s or 1970s as the industry was expanding. However, many of the fishermen also have last names found in the 1774 census for South Kingstown, indicating that many of the fishermen are from families who have lived in the area for generations (Poggie and Gersuny 1974). Most of the commercial fishermen who dock their vessels here live within a 20-mile radius of Point Judith, but not in the immediate vicinity of the port, because of a lack of housing around Point Judith. However, there is still a distinct community of fishermen, and culture of commercial fishing, in Point Judith (Hall-Arber et al. 2001).

6. Today Point Judith is the center of the Rhode Island commercial fishing industry. The vast majority of vessels docked at Point Judith use the port on a full-time basis, rather than being transient among multiple ports. Most of Point Judith's fishermen land there throughout most of the year, although they frequently change targeted fisheries several times throughout the year (Sedgwick et al. 1980).

7. Point Judith has sufficient infrastructure to support its commercial fishing industry, as well as to provide shoreside services to fishermen around the state. There are a number of docks, processing facilities, and dealers, and a commercial bait dealer to serve trap fishermen (Clay et al. 2008). The Division of Coastal Resources of the Rhode Island Department of Environmental Management is responsible for the development and management of the port of Galilee. There are over 230 commercial fishing vessels, including charter fishing boats, berthed in Galilee (RIDEM Division of Coastal Resources n.d.).

8. The largest fish processors in Point Judith are the Town Dock Company and the Point Judith Fishermen's Company. Town Dock came to Point Judith in 1980 and is now one of the largest seafood processing companies in Rhode Island. Its facility supports

unloading, processing, and freezing facilities under one roof and services over half of the trawlers based out of Point Judith (approximately 30 full-time deep sea fishing trawlers), as well as a large day-boat fleet. They handle and process species including squid, scup, and butterfish (Clay et al. 2008).

9. The Point Judith Fishermen's Company, which employs approximately fifteen people at its plant, processes squid which are sold wholesale at the Hunts Point Market in New York. Handrigan's is another unloading facility located in Point Judith. Several smaller processors located in the Point Judith area include: Deep Sea Fish of RI, Ocean State Lobster Co., Narragansett Bay Lobster Co., Fox Seafood, South Pier Fish Company, and Osprey Seafood (also known as the Black Point Fish Trap Company) (Clay et al. 2008).

10. Trawlworks, Inc. in Narragansett is a manufacturer, supplier and distributor of marine hardware and rigging supplies for industrial, institutional, and commercial fishing for both mid-water and bottom use. The corporation was formed in 1980. Superior Trawl is also located in Narragansett, and builds fishing gear sold throughout New England and the Mid-Atlantic. The Bait Company sells bait to local lobstermen (Clay et al. 2008).

11. The majority of commercial vessels docked at Point Judith are bottom trawlers, and most of these are between 45 and 75 feet in length. There are a few larger boats (70' and longer) which fish primarily for squid, herring, and whiting (silver hake), while many of the medium sized boats target a mix of pelagic and groundfish species. Typically, the smaller vessels have 1-2 person crews, while the larger boats may have a crew of four or five. Generally, fishermen in Point Judith are flexible, and target whatever species are available and marketable. Fishermen in Point Judith have the advantage of being close to fish stocks, and of being able to switch between traditionally mid-Atlantic stocks such as butterfish as well as traditionally northern fisheries such as the groundfish species complex, which includes bottom-dwelling fish such as cod, haddock, and flounders. Squid are usually caught year round, with the bulk of squid fishing done in May; herring are caught December to April, mackerel are caught from March through May, and both whiting and scup are caught year-round. Groundfishing boats fish both inshore and offshore depending on the season, targeting traditional groundfish species offshore, and yellowtail, winter, and summer flounder closer to shore. There are also a number of lobster boats located in Point Judith, including both inshore and offshore lobster boats (Hall-Arber et al. 2001). Much of the fish landed at Point Judith ends up either at the Hunts Point Fish Market in New York or the Boston Fish Exchange. Fish product from Point Judith is usually considered to be of high quality, and fetches a good price. Most of Rhode Island's fish exports are made up of squid and lobster (Hall-Arber et al. 2001).

12. Today Point Judith is still a major commercial fishing port. In 2009, there were 179 vessels with federal permits home ported in the Point Judith area (NMFS 2010e). The most valuable species landed here were squid, butterfish, and mackerel, followed by lobster. In 2008, it was ranked 17th among U.S. fish ports for total value of landings in the United States, and 21st for weight (NMFS 2009a).

13. Point Judith is also a significant recreational fishing port. The majority of charter boats in the state are based at Point Judith or in the port of Galilee, and all of the state's party

boats are found here. By one count, between 2001-2005, 66 different charter and party boats made a total of 7,709 trips out of Point Judith, carrying almost 100,000 anglers (Clay et al. 2008). The shores around Point Judith Pond are filled with marinas and private docks, supporting a large number of recreational boats, a majority of which will spend some time fishing within the Ocean SAMP area. Snug Harbor, across the pond from Point Judith and Galilee, is home to numerous recreational fishing boats and hosts several fishing tournaments.

14. Commercial and recreational fisheries are presently competing for space in Point Judith. While the commercial fishing presence has diminished in Point Judith, as it has done elsewhere around the state, recreational and for-hire fishing has expanded as part of the state's growing recreation and tourism economy. Many of the former gathering spots for fishermen have been converted to ice cream shops and seafood restaurants. The commercial fishing infrastructure cannot be further expanded because of competition from the recreational boating sector (Hall-Arber et al. 2001). However, because of the significant economic value of both recreational and commercial fishing in Point Judith, and the cultural importance of both commercial and recreational fishing to this area, commercial fishing is likely to retain a stronghold in Point Judith alongside a thriving recreational fishing industry.

15. Point Judith has a Blessing of the Fleet celebration for the fishing fleet, featuring food, games, parades, and other festivities. Traditionally, visitors would get to tour a commercial fishing vessel and participate in the parade. However, the fishermen's insurance companies refused to cover the liability of any non-fisher who might be injured on one of the vessels, and much of the commercial fleet had to stop participating in the event (Griffith and Dyer 1996). The Blessing of the Fleet still takes place today, and features a road race and seafood festival, but primarily involves recreational vessels. This event has shifted away from a tradition of cultural importance for fishermen toward a tourism-oriented event (Hall-Arber et al. 2001).

530.2.2. Newport

1. Newport's history and cultural traditions are strongly tied to tourism and recreational boating, and commercial fishing has also always had a presence here (Hall-Arber et al. 2001). Newport has one of the best natural harbors in the Northeast (Olsen and Stevenson 1975). Although not much historical information is available on fishing during Newport's early history, it is a safe assumption that fishing played a vital role in Newport's economy in the early days when the city was first settled by Europeans (Poggie and Pollnac, eds. 1981). Before the port of Galilee was developed, Newport was the center of both shipping and fishing in Rhode Island. During the 1870s, there were four industrial fish processing plants on Aquidneck Island processing menhaden, mackerel, herring, and scup as agricultural fertilizers (Sedgwick et al. 1980). Commercial fishing declined in prominence here after World War II, just as the Naval Base was gaining in size and importance to the economy.

2. Newport was Rhode Island's principal commercial fishing port in the 1930s but was surpassed by Point Judith when its industrial fishery blossomed in the late 1940s and 50s.

Some suggested factors in the decline of commercial fishing in Newport at that time include the growth of recreational boating and tourism, and commercial fishermen being enticed to New Bedford and Point Judith by the increase in services and infrastructure in those ports (Poggie and Pollnac, eds. 1981). During the 1960s, Newport again became an important port for trawlers from New Bedford (Olsen and Stevenson 1975). At this time, many of the trawlers fishing in New Bedford and other ports, including many New Jersey vessels, were dissatisfied with the dealers in these locations, and were enticed to Newport by the dealers there (Poggie and Pollnac, eds. 1981). Olsen and Stevenson noted of Newport in 1975 that the vessels landing here were on average larger than those landing in Point Judith, making longer trips out to Georges Bank as opposed to shorter trips closer to home. Newport was still the dominant commercial fishing port in Rhode Island until around 1973 (Hall-Arber et al. 2001), but fishing here has declined considerably since that time. During the 1970s, Newport's waterfront underwent a dramatic transformation as recreational boating, tourism, and residential development out-competed commercial fishing for use of much of the city's waterfront. There have been no new commercial fishing-related businesses coming into the fishery in Newport for close to thirty years. This has been the result of increasing property values, restricting fishing-related businesses from opening, and increased competition for dock space with recreational vessels (Hall-Arber et al. 2001).

3. Traditionally, a number of transient commercial vessels from New Bedford and other ports have landed in Newport. These are usually long-trip boats fishing for scallops or groundfish on Georges Bank that come to Newport to sell to one of the fish buyers here. There are also a number of lobster boats that fish out of Newport. The Division of Coastal Resources of the Rhode Island DEM is responsible for managing and maintaining State Pier 9, the only state-owned commercial fishing facility in Newport. The pier provides dockage for approximately 60 full-time commercial fishing vessels (RIDEM Division of Coastal Resources n.d.), the majority of which are lobster boats (Clay et al. 2008).

4. Newport has the infrastructure and services to support its commercial fishing fleet, but has been losing fishing-related business in recent years, and at present commercial fishermen must go to New Bedford or Point Judith for most fishing supplies. The city has several seafood wholesalers and retailers. The most significant of these include: Omega Sea, which markets scallops and coldwater shrimp; Aquidneck Lobster, a large lobster wholesaler; and Parascandolo and Sons, which buys finfish. Other commercial fishing-related businesses here include International Marine Industries, Long Wharf Seafood, and Neptune Trading Group. Parascandolo and Sons maintains a private dock, primarily used by the multispecies groundfish fleet who land fish here, but they also have a substantial number of vessels landing squid here. Parascandolo and Sons requires a large volume in order to be able to maintain their business (Clay et al. 2008).

5. In 2009, there were 41 commercial vessels with federal licenses listing Newport as their home port (NMFS 2010e). Newport was ranked 75th among U.S. fish ports for landings value in 2008, and 60th by weight (NMFS 2009a). In recent years, scallops and lobster have been among the most valuable commercial species landed in Newport (Clay et al. 2008).

6. Recreational fishing is an important activity in Newport because of the large number of recreational boats located here.[9] The harbor's location means that recreational boats can easily access the Ocean SAMP area. There are also several charter boats located in Newport harbor.

7. Newport also has an annual Blessing of the Fleet that takes place each December as part of the city's Christmas celebrations, where both recreational and commercial vessels are decorated for a parade around the harbor (Clay et al. 2008).

530.2.3. Sakonnet Point

1. Sakonnet Point in Little Compton is a considerably smaller port than either Point Judith or Newport, but fishermen here also fish within the Ocean SAMP area. Commercial fishing is considered to be one of the most important economic activities in Little Compton. Most fishermen based in Sakonnet Point are combination lobster-gillnet fishermen (Hall-Arber et al. 2001). There are a number of fish traps outside of Sakonnet Harbor and at the mouth of the Sakonnet River, many currently operated by Parascandolo and Sons. Some of the permits and sites for the traps date back to colonial times (Clay et al. 2008).

2. There are three major fishing related businesses here. Sakonnet Lobster is a lobster wholesaler located in Sakonnet Point adjacent to the harbor (Clay et al. 2008). The Point Trap Company and H.N. Wilcox Inc. are primarily engaged in trap fishing (Little Compton Harbor Commission 2008).

3. The fishery at Sakonnet Point is small but highly diverse. According to the Sakonnet Harbor Management Plan, there are currently approximately 30 commercial fishing vessels based in the harbor, which may include both vessels with federal permits and vessels with state permits (Little Compton Harbor Commission 2008). According to NMFS, in 2009 there were 17 vessels with federal permits home ported in the Sakonnet Point/Little Compton area (NMFS 2010e). There are also one or two transient fishing vessels that use the harbor regularly. About three quarters of these vessels engage in commercial lobstering, primarily from April through November. The remainder of the boats target finfish or shellfish using a variety of different gear types including fish traps. Vessels that fish in the winter months primarily engage in gillnetting, and many of the harbor's lobster boats can be adapted for this use (Little Compton Harbor Commission 2008). The most valuable commercial species landed at Sakonnet Point in recent years have included monkfish, summer flounder, scup, black sea bass, and lobster (Clay et al. 2008).

530.2.4. Block Island

1. Block Island has a small commercial fishing presence; in 2009, there were 10 federally licensed fishing vessels listed as having their home port in Block Island (NMFS 2010e).

[9] Data are not available on what percentage of the vessels in Newport harbor might engage in recreational fishing activities.

Similar to Sakonnet Point, the most valuable commercial species landed at Block Island in recent years have included monkfish, summer flounder, scup, black sea bass, and lobster (Clay et al. 2008).

2. Block Island is an important port for recreational fishing, with at least seven charter boats listed for the island. There are several recreational fishing tournaments held out of Block Island each year (Clay et al. 2008). Consultation with Rhode Island recreational fishing stakeholders has indicated that many recreational fishing vessels, including charter boats, docked at other ports in Rhode Island frequently fish the waters around Block Island.

530.2.5. Other Commercial and Recreational Fishing Ports

1. While Rhode Island does have several other ports involved in fisheries, the vast majority of commercial fishing activity out of other ports takes place within Narragansett Bay (e.g. quahogging) and is thus outside of the Ocean SAMP waters. However, there are a few other fishing vessels scattered around Narragansett Bay that may make use of or pass through the Ocean SAMP area. North Kingstown, Tiverton, and Jamestown all have a small number of lobster boats that may fish within Rhode Island Sound. Warren has a couple of hydraulic dredge clam boats that fish for ocean quahogs in the waters south of the Ocean SAMP area at around 35 to 40 fathoms; if quahog populations rebound in Rhode Island and Block Island Sounds, they may again fish this area.

2. In the Davisville area of North Kingstown there are two large freezer trawlers owned by Sea Freeze that target squid, herring, mackerel, and butterfish within the Ocean SAMP area as well as further offshore. The most valuable species landed in North Kingstown in recent years have included squid and mackerel. Port-specific landings value data are not available for North Kingstown as this information is kept confidential by NMFS in order to protect the privacy of the one major company located in this port (Clay et al. 2008).

3. Numerous other ports throughout the state serve an important role for recreational fisheries, as recreational vessels docked at any location throughout Rhode Island may occasionally or frequently fish within the Ocean SAMP area. As noted above, the majority of the state's recreational fishing party and charter boats are based out of Point Judith and, to a lesser extent, Newport. Point Judith and Newport also provide dockage and support services for numerous private recreational fishing vessels that operate in the Ocean SAMP area. In addition, many private recreational fishing vessels that operate in the Ocean SAMP area are based in the ports of Sakonnet Point and Block Island (discussed above), as well as Charlestown, Westerly, Wickford, Warwick, and East Greenwich (R. Hittinger, pers. comm. a).

530.3. Description of Rhode Island's Fisheries

1. For the purposes of the Ocean SAMP, fisheries have been divided up into commercial and recreational fisheries. Commercial fisheries is further divided into two categories – mobile gear and fixed gear fisheries. Mobile gear fisheries are those in which fishing gear such as an otter trawl is deployed while in motion aboard a vessel, while fixed gear fisheries employ static gear such as lobster pots, fish pots, and gillnets, which are set in one location and then retrieved later. The term recreational fisheries is used here to describe both recreational anglers and recreational fishing aboard private boats and party and charter boats. See Section 530.7 below for further discussion.

530.3.1. Bottom Types, Seasonal Migrations, and Fishing

1. Commercial and recreational fishing activity can be further characterized by the fisherman's target species and the benthic features, or bottom types, which may present the fishermen with the best possible harvest of those species. Many migrating bottom species congregate in areas of habitat change, known as transition zones or "edges," whenever possible because they can exploit the benefits of both habitats in order to find food or shelter, or for reproductive purposes. Transition zones include, but are not limited to, the edges that represent changes from mud to sand, sand to gravel, gravel to boulders, and boulders to ledge. In the Ocean SAMP area, many targeted species make seasonal migrations from offshore to inshore, and back offshore; each transition zone provides a point in that migration where fish can stop and exploit the benefits of both habitat types. Fishermen know these seasonal migratory patterns as well as the tendency of fish to congregate in these transition zones, and concentrate their fishing effort accordingly.

2. These migratory patterns are particularly pronounced for species such as lobster that are targeted by fixed gear fishermen (both lobstering and gill-netting), and so transition zones such as moraines and moraine edges are especially important to these fishermen. Transition zones of other bottom types can be equally important to fixed gear fishermen following fish on their seasonal migrations. Mobile gear fishermen such as bottom trawlers also follow fish on their seasonal migrations and seek to exploit transition zones, although the nature of bottom trawling limits the types of bottom that can be trawled, and so these fishermen only exploit transition zones that are conducive to this gear type. In the Ocean SAMP area, most bottom trawling takes place on smooth bottom types (e.g. sand, mud, and gravel), although some trawlers with rockhopper gear occasionally trawl in areas with boulders. See Chapter 2, Ecology of the Ocean SAMP Region for further discussion of moraines and other benthic features, as well as a broader discussion of the geology and benthic ecology of the Ocean SAMP area.

530.3.2. Mapping Fisheries Activity Areas

1. Commercial and recreational fishing takes place throughout most of the Ocean SAMP area. A two-part approach was taken to map fishing activity for inclusion in the Ocean SAMP document. First, commercial and recreational fishing activity was characterized and mapped through qualitative input from fishermen. In a series of interviews and meetings that took place in 2008-2009, Rhode Island commercial and recreational

fishermen were asked to indicate, on nautical charts, areas where they fish (see Appendix B for detailed methodology). Second, commercial fishing activity was characterized and mapped through analysis of quantitative fisheries-dependent data collected from 1998 - 2008. As a means of monitoring fisheries activity, NMFS requires commercial fishermen with federally-permitted groundfish, scallop, and monkfish vessels to submit one Vessel Trip Report (VTR) for each fishing trip. On each report, the fisherman reports the location of that trip as one set of coordinates (latitude/longitude or Loran). These maps were created by aggregating the VTRs of all RI-based vessels using these gear types from 1998 – 2008 as a set of point data, and then creating a density plot using a 1-minute by 1-minute grid overlay to determine the relative density of fishing trips. Darker-shaded areas represent the areas with a higher density of fishing activity. Although these VTR maps are based on quantitative data, they must still be viewed with caution. VTR location information is only an approximation of fishing activity because the fisherman self-reports only one set of coordinates for the trip, despite the fact that one trip may include multiple tows that take place in many different locations across a much wider area.

2. Figure 5.17 shows total fishing activity based on qualitative input from fishermen. Figure 5.18 shows total commercial mobile gear and gillnet fishing based on NMFS VTR data. Additional maps are provided in the subsequent sections below to illustrate fishing activity by gear type. See Appendix B for a detailed methodology and additional maps. Together, these mapping processes resulted in a series of maps that create an accurate approximation of many types of Ocean SAMP area fishing activity. However it is important to note that fishing is a very dynamic activity and as such is inherently difficult to capture through a static mapping exercise. Fishing effort varies widely throughout the year, and from year to year, depending on the individual fisherman, vessel type, target species, regulatory environment, and market demand. In addition, fishing effort varies in location and intensity throughout the year because fishermen follow their target species on their seasonal migrations. A number of the targeted species move within the Ocean SAMP area, while others move into and out of the Ocean SAMP area, throughout the course of a year.

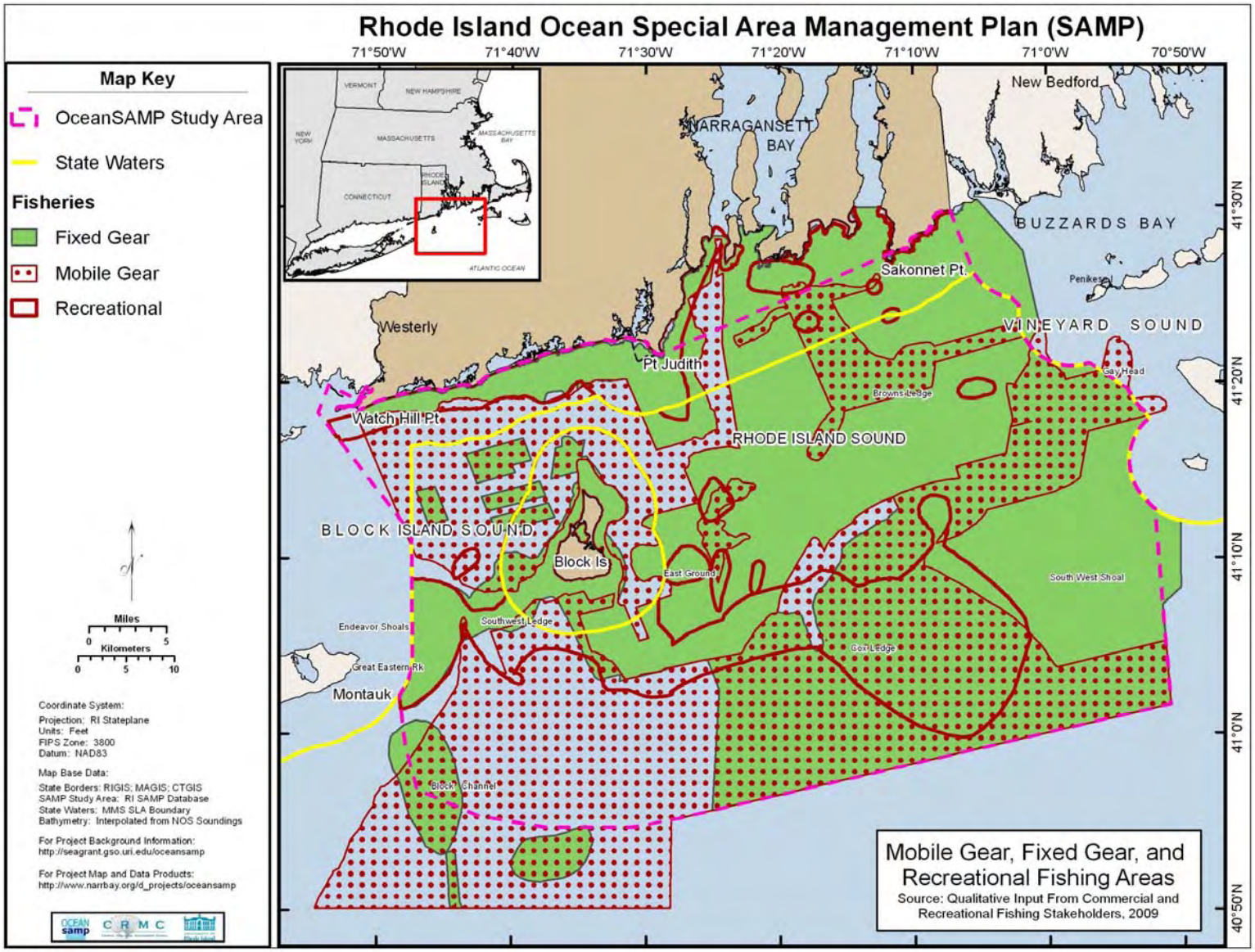


Figure 5.17. Mobile gear, fixed gear, and recreational fishing areas based on qualitative input.

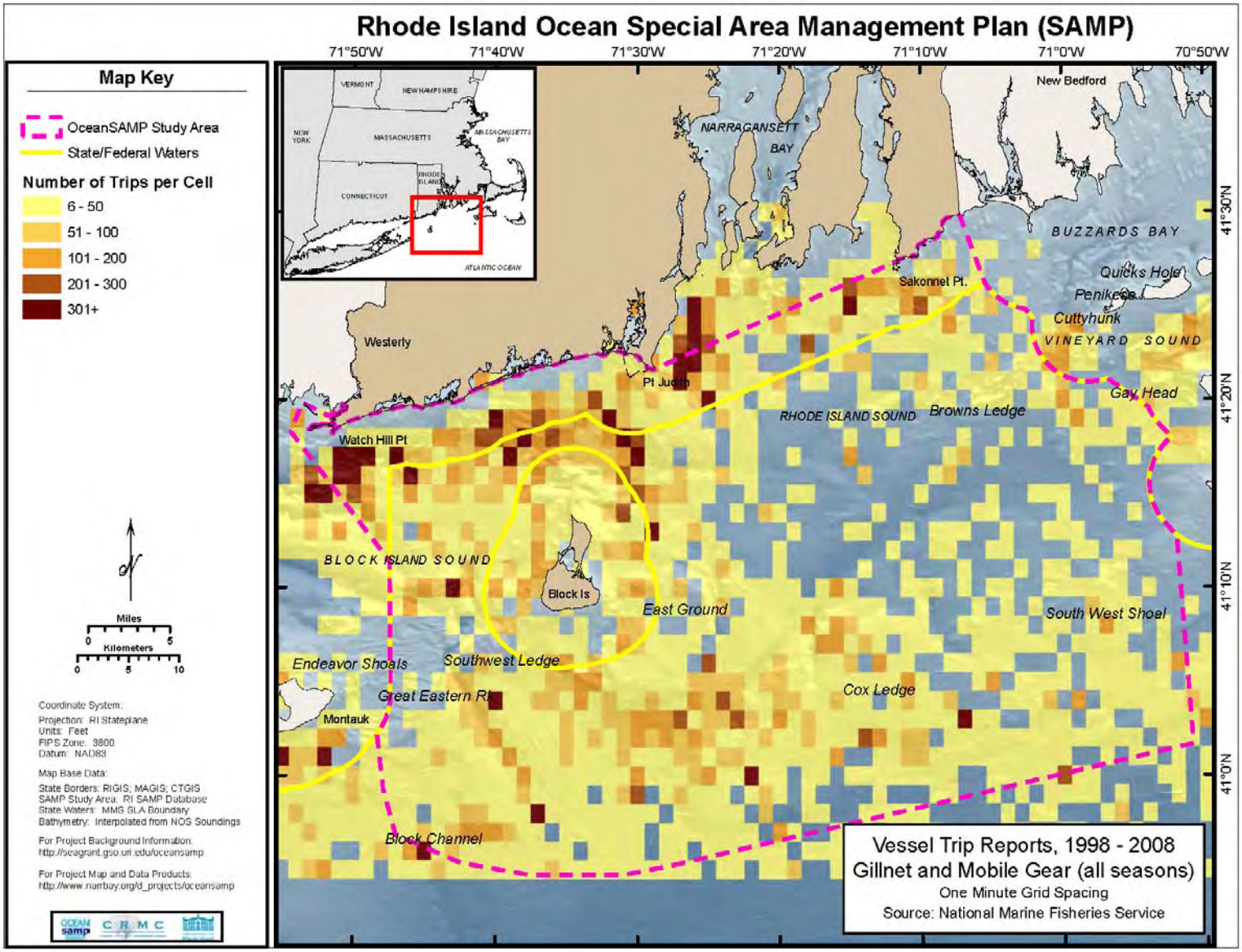


Figure 5.18. Commercial mobile gear and gillnet fishing areas based on NMFS Vessel Trip Reports, 1998 - 2008.

530.4. Contemporary Commercial Mobile Gear Fisheries

530.4.1. Description

1. Commercial fishing activity in the Ocean SAMP area can mostly be divided into two categories – mobile gear and fixed gear fisheries. Mobile gear fisheries are those in which the fishing gear is being actively employed from a vessel while capturing the fish, as opposed to fixed (static) gear, which is set in one location to fish and then retrieved later (for more on fixed gear fisheries, see Section 530.5). Commercial mobile gear fishing methods employed in fisheries in the Ocean SAMP area include: bottom and mid-water trawling (also called dragging), dredging, purse seining, and rod and reel fishing. While the majority of mobile gear fishing taking place within the Ocean SAMP area is by Rhode Island-based vessels, fishing vessels from other states, including Massachusetts, Connecticut, and New York, will frequently transit through or fish in the federal waters of the Ocean SAMP area.

2. One of the most common and traditional methods for fishing within the Ocean SAMP area is otter trawling (commonly referred to as dragging), in use in Rhode Island since the 1930s. Trawlers fishing within the Ocean SAMP area are primarily either day boats or short-trip boats (at sea from one to three days). Species traditionally targeted by the trawlers in the Ocean SAMP area include squid, butterfish, fluke, scup, hake, cod, monkfish, yellowtail flounder, and winter flounder. Rhode Island fishermen, more so than fishermen from elsewhere in New England, typically fish for "mixed species" throughout much of the year, including squid, butterfish, and scup, or whiting (silver hake), all of which are fished with an otter trawl. Squid are at present the most important fishery to Rhode Island fishermen, both in terms of landings value and landed weight (see Section 530.6 for further discussion). Most of the fishing for squid takes place outside the Ocean SAMP area by large trawlers. However, from May through September or October, squid can often be found within the northern Ocean SAMP area in the waters south of Point Judith and Charlestown. Many of the smaller inshore draggers as well as some larger vessels from Rhode Island ports will focus on this fishery during these months, and vessels will sometimes come from Massachusetts to target these squid as well. During those months, this is an important fishery for the dayboat fleet. Whiting, or silver hake, is another important fishery for Rhode Island fishermen, who will fish for it all year long, frequently within the southern portions of the Ocean SAMP area. Many of the Rhode Island fishermen will target groundfish species when available. Most of the groundfish targeted in the Ocean SAMP area are flounder and are harvested from the smoother bottom areas south of Block Island. Codfish catches within the Ocean SAMP area have been improving in recent years and are a late winter/early spring target. Skates are both a directed fishery and bycatch. In the Ocean SAMP area, most bottom trawling takes place on smooth bottom types (e.g. sand, mud, and gravel), although some trawlers with rockhopper gear occasionally trawl in areas with boulders.

3. Rhode Island mid-water trawlers will fish in the Ocean SAMP area for herring and mackerel in the fall and winter months; purse seine vessels are also used to target herring. Other vessels from ports including Massachusetts, Maine, New Jersey, and North Carolina come to Rhode Island Sound just for this season. When the herring are close to

shore, a number of vessels will participate in this fishery. This is an important fishery for small boats in Rhode Island during the months these fish are in the area.

4. A number of vessels with general access scallop permits, which limit them to 400 pounds of scallops per day, may fish in the Ocean SAMP area. Scalloping is traditionally done using a dredge towed behind the vessel. These boats make up a small percentage of total sea scallop landings for Rhode Island, but this is an important fishery for vessels without limited access permits for scallop. This fishery is generally restricted to smaller boats that take day trips to the southern part of the Ocean SAMP area.

5. There is a commercial rod and reel harvest in the Ocean SAMP area for striped bass, tuna, scup, and fluke. According to the RIDEM state license reports, vessels with commercial rod and reel permits operating in statistical area 539 made 8,304 trips in 2007, 9,699 trips in 2008, and 8,882 in 2009. In all three years commercial rod and reel trips represented the largest number of fishing trips made by any single gear type; see Table 5.35 (RIDEM 2010b).

530.4.2. Mobile Gear Fisheries Activity Areas

1. Mobile gear fishing takes place throughout most of the Ocean SAMP area. Characterizing the locations of fishing activity requires both qualitative input from fishermen as well as analysis of NMFS fisheries dependent datasets. Together, these data create an accurate approximation of mobile gear fishing activity. However it is important to note that fishing is a very dynamic activity and as such is inherently difficult to capture through a static mapping exercise. Fishing effort varies widely throughout the year, and from year to year, depending on the individual fisherman, vessel type, target species, regulatory environment, and market demand. In addition, fishing effort varies in location and intensity throughout the year because fishermen follow their target species on their seasonal migrations. A number of the targeted species move within the Ocean SAMP area, while others move into and out of the Ocean SAMP area throughout the course of a year.

2. Figure 5.19 shows mobile gear fishing areas based on qualitative input from fishermen. See Appendix B for the methodology used to develop these maps. All of the areas shown as mobile gear fishing areas are used at some point in the course of the fishing season. Because of the dynamic nature of fishing described above, all mobile gear fishing areas are not in use all of the time. This does not, however, diminish the importance of the use of these areas.

3. Figures 5.20, 5.21 and 5.22 show bottom trawling, scallop dredging, and mid-water trawling areas based on NMFS Vessel Trip Report data. As noted above, bottom trawling and scallop dredging are the two main types of mobile gear fishing in the Ocean SAMP area. As a means of monitoring fisheries activity, NMFS requires commercial fishermen with federally-permitted groundfish, scallop, and monkfish vessels to submit one Vessel Trip Report (VTR) for each fishing trip. On each report, the fisherman reports the location of that trip as one set of coordinates (latitude/longitude or Loran). These maps were created by aggregating the VTRs of all RI-based vessels using these gear types from

1998 – 2008 as a set of point data, and then creating a density plot using a 1-minute by 1-minute grid overlay to determine the relative density of fishing trips. Darker-shaded areas represent the areas with a higher density of fishing activity. Although these VTR maps are based on quantitative data, they must still be viewed with caution. VTR location information is only an approximation of fishing activity because the fisherman self-reports only one set of coordinates for the trip, despite the fact that one trip may include multiple tows that take place in many different locations across a much wider area. See Appendix B for a more detailed discussion of data sources and methodology.

4. A comparison of Figure 5.19 (which represents both methods of mobile gear fishing) with Figures 5.20-5.22 reveals that these maps create a relatively consistent depiction of mobile gear fishing in the Ocean SAMP area. Bottom trawling is concentrated in the waters between Block Island and the mainland, as well as the waters south and southeast of Block Island. Scallop dredging is concentrated in the furthest offshore parts of the Ocean SAMP area, including waters south and southwest of Block Island and the Cox Ledge area.

5. Mobile gear fishermen follow their target species on their seasonal migrations and work the areas with bottom type suitable to their gear types. For example, while much dragging takes place in areas with soft bottom, some scallop dredging takes place in rockier areas. One fishing area of particular importance is Cox Ledge, which is used by mobile gear as well as fixed gear and recreational fishermen. Distinct polygons shown within the shaded mobile gear areas represent areas that are only used by mobile gear fishermen during certain parts of the year; these areas are used during other times of the year by fixed gear fishermen through informal cooperative agreements between fishermen. See Section 530.5 for further discussion of fixed gear fisheries, and Section 530.7 for further discussion of recreational fisheries.

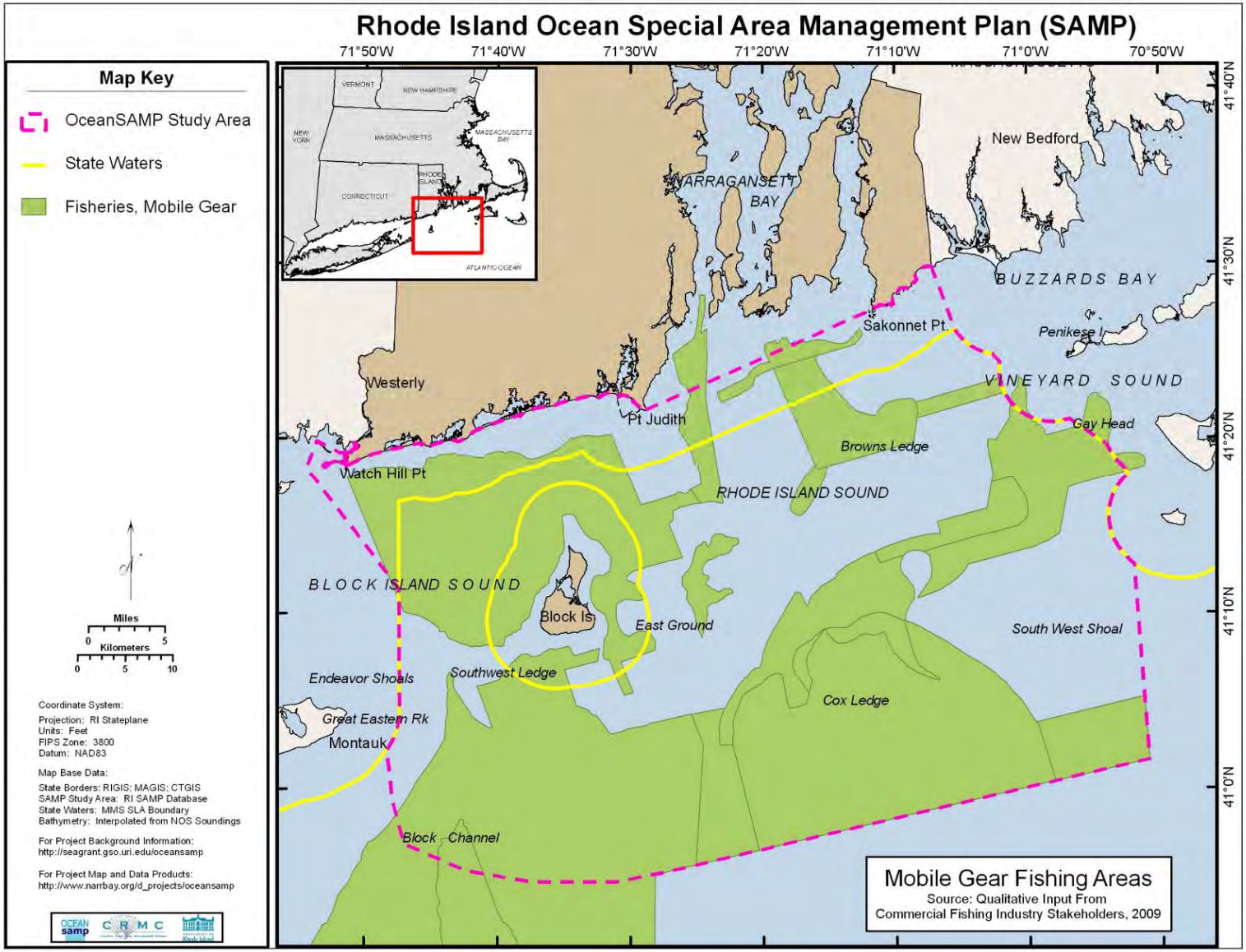


Figure 5.19. Mobile gear fishing areas based on qualitative input.

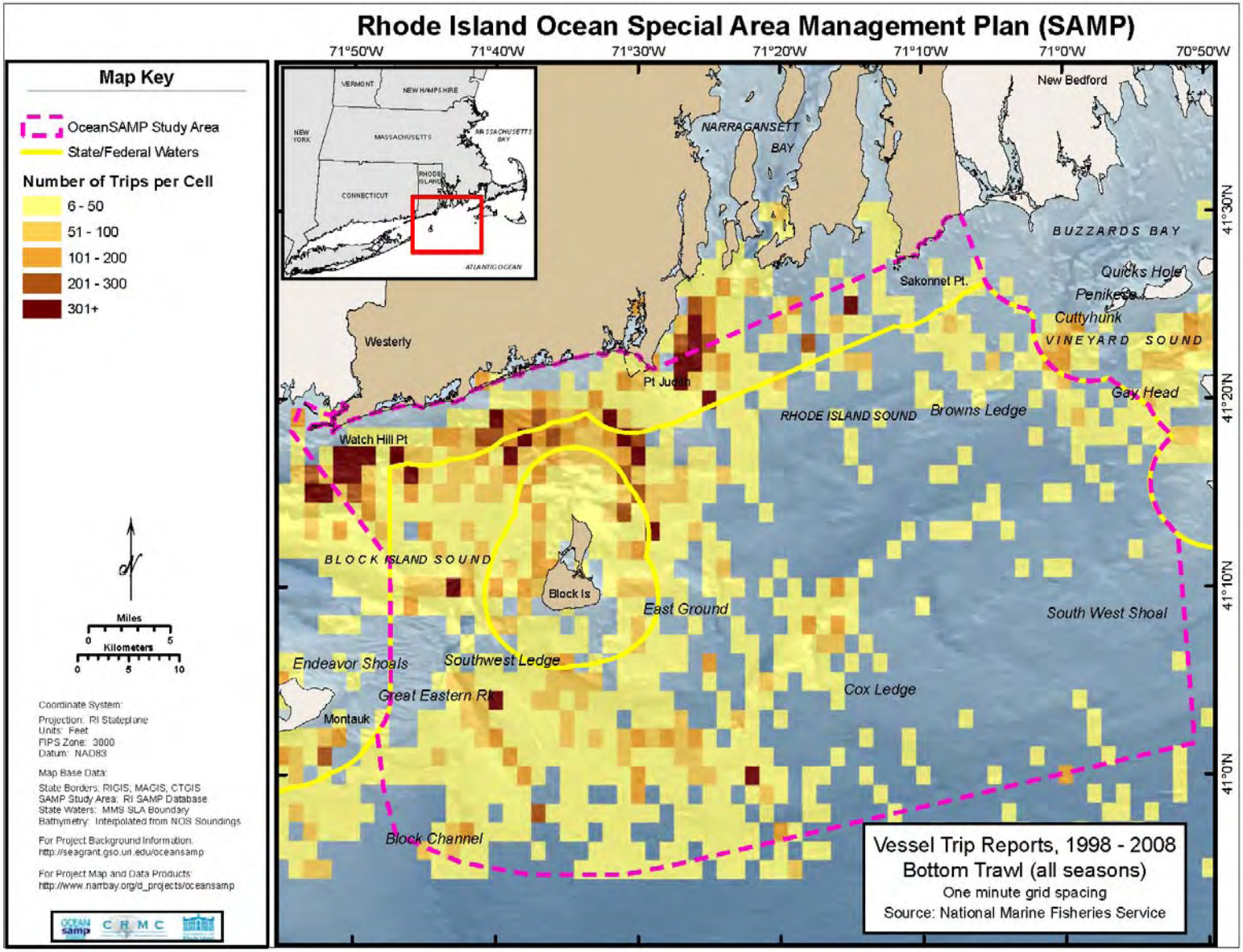


Figure 5.20. Bottom trawling areas based on NMFS Vessel Trip Reports, 1998 - 2008.

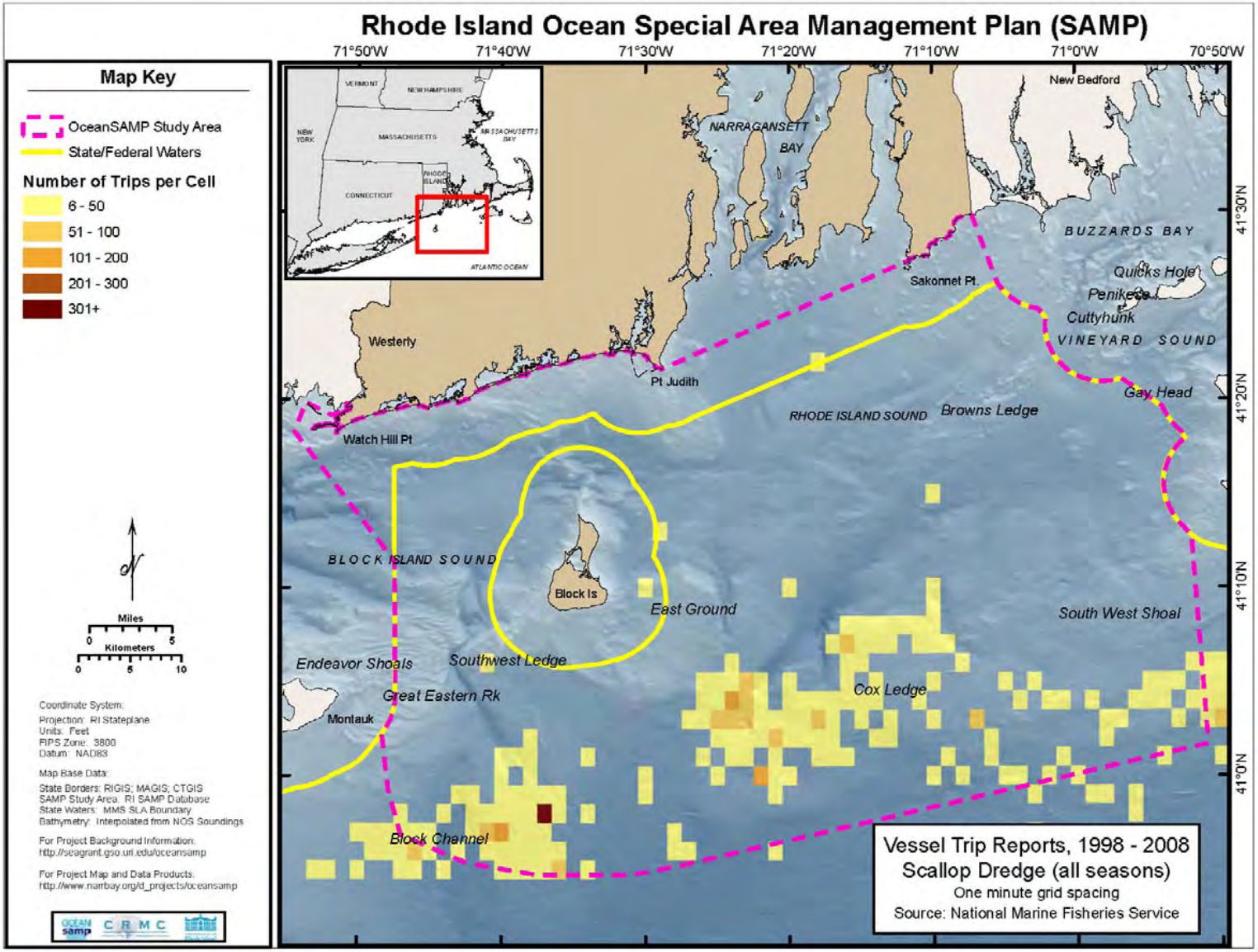


Figure 5.21. Scallop dredging areas based on NMFS Vessel Trip Reports, 1998 - 2008.

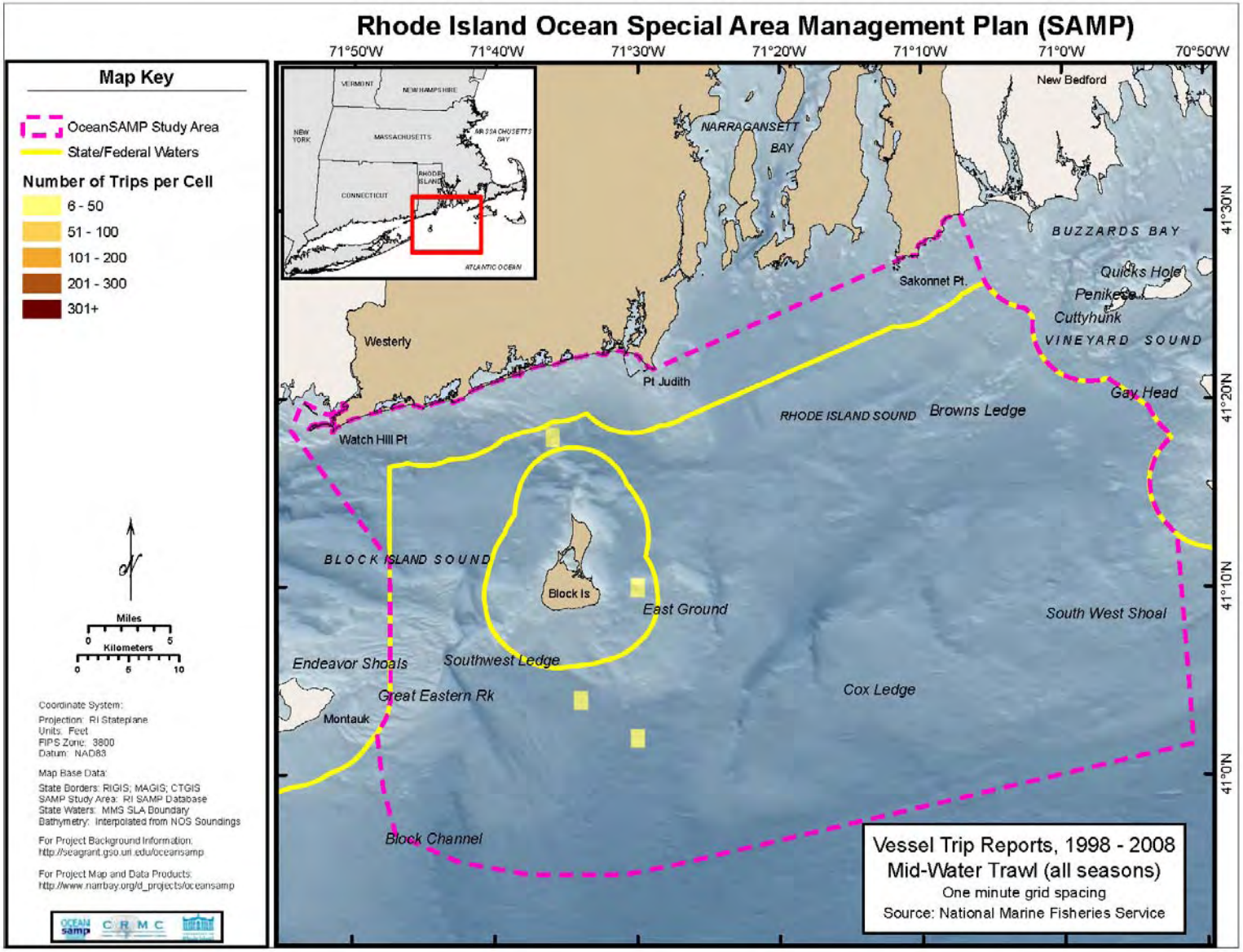


Figure 5.22. Mid-water trawling areas based on NMFS Vessel Trip Reports, 1998 - 2008.

530.5. Contemporary Commercial Fixed Gear Fisheries

530.5.1. Description

1. Rhode Island has a number of significant fixed gear commercial fisheries. These include gillnetting as well as trap fisheries, which includes the use of lobster pots, fish pots, and floating fish traps (which are used within state waters). These fisheries are primarily near shore fisheries, conducted on day trips using smaller vessels, usually with a crew of only one or two fishermen. Because these fisheries tend to occur near shore, the vast majority take place within the Ocean SAMP area. Also, because of the nearshore nature of these fisheries, the majority of fishermen and vessels participating in this fishery are based out of Rhode Island.

2. Fishing for lobster using traps is common throughout the Ocean SAMP area; most lobsters landed within Rhode Island are caught in this area. Lobster fishing is generally seasonal, and takes place primarily from the spring through late December. Lobster fishing within the Ocean SAMP area is commonly done by small boats with a crew of one or two, while offshore lobstermen will travel further out beyond the Ocean SAMP area to fish the canyons. Lobster boats are permitted to set up to 800 traps, and typically a boat will set a few dozen strings of 15-25 traps each. Before 1950, lobsters were primarily taken as incidental catches in trawls for demersal finfish. Of lobsters landed in Rhode Island, 98.5% are taken with traps, and the remaining 1.5% by otter trawl (DeAlteris et al. 2000).

3. Rhode Island has a significant floating fish trap fishery concentrated in state waters. Figure 5.23 shows currently active or permitted fish trap locations. Most floating fish traps are located off Sakonnet and Newport, and off of Narragansett and Pt. Judith. It should be noted that there are additional possible fish trap locations that are identified in RI DEM regulations but not presently active.[10] Floating fish trap catch includes scup, squid, striped bass, and other migratory fish. Floating fish trap fishermen would be seriously affected if these targeted fish were diverted to other areas.

4. Gillnets make up an important segment of the state's fixed gear fisheries. Gillnet fishermen target a number of species including groundfish, scup, bluefish, fluke, and skate. Gillnets are also the primary gear used in the monkfish fishery; a large majority of the Rhode Island monkfish fishery takes place within the Ocean SAMP waters. There are a number of gillnet fishermen out of Sakonnet Point who fish primarily within the Ocean SAMP area.

[10] See RI Marine Fisheries Statutes and Regulations, Part XIV – Fish Traps, online at http://www.dem.ri.gov/pubs/regs/regs/fishwild/rimf14.pdf , for further information on fish trap locations.

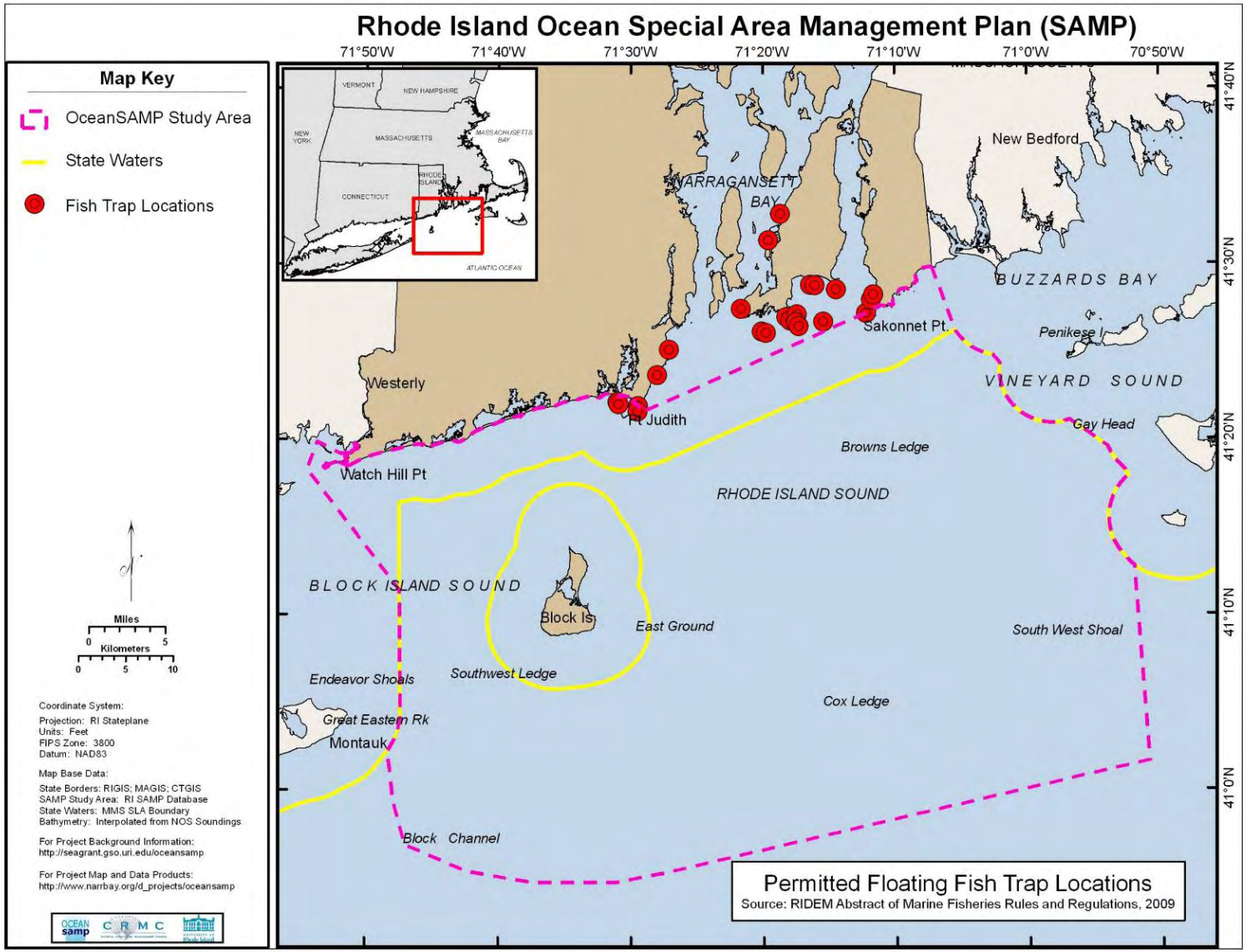


Figure 5.23. Currently active or permitted floating fish trap areas.

530.5.2. Fixed Gear Fishing Activity Areas

1. Fixed gear fishing, which here includes fishing with lobster pots, fish pots, and gillnets, also takes place throughout most of the Ocean SAMP area. As noted above in section 530.4.2, characterizing the locations of fishing activity requires both qualitative input from fishermen as well as analysis of NMFS fisheries dependent datasets. Fixed gear fisheries are similar to mobile gear fisheries in that fishing effort varies widely throughout the year, and from year to year, depending on the individual fisherman, vessel type, target species, and regulatory environment. In addition, fishing effort varies in location and intensity throughout the year because fishermen follow their target species on their seasonal migrations.

2. Figure 5.24 shows fixed gear fishing areas based on qualitative input from fishermen. See Appendix B for the methodology used to develop these maps. All of the areas shown as fixed gear fishing areas are used at some point in the course of the fishing season, though not all fixed gear fishing areas are not in use all of the time. One fishing area of particular importance is Cox Ledge, which is used by fixed gear as well as mobile gear and recreational fishermen. Distinct polygons shown within the shaded fixed gear areas represent areas that are only used by fixed gear fishermen during certain parts of the year; these areas are used during other times of the year by mobile gear fishermen through informal cooperative agreements between fishermen. See Section 530.4 for further discussion of mobile gear fisheries, and Section 530.7 for further discussion of recreational fisheries.

3. Figure 5.25 shows gillnetting areas based on NMFS Vessel Trip Report data. As noted above, gillnetting and lobstering are the two main types of fixed gear fishing in the Ocean SAMP area. NMFS requires commercial fishermen with federal-permitted vessels to submit one Vessel Trip Report for each fishing trip; each VTR includes self-reported location information about the trip. It is important to note that no Vessel Trip Report data, or equivalent data, are available for lobstering. NMFS does not collect VTRs from lobstermen because the lobster fishery is managed by the ASMFC (see Section 510.2.1). Whereas RIDEM collects logbook data from lobstermen, these data include location information reported by statistical area, not by latitude/longitude or Loran, which do not allow for a fine-resolution analysis of lobstering activity. See Section 530.3.2 above and Appendix B for further discussion of data sources and methodology.

4. In Figure 5.25, darker-shaded areas represent the areas with a higher density of gillnetting activity. This map reveals that some gillnetting is concentrated in a couple of areas just outside the mouth of Narragansett Bay, whereas other gillnetting activity is concentrated much further offshore in the waters southeast and east of Block Island and in the Cox Ledge area. It is difficult to accurately compare Figures 5.24 and 5.25 given the absence of VTR lobstering data.

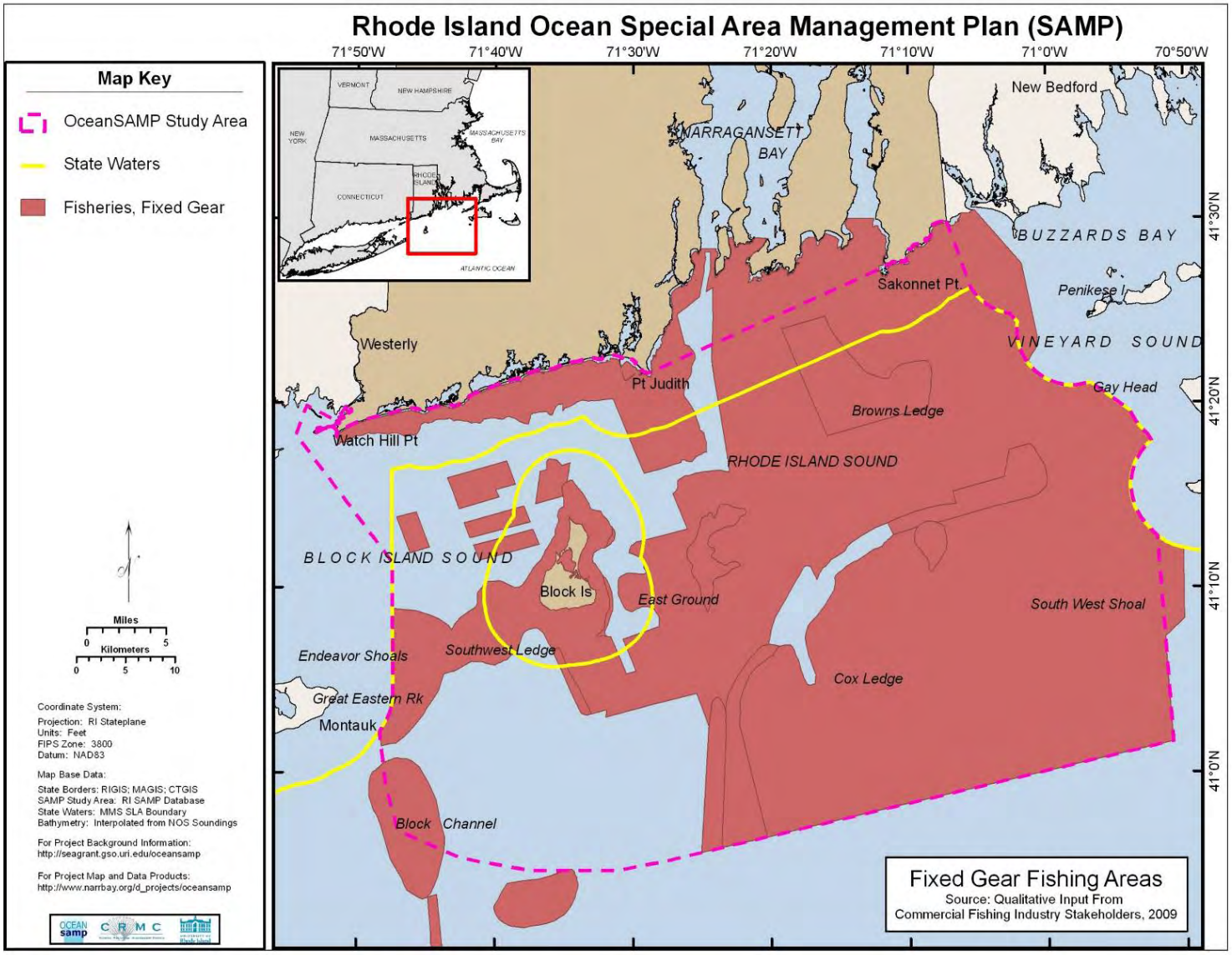


Figure 5.24. Fixed gear fishing areas based on qualitative input.

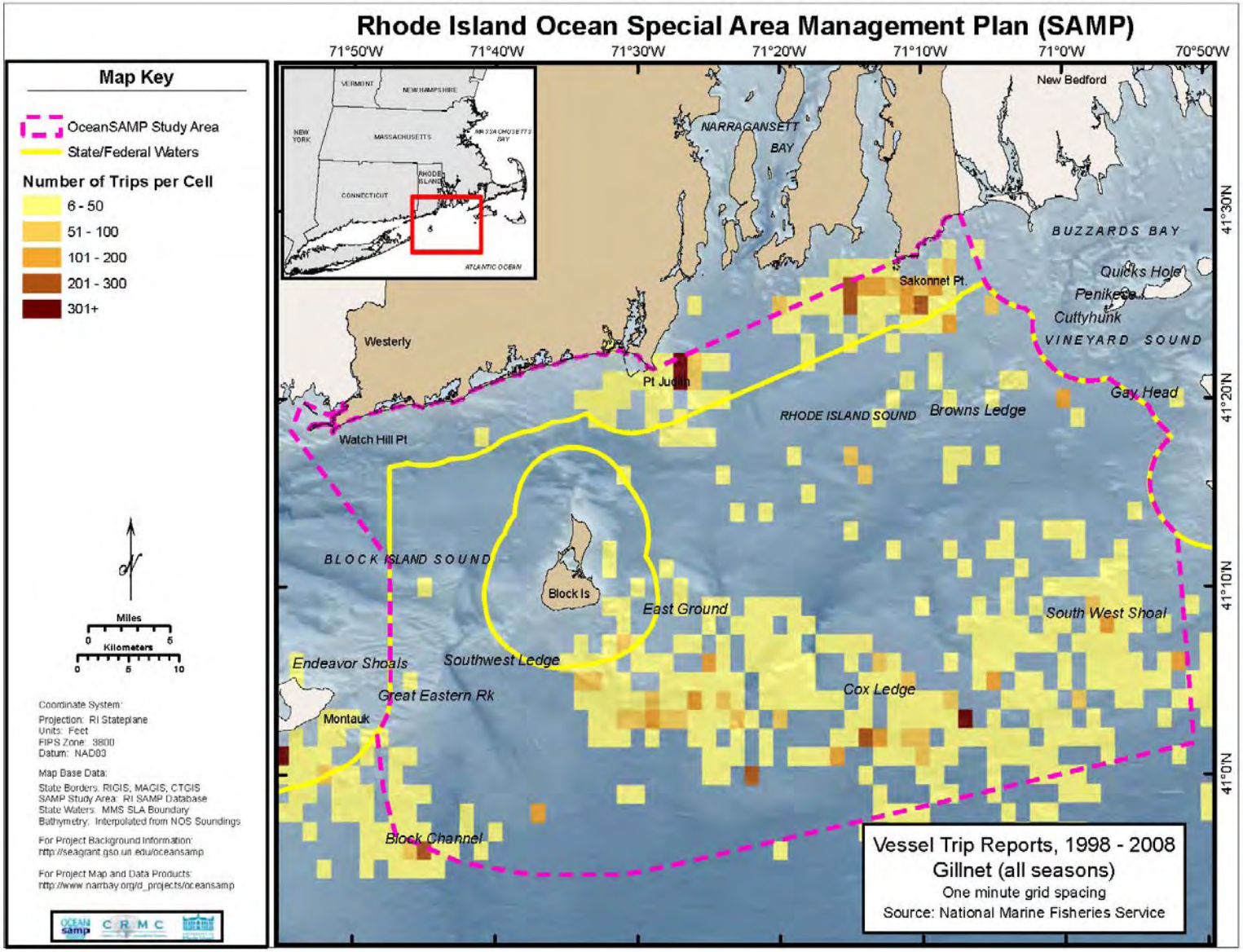


Figure 5.25. Gillnetting areas based on NMFS Vessel Trip Reports, 1998 - 2008

530.6. Rhode Island Commercial Fisheries Effort and Landings

530.6.1. Rhode Island Commercial Fisheries Landings

1. Commercial fisheries landings data presented below are provided by the National Marine Fisheries Service, Fisheries Statistics Division. Landings data for the state of Rhode Island is dealer-reported; seafood dealers within the state report twice per week to the Standard Atlantic Fisheries Information System (SAFIS) on the pounds and ex-vessel dollar value of landings sold at each dealer.[11] These data encompass all landings taking place at Rhode Island ports. Vessels based in Rhode Island may at times land their catch outside of the state, in New Bedford, for example. Likewise, some of the landings in Rhode Island may be from vessels based outside of the state; during the winter months, boats from New Jersey and other Mid-Atlantic states will fish in Rhode Island waters, and land their catch here. Landings data do not include where the catch was actually harvested. Thus, it is not possible to differentiate among catch from within the Ocean SAMP area or outside of the Ocean SAMP area.

2. Much of the effort data provided here, given as the numbers of trips taken by vessels and the number of trips on which vessels caught certain species, are provided only for Rhode Island state fishing licenses. This means these data include only vessels targeting certain species managed at the state level, such as lobster and herring, or vessels fishing only within state waters (within three miles of shore). Thus, much of the activity taking place within the Ocean SAMP area, including fishing done through federally-permitted vessels and fishing done by out-of-state vessels, is not encompassed in this effort data provided below. In lieu of effort data for federal waters, included below are federal data on the pounds and dollar value of Rhode Island landings, broken down by gear type, which provide some insight into fishing effort. These landings data reflect federally permitted vessels which land their catch in Rhode Island.

3. The top fishery in Rhode Island averaged for the years 1999-2008 by weight was Atlantic herring, followed by *loligo* (longfin) squid and Atlantic mackerel (see Table 5.34).[12] The squid fishery in Rhode Island has been and continues to be an important and profitable fishery in the state. Herring and mackerel are taken in midwater trawls, and are part of an important fishery occurring within the Ocean SAMP area. The next species by weight is skates, which are taken in large numbers but are often considered a trash fish or used as bait (little skate and winter skate are also listed individually; the skates category includes both species, and if the three are combined, the average landings are more than those for mackerel). Of all Rhode Island commercial fisheries, finfish caught in Narragansett Bay account for only 5%, meaning the remaining 95% of finfish landings were caught in the Ocean SAMP area or beyond. Likewise, Narragansett Bay accounts for about 10-25% of

[11] The Standard Atlantic Fisheries Information System (SAFIS) is an electronic reporting system developed by the National Marine Fisheries Service (NMFS) and the Atlantic Coastal Cooperative Statistics Program.

[12] "Other shellfish" is the term used by NMFS to report some shellfish landings. NMFS landings data are sometimes classified broadly in this way (finfish or shellfish) in order to protect the confidentiality of dealers purchasing the species. See NMFS Fisheries Statistics Division. 2009. "Data Caveats." Online at http://www.st.nmfs.noaa.gov/st1/commercial/landings/caveat.html.

all lobster landings, leaving the remaining 75-90% to the Ocean SAMP area and further offshore (DeAlteris et al. 2000).

Table 5.34. Top landed species in Rhode Island by weight for 1999-2008.[13] (ACCSP 2010)
Note: Important species in the Ocean SAMP area are italicized. Average dollar value calculated based on each year's nominal landings value, which do not account for inflation.

Species	**Average Pounds 1999-2008**[14]	**Average Dollar Value 1999-2008**	**Number of Years Landed**
Herring, Atlantic	19,426,667	$1,637,564	10
Squid, Longfin inshore	18,426,084	$14,018,015	10
Mackerel, Atlantic	7,623,878	$1,921,248	10
Skates	6,455,051	$627,053	10
Hake, Silver	6,290,385	$2,543,255	10
Goosefish (Monkfish)	5,148,746	$4,921,970	10
Lobster, American	4,340,526	$19,113,035	10
Scup	3,131,617	$2,381,122	10
Squid, Northern shortfin	3,089,620	$882,507	6
Skate, Little	2,374,344	$196,849	6
Flounder, Summer	2,158,836	$4,660,022	10
Butterfish	1,588,842	$680,673	10
Flounder, Winter	1,173,497	$1,599,963	10
Crab, Atlantic rock	952,517	$489,484	8
Flounder, Yellowtail	941,055	$1,067,699	10
Crab, Jonah	892,223	$471,098	10
Quahog, Northern	890,965	$5,675,621	10
Hake, Red	797,796	$191,042	10
Scallop, Sea	719,914	$4,847,792	10
Crab, Red	608,303	$452,849	6
Bluefish	553,631	$185,447	10
Crabs, Brachyura	484,718	$242,149	7
Cod, Atlantic	454,363	$511,321	10
Dogfish, Spiny	409,938	$71,208	10
Haddock	336,594	$369,411	10
Menhadens	326,289	$38,916	10
Bass, Black sea	315,991	$758,978	10
Skate, Winter	217,973	$42,254	6
Bass, Striped	202,593	$540,829	10
Surfclam, Atlantic	181,261	$6,272	1
Flounder, Witch	168,881	$211,958	10
Plaice, American	119,517	$118,531	10
Clam, Soft	102,742	$711,869	10

[13] Includes all species landed in Rhode Island for 1999-2008, both within and outside of the Ocean SAMP area, where average pounds landed over the ten year period is more than 100,000. Some species included here are primarily caught outside of the SAMP area.
[14] Shellfish weights are expressed in meat weights

5. Figures 5.26 and 5.27 below show average landings of species both by pounds and by value for all of Rhode Island for the years 1999-2008. Landings by pounds are dominated by Atlantic herring, followed by longfin (*loligo*) squid and mackerel. The most valuable landings for this period, on the other hand, were of lobster, followed by longfin squid. See Section 540.1 for more on the value of commercial fisheries landings within Rhode Island.

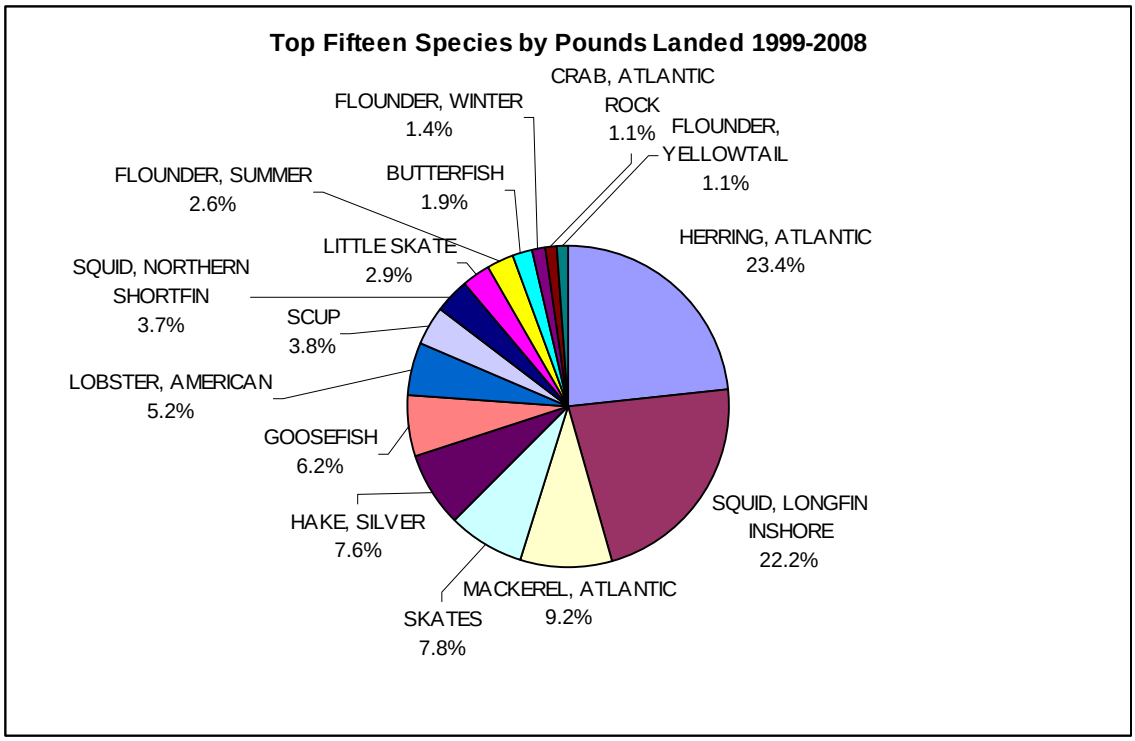


Figure 5.26. Top landed species in Rhode Island by weight, 1999-2008 (includes fish caught both within and outside of the Ocean SAMP area). (ACCSP 2010)[15]

[15] Shellfish weights are expressed in meat weights

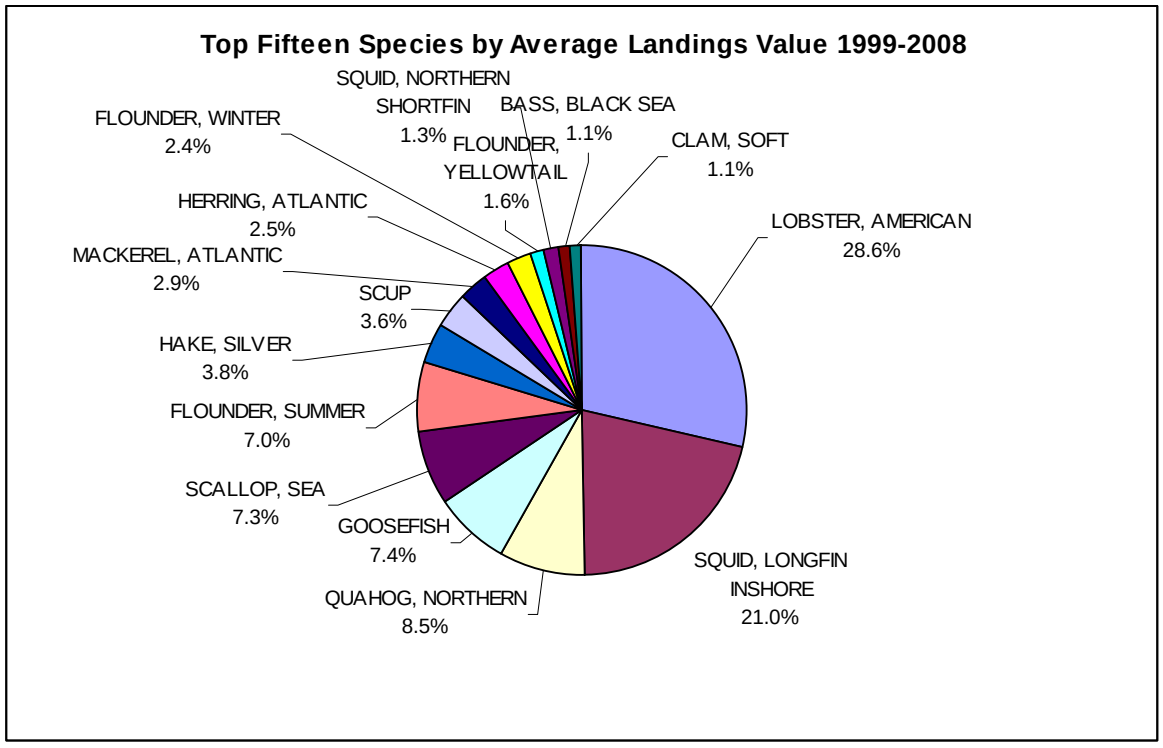


Figure 5.27. Top landed species in Rhode Island by dollar value averaged for 1999-2008 (includes fish caught both within and outside of the Ocean SAMP area). (ACCSP 2010)
Note: Average dollar value calculated based on each year's nominal landings value, which do not account for inflation.

5. Figure 5.28 below shows a longer-term time series of total commercial fisheries landings by weight from 1970 - 2008. Landings increased to a high in the early and mid-1990s, and have been declining since then.

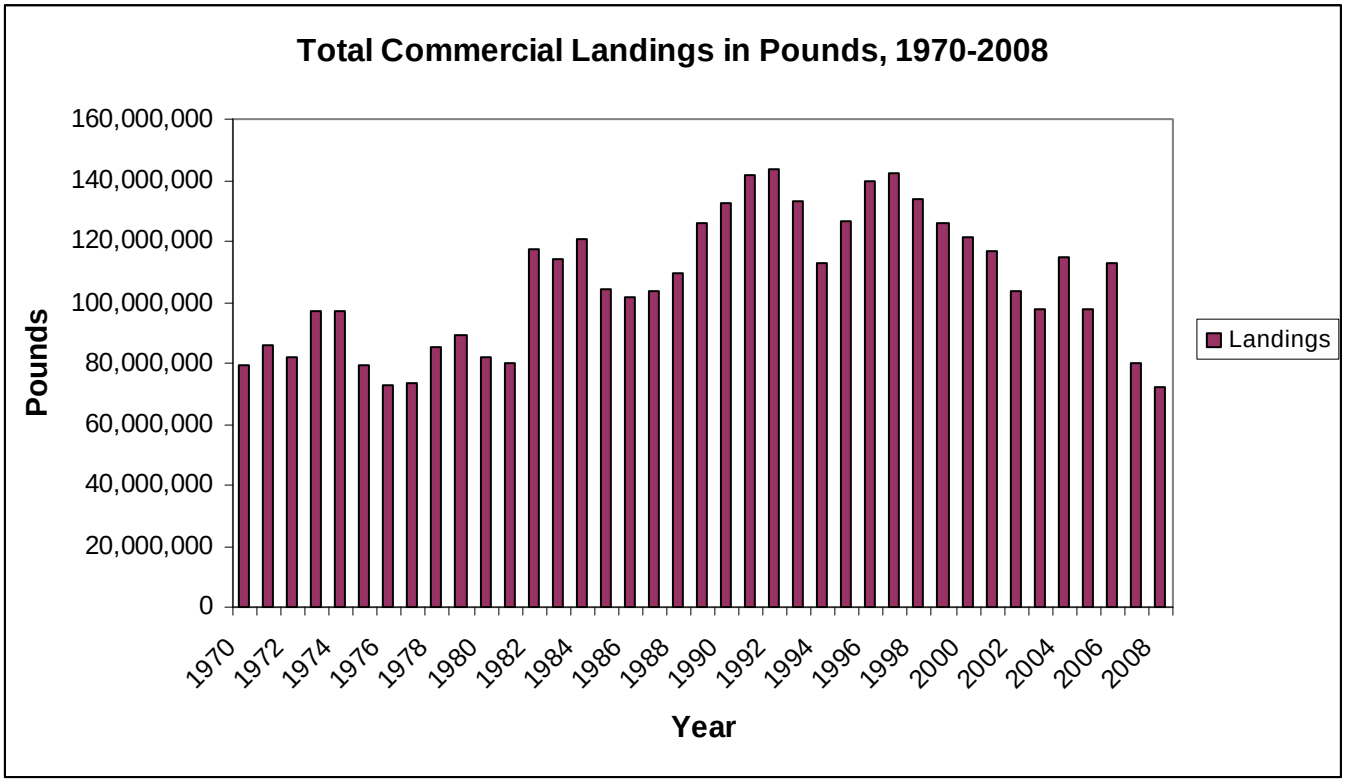


Figure 5.28. Rhode Island landings by weight, 1970-2008 (includes fish caught both within and outside of the Ocean SAMP area). (NMFS, Fisheries Statistics Division 2009a)

530.6.2. Rhode Island Commercial Fishing Effort

1. Commercial fisheries effort is defined as the amount of fishing activity that takes place within a specified period of time. Effort is typically quantified by the number of fishing trips, and/or the number of "days at sea" (as defined by the management regime, not a calendar day). Data provided below includes the numbers of trips on which various species were caught, indicating how often those species are harvested, although not necessarily how often they are targeted. Effort is also not indicative of the volume of catch. Data are also provided for the weight and dollar value for landings of various gear types, indicating which types of fisheries produce the greatest harvest and have the greatest economic value within the state. Some of the data provided below are only for state-licensed vessels, while others are for federally permitted fisheries.

2. Table 5.35 below lists species caught in 2007-2009 in NMFS statistical area 539 by vessels with state permits, and the number of trips within each month on which those species were caught. See Figure 5.29 for a map showing statistical area 539. Only species caught on an average of 50 or more trips in a given year are included. These data include only species landed with a state permit, and therefore include only species caught within state waters, including Narragansett Bay, and do not include species caught within federal waters of the SAMP area, or by vessels possessing federal permits. This means these data do not reflect the majority of activity taking place in the SAMP area. These numbers reflect effort, but not necessarily abundance, as certain fisheries may be closed

during certain times of the year (e.g. monkfish, tautog), and effort may be shifted elsewhere during that month.

Table 5.35. Average number of trips on which species were landed (state data only – includes trips both within and outside of the Ocean SAMP area), 2007-2009 (RIDEM 2010b).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Summer Flounder	3	3	4	107	1,663	1,753	2,142	1,252	18	2	35	7	**6,989**
Lobster, American	215	115	122	225	479	1,050	1,624	1,279	650	428	394	317	**6,898**
Scup	2		2	66	364	388	1,126	957	812	383	82	8	**4,190**
Black Sea Bass	2	3	1	25	375	345	558	895	478	278	82	1	**3,044**
Striped Bass	1			9	60	1,299	93	71	451	108	4	2	**2,096**
Bluefish				2	100	272	308	319	230	124	41	7	**1,402**
Tautog	1			114	316	2	130	147	9	294	116	3	**1,131**
Skate	7	4	9	49	245	185	132	71	38	24	26	8	**798**
Winter Flounder	11	2	6	89	246	86	56	24	21	18	28	10	**598**
Squid, Loligo	11			19	174	84	54	35	12	5	21	7	**422**
Conger Eel	2	4	2	3	11	16	70	153	80	59	16	1	**418**
Butterfish	6			8	100	69	43	14	14	8	19	3	**284**
Gray Triggerfish						11	71	85	64	26	1		**258**
Monkfish	3	2	4	7	48	49	30	12	6	11	26	5	**200**
Menhaden				15	45	61	35	20	10	5	4	3	**199**
Sea Robin				11	73	49	36	17	4	1	3	3	**198**
American Eel			2	4	28	17	14	25	33	27	13	11	**174**
Spiny Dogfish					50	58	32	12	8	3		1	**163**
Crab, Jonah	7	3	7	9	16	23	22	18	19	12	9	6	**151**
Weakfish				7	31	22	19	13	9	6	3		**110**
Crab, Rock	1	2	2	5	10	15	22	16	12	6	4	4	**98**
Smooth Dogfish				2	30	30	16	8	7	1			**95**
Windowpane Flounder	2		1	19	43	11	8	1	7		1		**92**
Cunner					5	3	6	25	21	17	5		**84**
Hickory Shad				3	12	26	25	12	5	2			**83**
Bonito						7	16	27	20	13			**82**
Cod	5	3	7	11	11	4	6	4	4	4	13	5	**77**
Winter Skate	1			5	12	15	6	13	6	3	7		**68**
False Albacore							1	14	39	13			**67**
Crab, Green				3	5		3	1	6	23	13	2	**55**
Red Hake		3	2	1	12	17	4	2	3	4	5	2	**54**
Horseshoe Crab			5	14	21	7	1	1	1	1			**51**
Silver Hake	7	1			10	13	8	2	1		4	4	**50**

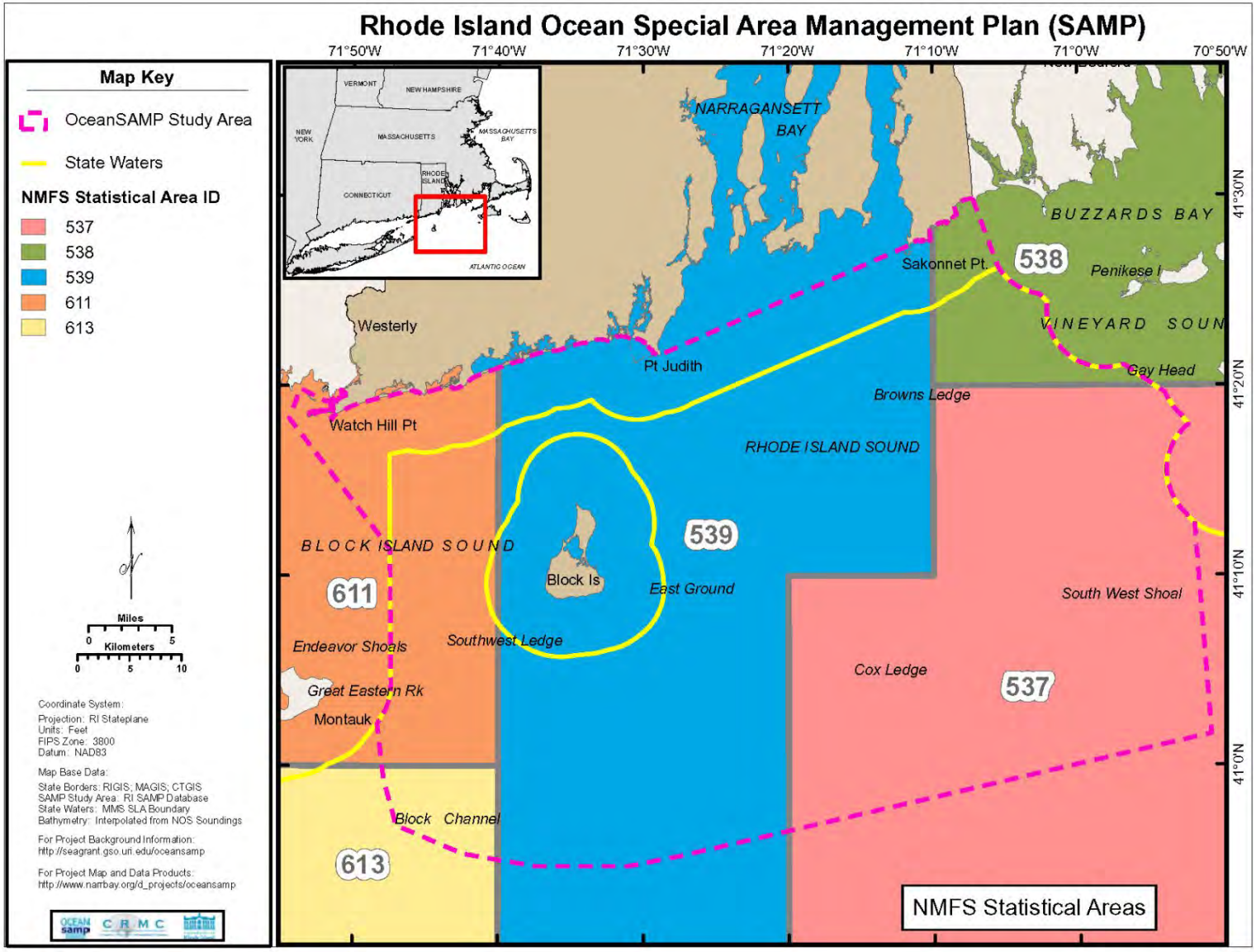


Figure 5.29. NMFS Statistical Areas.

3. Prior to 2007, RI DEM only collected data on lobster trips; these data are available from 2003 to 2006. In 2003, 8,964 lobster trips took place in NMFS Statistical Area 539; 8,812 trips in 2004; 10,226 trips in 2005; and 10,797 trips in 2006 (RIDEM 2010b). Though these data represent too few years to indicate a trend, they suggest a short-term increase in the number of lobster trips in Area 539.

4. Table 5.36 and Figure 5.30 below show what types of fishing gear have been used most commonly by Rhode Island fishermen over the last decade, and how much they land for each gear type, both by pounds and the dollar value of landings. The gear used by Rhode Island fishermen to catch the most fish by weight is the otter trawl, and the value of species landed by otter trawl is the highest among all gear. In addition to the groundfish species such as cod and flounders landed with an otter trawl, the small-mesh net otter trawl is used in Rhode Island's squid fishery, which is why this gear represents more than 50% of landings by weight. The next gear type weight is the paired midwater trawl, followed by pots and traps (other), which may include some lobster landings as well as squid landings. Ranked second by value of landings among gear types is inshore lobster pots and traps, which averaged over $9 million in landings over this time period.

5. Of the gear types listed below, most are used either predominantly or partially in the Ocean SAMP area. Most of the lobster traps are fished in the Ocean SAMP area, and fish pots and gillnets occur almost exclusively in the Ocean SAMP area.[16]

Table 5.36. Rhode Island landings by gear type, 1999-2008 (includes fish caught both within and outside of the Ocean SAMP area). (NMFS, Fisheries Statistics Division 2009a)
Note: Average dollar value calculated based on each year's nominal landings value, which do not account for inflation.

Gear	Average Landings in Pounds 1999-2008	Average Dollar Value of Landings 1999-2008
Otter Trawl, Bottom, Fish	59,131,329	$29,159,418.80
Trawl Midwater, Paired	10,380,727	$686,795.60
Pots And Traps, Other	9,968,096	$6,567,691.60
Not Coded/Other	7,898,880	$9,646,535.00
Otter Trawl, Midwater	7,649,674	$480,073.40
Gill Nets	4,245,477	$3,386,439.60
Pots And Traps, Lobster Inshore	2,446,071	$9,148,139.80
Dredge, Clam	1,874,640	$1,095,295.80
Pots And Traps, Lobster Offshore	1,780,073	$5,687,875.70
Dredge, Other	1,775,492	$4,312,557.70
Floating Traps (Shallow)	983,610	$776,261.70
Rakes	812,491	$4,556,840.90
Lines Hand, Other	654,659	$1,144,331.30
Pound Nets	364,243	$297,889.00
Purse Seines	297,909	$12,837.30
Long Lines	275,902	$636,117.20
Pots And Traps, Fish	186,843	$237,619.80

[16] NMFS and RI DEM use different categories for differentiating fishing activity by gear type (see Table 5.36 below). For this reason it is not possible to accurately compare federal and state data by gear type.

Dredge, Sea Scallop	173,667	$947,181.00
Diving Outfits, Other	171,106	$856,444.80
Lines, Troll, Other	62,752	$21,311.30
Hoes	61,181	$351,099.00
Tongs	38,513	$214,584.30
By Hand, Other	35,083	$90,976.00
Otter Trawl, Bottom, Other	28,628	$52,474.60

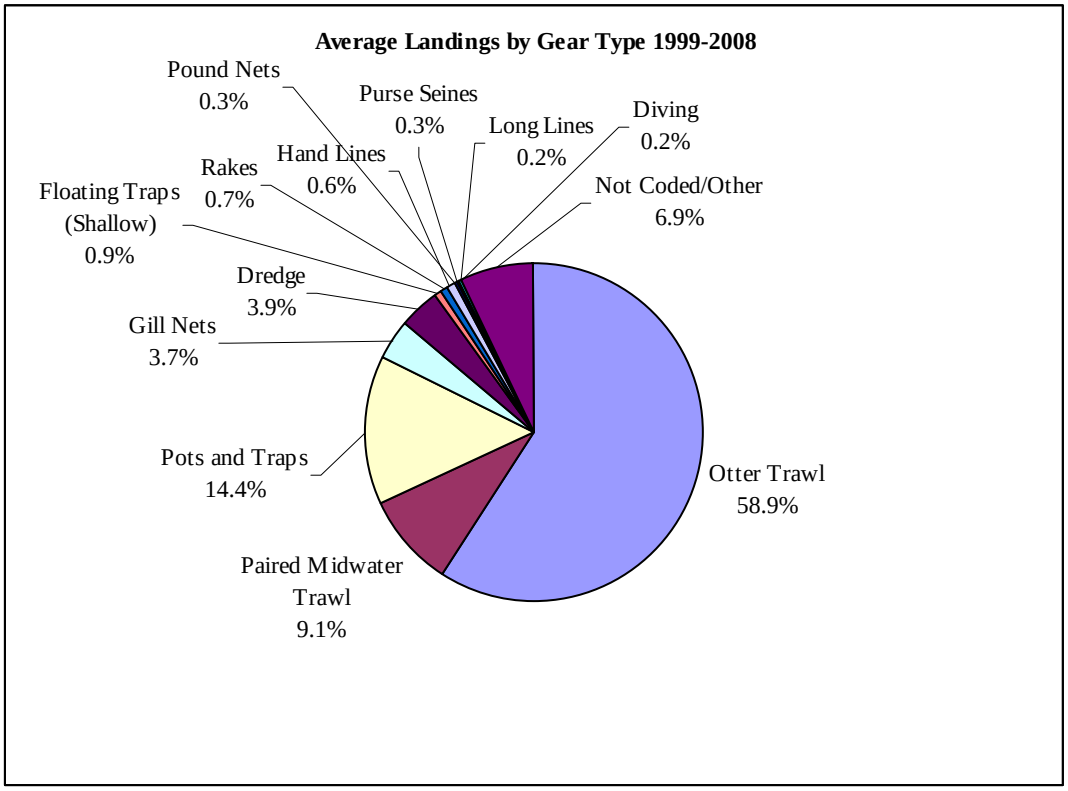


Figure 5.30. Rhode Island landings in pounds by gear type for 1999-2008 (includes fish caught both within and outside of the Ocean SAMP area). (NMFS, Fisheries Statistics Division 2009a)[17]

6. Table 5.37 below displays average commercial fishing effort for 2007-2009 in NMFS Statistical Area 539 for vessels with state permits. This table shows the number of trips per month by gear type, this time broken out into the number of fishing trips taken with each gear type for each month. These data show that commercial rod and reel trips were most prevalent during 2007-2009, and lobster trips were the second most common type of commercial fishing activity. As stated above, these data are only for state fisheries, and include fishing effort within Narragansett Bay. These numbers indicate the frequency with which these gear types are used, which is very different than the above table illustrating the pounds of fish taken by each gear type, and the value of the landings taken with each gear type.

[17] Some gear types are combined in this figure, and gear types with fewer than 500,000 pounds of landings are excluded.

Table 5.37. Average number of trips per month by gear type, 2007-2009 (includes trips taken both within and outside of the Ocean SAMP area) (state fishing licenses only).[18] (RIDEM 2010b)

Gear Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rod & Reel	3	3	7	49	1057	2546	2085	1542	974	544	144	8	**8962**
Pots & Traps (Lobster)	207	112	119	209	423	959	1496	1201	642	430	384	314	**6496**
Pots & Traps (Fish)	2	2	2	7	115	191	544	555	464	263	50	4	**2198**
Gillnet	2	1	6	97	455	247	208	121	38	55	29	4	**1262**
Otter Trawl	18	9	9	28	238	216	237	154	54	26	40	20	**1050**
Floating Fish Trap				19	95	77	69	54	35	19	2		**370**
Other	6	7	8	27	37	50	39	26	20	18	20	6	**262**

[18] 2007 is the most recent data provided by RI DEM and the only year for which complete finfish and crustacean data are available. RI DEM did not collect data on species other than lobsters prior to 2007. Please note that monthly effort is affected by closures and other regulatory measures. .

530.7. Contemporary Recreational and For-Hire Fishing

530.7.1. Description

1. Recreational fishing, which here includes both recreational fishing that takes place aboard for-hire party and charter boats as well as recreational anglers from shore or aboard private boats, has a long history in Rhode Island. Marine recreational fishing is a major recreational activity for Rhode Islanders as well as a major tourist attraction that brings in visitors from out-of-state. Recreational fishing also has a significant economic impact on the state, which is discussed below in Section 540.2. Recreational fishing in the Ocean SAMP area is done both from shore and by boat, including both private vessels and party and charter boats. Whereas there is a great deal of recreational fishing that takes place within Narragansett Bay, this section is focused primarily on fishing that takes place outside of the Bay in offshore waters.

2. Recreational fishermen, or anglers, who fish aboard private vessels or from shore, are regular users of the Ocean SAMP area. According to NMFS, the most common recreationally targeted species in marine waters in RI include Atlantic bonito, Atlantic cod, black sea bass, bluefish, scup, striped bass, summer flounder, tautog, winter flounder, and yellowfin tuna (NMFS 2008b). A different recreational fishing study, commissioned by the RIDEM, found striped bass and bluefish to be the two most popular species targeted by recreational anglers in Rhode Island. This survey includes anglers fishing both within and outside of Narragansett Bay. The most popular shore sites for fishing according to this survey were all bordering along the Ocean SAMP area, and include shore sites in Narragansett, Newport, and Jamestown (RIDEM 2006).

3. Some recreational fishermen who fish in the Ocean SAMP area only fish there occasionally, while others are regular users of the area. The Rhode Island Saltwater Anglers Association (RISAA), which is the largest recreational fishing organization in the state, estimates that of its 1,800 members, approximately 30% fish outside of Narragansett Bay in the Ocean SAMP area on a regular basis – roughly once a week - whereas 70% of their members fish in the Ocean SAMP area at least once a year. RISAA further estimates that there are recreational fishing vessels from every RI coastal town that use the Ocean SAMP area. Almost half of all boaters who use the Ocean SAMP area launch their boats directly from Point Judith boat ramps (Hittinger, pers. comm. a).

4. Recreational fishermen may also participate in organized fishing tournaments. RISAA currently sponsors 15 special fishing tournaments each year. According to RISAA, of these events, the Fluke, Team Fluke, Junior Catch and Release All-Species, Cod, Black Sea Bass, Bluefish/Striped Bass Combo, and Fall Bluefish/Striper Catch and Release tournaments all involve a significant amount of fishing in the Ocean SAMP area. In addition, RISAA sponsors a "Yearlong Tournament" which targets 15 different species. According to RISAA, of these species, the cod, haddock, striper, false albacore, bonito, pollock, tuna, mahi mahi, and fluke categories are usually won by a fish caught in the Ocean SAMP area (RISAA 2010; Hittinger, pers. comm. b).

5. Most of the RI-based party and charter boats that run fishing trips regularly operate in the Ocean SAMP area. Charter boats are for-hire vessels operated by a licensed captain and crew, usually carrying up to six passengers who have hired out the boat for the entire trip. A party or head boat, on the other hand, is typically a larger vessel where passengers pay individually for a space fishing on the vessel. The Rhode Island Party and Charter Boat Association has 70 members, and there are other charter boats in Rhode Island that are not a part of the association (Bellavance pers. comm.). However, many of the boats belonging to the association and most of the boats that are not members fish only on a limited basis. One member of the association estimated that about 30 party and charter boats are actively fishing, each making at least 30 trips each year (Donilon, pers. comm.). All of these vessels fish within the Ocean SAMP area for most or all of the year, although they move to different fishing grounds based on the time of year and the species they are targeting. The vast majority of the charter boats are based in Galilee, with one or two in Watch Hill, and one or two located further up in Narragansett Bay. The charter boats located in the Upper Bay often fish in the Bay instead of going out to the Ocean SAMP area, but they do fish in the Ocean SAMP area, as do the boats in the Lower Bay (Rainone, pers. comm.).

6. Table 5.38 below lists the number of charter and party boat licenses issued each year since 1999, when the licensing program took effect. The license is for two years; thus in 2009, there are 240 active charter and party boat licenses within the state of Rhode Island, reflecting those issued in 2008 - 2009.

Table 5.38. Party and charter boat licenses issued by year. (RIDEM 2010b)

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Licenses	90	21	31	24	29	27	36	63	167	94	146

7. There are five party boats fishing out of Rhode Island, all of them based in Galilee. The larger party boat operation runs about 700 trips each year, and carries approximately 18,000 passengers a year (Blount, pers. comm.).

530.7.2. Recreational Fishing Catch and Effort Data

1. Recreational fishing catch, effort, economic impact, and activity areas are generally more difficult to characterize than those of commercial fishing because, generally speaking, less information on recreational fishing is collected and published by federal and state regulatory agencies. This is in part because there is no federal recreational fishing licensing program currently in place in the northeastern U.S., though it should be noted that the National Saltwater Angler Registry and the Rhode Island Recreational Saltwater Fishing License Program, both of which took effect in 2010, are both designed to improve recreational fishing data collection.[19]

2. This section and Section 540.2, below, include the most recent and best available existing data and information that has been published to date by federal and state agencies and

[19] See https://www.countmyfish.noaa.gov/index.html for further information on the National Saltwater Angler Registry and http://www.dem.ri.gov/programs/bnatres/fishwild/reclic.htm for further information on Rhode Island's Recreational Saltwater Fishing License Program.

other parties. Recreational data sources used here and in Section 540.2 include the NMFS Marine Recreational Fisheries Statistics Survey program (MRFSS) (updated through 2008). The MRFSS program provides data extrapolated from surveys administered to a sampling of recreational fishermen. The MRFSS program consists of two independent surveys - an intercept survey of marine anglers at fishing access sites, and a random digit dial telephone survey conducted in coastal counties. Survey results are then extrapolated to estimate fishing effort across the nation. Because of these methods and the associated margin of error, these data should be viewed as estimates, rather than verifiable facts. Moreover, the MRFSS data must be interpreted with additional caution, as methodological issues have recently been identified with the program's survey methods, such that NMFS is developing a new program to gather data on recreational fishing.[20] However, because the MRFSS data are among the few available datasets to characterize recreational fishing, they may be considered the best available data and are included here for illustrative purposes. In this section and Section 540.2 below, MRFSS data are supplemented with other data and information provided in recent surveys and reports, though it should be noted that these documents and all other sources should also be viewed with caution insofar as they include survey-based estimates of recreational fishing activity.

3. Figure 5.31 and Table 5.39 below show average estimated recreational catch, by species, for 1999 – 2008, as illustrated by MRFSS data. These data include only fish caught in the ocean waters, including both federal and state waters, and not fish caught within Narragansett Bay. Striped bass and summer flounder (fluke) are the two most commonly caught species, followed by bluefish and scup. Although bluefish and striped bass are often cited as the two most commonly targeted recreational species within the state, much of the fishing for these species takes place within the waters of Narragansett Bay. These data are only projected estimates of catch, and have a large standard error associated with the projected numbers.

[20] In 2006 the National Research Council studied the MRFSS program and identified several problems with the program, including issues a lack of resources and problems with the sampling and survey methods. See National Research Council. 2006. "Report in Brief: Review of Recreational Fisheries Survey Methods." Online at http://dels.nas.edu/dels/rpt_briefs/rec_fish_brief_final.pdf. Because of these issues, the MRFSS program will be replaced with the Marine Recreational Information Program (MRIP).

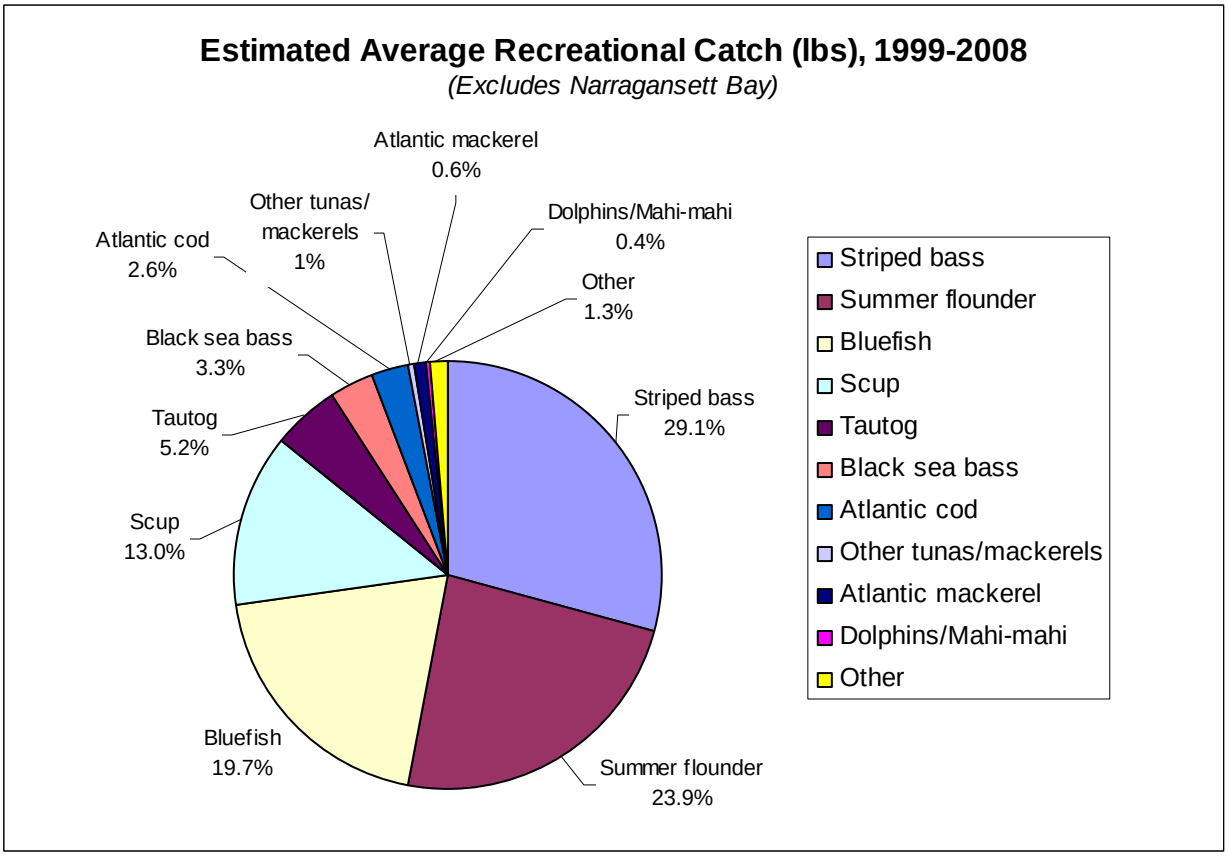


Figure 5.31. Estimated average recreational catch by species, 1999-2008, based on MRFSS data. (Pers. comm., NMFS Fisheries Statistics Division, MRFSS, 2010)

Table 5.39. Estimated average recreational catch, 1999-2008, based on MRFSS data. (Pers. comm., NMFS Fisheries Statistics Division, MRFSS, 2010)

Species Name	Average catch (lbs)
Striped bass	835,941
Summer flounder	687,416
Bluefish	566,135
Scup	374,226
Tautog	149,944
Black sea bass	94,146
Atlantic cod	74,431
Other tunas/mackerels	22,096
Atlantic mackerel	18,499
Dolphins (Mahi mahi)	12,493
Winter flounder	11,650
Little tunny/Atlantic bonito	8,573
Other sharks	4,234
Other fishes	2,612
Dogfish sharks	1,953
Weakfish	1,721
Skates/rays	1,468
Cunner	1,197
Herrings	1,085
Other cods/hakes	853
Red hake	678
Pollock	652
Triggerfishes/filefishes	574
Sea robins	345
Other jacks	266
Spanish Mackerel	130
Sculpins	29
Eels	20
King mackerel	7
Other flounders	2

4. According to the MRFSS program, it is estimated that during 1999-2008, an average of nearly 385,000 people participated in recreational ocean fishing in RI each year, making over 785,000 fishing trips yearly. These figures include both RI residents and out-of-state fishermen; for this time period, an average of approximately 143,000 (37%) Rhode Islanders and 242,000 out-of-state residents (63%) fished in RI ocean waters. These data include only recreational fishing in ocean waters, including both federal and state waters, and not fishing within Narragansett Bay. As these figures are estimates, they vary considerably from year to year. Figure 5.32 and 5.33 below show the number of trips and participants from 1999-2008, as well as the annual breakdown of participants by residency. Together, these figures show that while the number of trips varies year to year, participation in recreational fishing has generally been growing over the past decade. Figure 5.33 also illustrates how out-of-state fishermen consistently comprise the majority of recreational fishermen fishing in RI ocean waters. For more information on the economic impact of these activities, see Section 540.2 below.

5. Figure 5.34 shows the breakdown of recreational fishing trips by mode. These data include only recreational fishing in ocean waters, including both federal and state waters, and not fishing within Narragansett Bay. Shore-based fishing makes up nearly 50% of recreational ocean fishing trips in Rhode Island. Fishing by private boat, whether owned or rented, makes up over 45% of saltwater fishing trips within the state, and many of these trips will take place in the Ocean SAMP area. Party and charter boat fishing (for-hire fishing), while having the smallest number of trips of the three fishing modes surveyed, occurs almost entirely in the Ocean SAMP area.

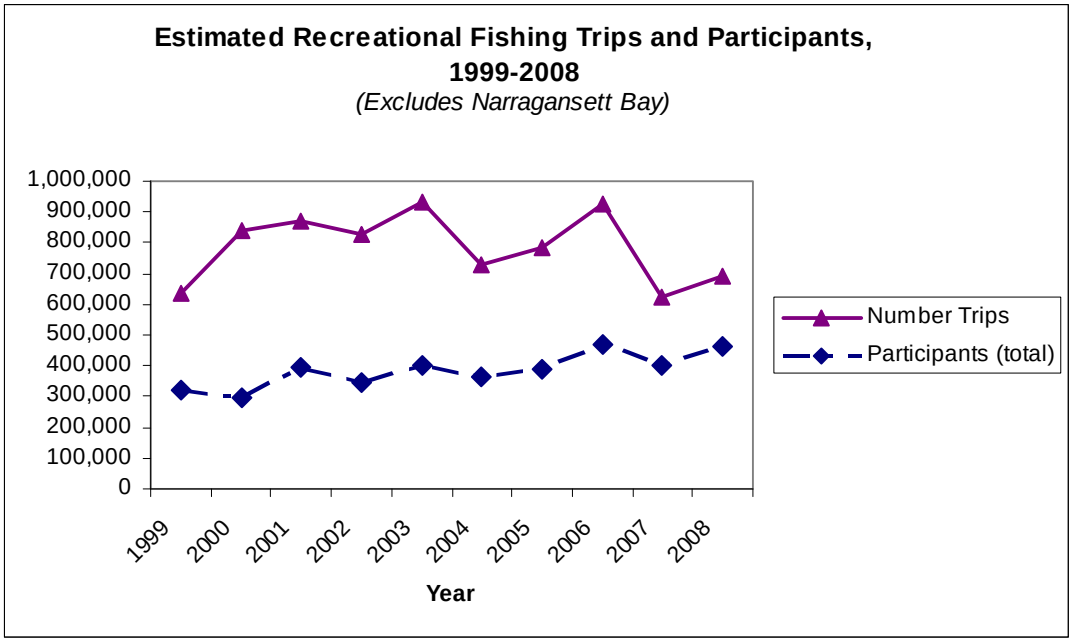


Figure 5.32. Estimated recreational fishing trips and participants, 1999-2008. (Pers. comm., NMFS Fisheries Statistics Division, MRFSS, 2010)

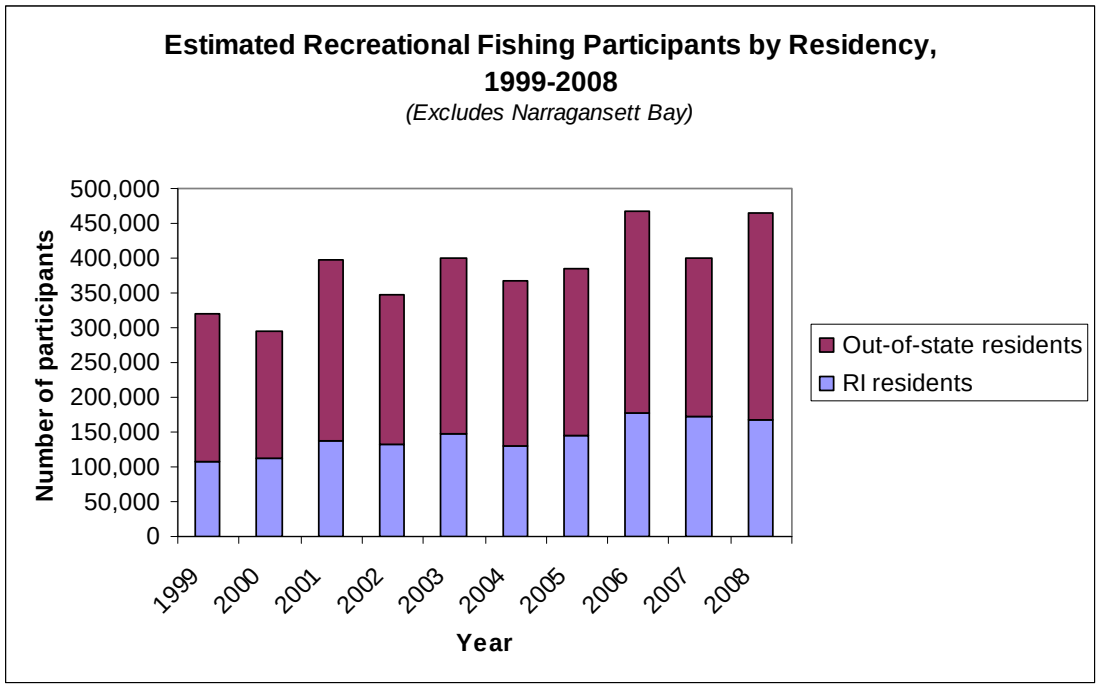


Figure 5.33. Estimated recreational fishing participants by residency, 1999-2008. (Pers. comm., NMFS Fisheries Statistics Division, MRFSS, 2010)

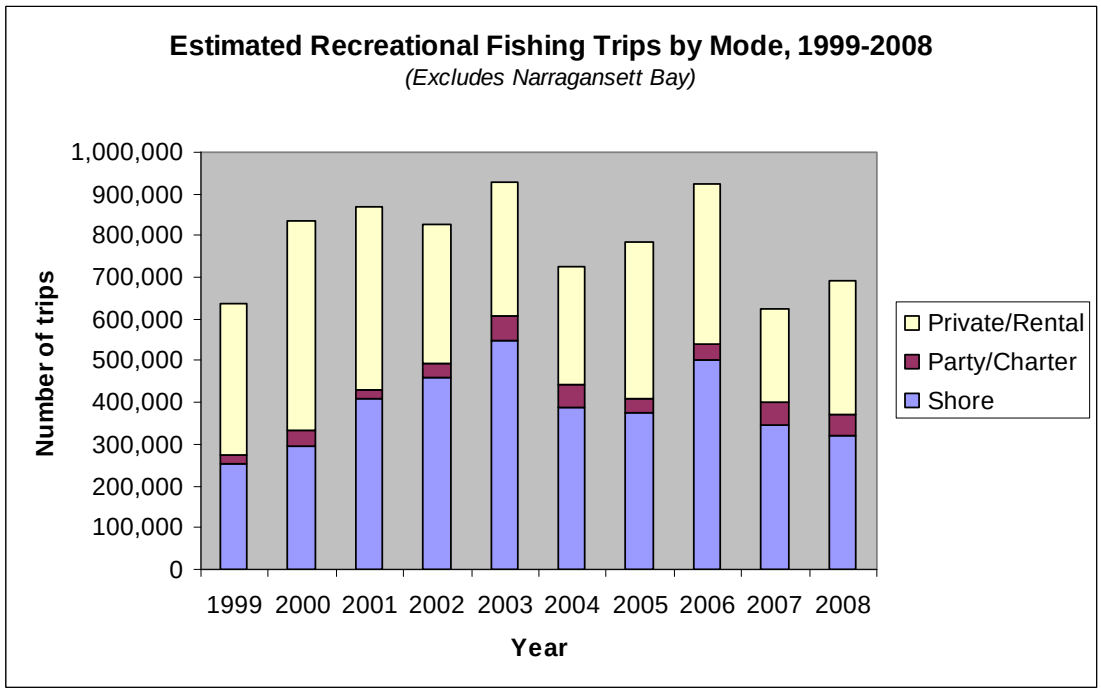


Figure 5.34. Estimated recreational fishing trips by mode, 1999-2008, based on MRFSS data. (Pers. comm., NMFS Fisheries Statistics Division, MRFSS, 2010)

530.7.3. Recreational and For-Hire Fishing Activity Areas

1. Recreational fishing takes place throughout much of the Ocean SAMP area. For the Ocean SAMP, recreational fishing has been characterized primarily through qualitative input from recreational fishermen. Figure 5.35 shows areas based on qualitative input from fishermen. Recreational fishing areas shown on this map represent both private recreational fishing and recreational fishing aboard for-hire party and charter boats. See Appendix B for the methodology used to develop these maps. It should be noted that fishermen involved in this mapping effort clearly indicated that all state waters surrounding Block Island were heavily used for recreational fishing. Other fishing areas of particular importance to recreational fishermen are the waters southwest of Block Island, including Southwest Ledge, and Cox Ledge. Like commercial fishing, recreational fishing effort varies widely throughout the year, and from year to year, depending on the individual fishermen, vessel type, target species, regulatory environment, and seasonal migrations of target species.

2. During the late spring, Rhode Island-based party and charter boats are almost exclusively targeting cod, which have started to make a recovery to numbers suitable for recreational fishing. Most fishing for cod is done on Cox Ledge and south of Block Island. Earlier in the spring season, the majority of party and charter boats target the migratory stocks of the mid-Atlantic such as striped bass, summer flounder, and black sea bass. During the summer, most recreational fishing is focused on striped bass and bluefish, with some boats targeting fluke closer to shore. Later in the summer, some of the recreational fishing boats will move further offshore to target sharks, which are generally caught anywhere from 20 to 50 miles offshore. Sharks targeted include blue, mako, thresher, and hammerhead sharks, and most shark fishing is catch and release. Some tuna fishing also takes place within an area east of Block Island and northwest of Cox Ledge known as the Mud Hole (often called Deep Hole by commercial fishermen). Starting in September, much of the fishing switches to sea bass and scup around Block Island, or to striped bass closer to shore at that time of year.

3. Some out-of-state party and charter boats from Connecticut, Massachusetts, and New York also regularly fish within the Ocean SAMP area. Some of these boats fish in Rhode Island state waters surrounding Block Island, target striped bass on Southwest Ledge off the southwest corner of the island and summer flounder in various areas around the island. Some of these boats also fish for scup, black sea bass, and tuna in federal waters south of Block Island (Bellavance, pers. comm.).

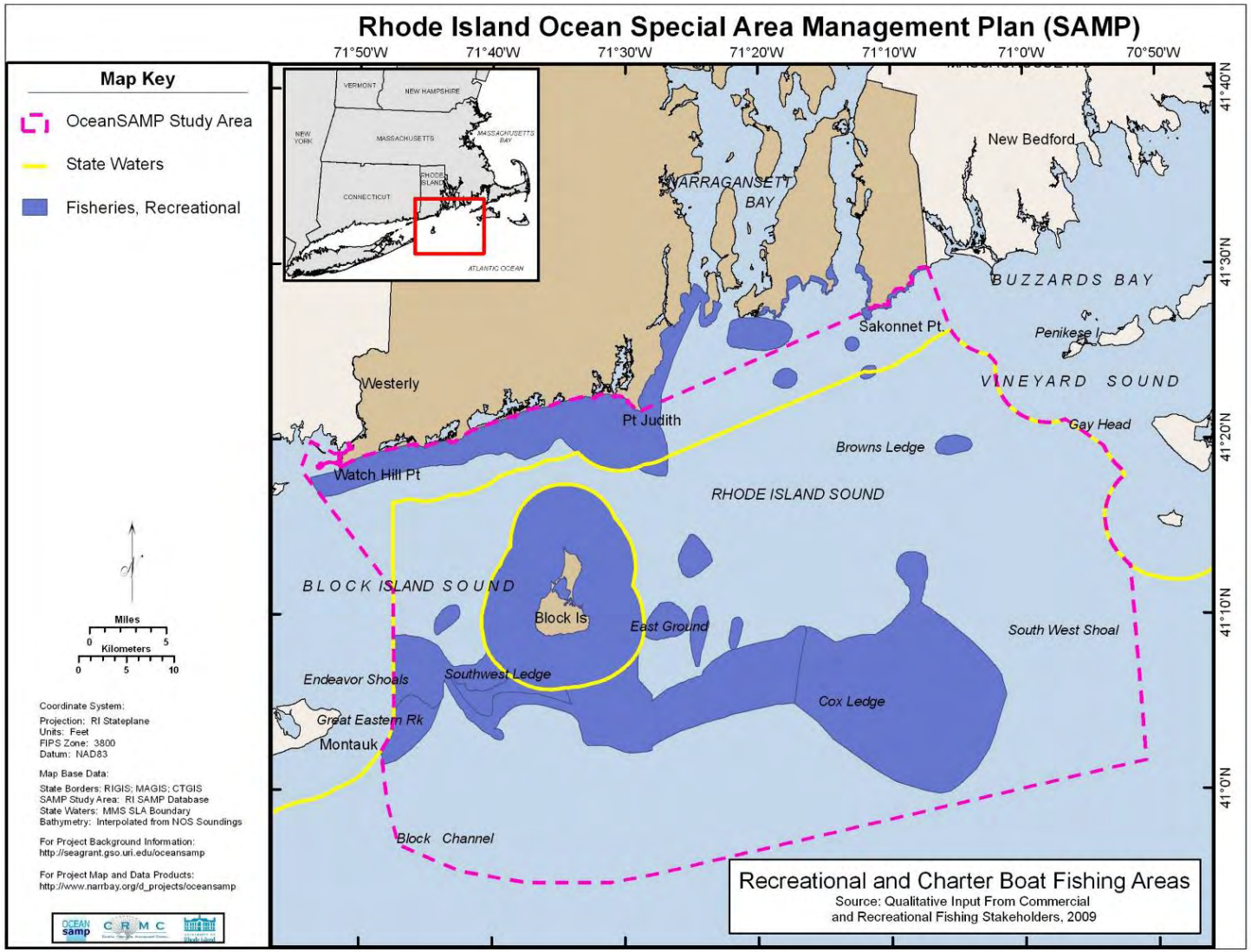


Figure 5.35. Recreational and charter boat fishing areas based on qualitative input.

Section 540. Economic Impact of Commercial and Recreational Fisheries

1. Commercial and recreational fisheries are both significant contributors to Rhode Island's economy. However, it is not possible to directly and accurately compare the values of commercial fisheries and recreational fishing. For commercial fisheries, the value of the fishery is primarily determined by the value of the fish landed within the state, regardless of where the fish were caught. Some economic analyses of commercial fisheries may also consider related activities, such as seafood processing and distribution, employment, and the multipliers associated with commercial fishing. By contrast, recreational fishing cannot be assessed by fish landed as many fish are not landed at all (but are caught through catch-and-release fishing), and none are sold on the market. Instead, the economic value of recreational fishing is in the act of fishing itself, and as such is measured by assessing the industry itself – i.e. income and employment associated with charter boat businesses, boat manufacturers, and tackle shops.

540.1. Commercial Fisheries Landings Value and Economic Impact

1. Commercial fishing is an important contributor to the state's economy. The economic contribution of commercial fishing is determined by the landings values of the fish landed within the state, the export of fisheries products, the impact of processing, distribution, and retail, the resulting employment, and other factors. The section below includes discussion of the ex-vessel revenue associated with commercial fisheries landings, and also summarizes available data on the broader economic impact of commercial fisheries to RI.

2. Because of the nature of fisheries activity and fisheries data, it is not possible to directly attribute a dollar amount to the contribution of fisheries in the Ocean SAMP area. Commercially harvested species that are landed in RI ports may be harvested anywhere; conversely, species harvested in the Ocean SAMP area may be landed in an out-of-state port and accounted for in that state's landings data. This section summarizes information about the value of all state landings as well as the economic impact of commercial fishing to the state. Where possible, distinctions are made to emphasize the particular value of Ocean SAMP area fishing to the state of Rhode Island.

3. A 2008 study conducted by NMFS found that ex-vessel revenue from commercial fisheries landings increased 41% (adjusted for inflation) from 1997 through 2006 in New England. This increase was largely due to an increase in revenue from shellfish – the revenue from finfish landings decreased in this period. The total landings revenue in Rhode Island in 2006 was roughly $98.6 million. This included $28 million in revenue for finfish landings, and more than $70 million in revenue for shellfish landings (which includes sea scallops, lobster, and squid) (NMFS 2008a).[21]

4. Table 5.39 below shows that the most valuable landings on average in Rhode Island for 1999-2008 were lobster ($19,113,035), followed by *loligo* squid ($14,018,015), northern quahogs ($5,675,621), monkfish ($4,921,970), and sea scallops ($4,847,792). The most

[21] At the time of this writing, NMFS "Fisheries Economics of the United States 2006" is the most recent commercial fisheries economic study available.

valuable species per pound on average was oysters at $14.35/pound, followed by sea scallops, averaging $6.73/pound, northern quahogs at $6.37/pound, and lobster at $4.40/pound. These figures include all ports in Rhode Island, and include species targeted both within and outside of the Ocean SAMP area, including Narragansett Bay. Of the species listed, all but oysters and quahogs are currently fished for within the Ocean SAMP area.

Table 5.40. Top landed species in Rhode Island by value averaged for 1999-2008 (includes fish caught both within and outside of the Ocean SAMP area).[22] (ACCSP 2010)
Note: Ocean SAMP area commercially important species highlighted. Data on landings values by port are based on the NOAA Fisheries commercial dealer weigh out data, which includes the pounds landed and sold to the dealer, and the total price paid for each species. Average dollar value was calculated using the annual nominal landings value, which does not account for inflation.

Species	**Average Pounds Landed 1999-2008[23]**	**Average Dollar Value 1999-2008**	**Average Price per Pound**
Lobster, American	4,340,526	$19,113,035	$4.40
Squid, Longfin inshore	18,426,084	$14,018,015	$0.76
Quahog, Northern	890,965	$5,675,621	$6.37
Goosefish (Monkfish)	5,148,746	$4,921,970	$0.96
Scallop, Sea	719,914	$4,847,792	$6.73
Flounder, Summer	2,158,836	$4,660,022	$2.16
Hake, Silver	6,290,385	$2,543,255	$0.40
Scup	3,131,617	$2,381,122	$0.76
Mackerel, Atlantic	7,623,878	$1,921,248	$0.25
Herring, Atlantic	19,426,667	$1,637,564	$0.08
Flounder, Winter	1,173,497	$1,599,963	$1.36
Flounder, Yellowtail	941,055	$1,067,699	$1.13
Squid, Northern shortfin	3,089,620	$882,507	$0.29
Bass, Black sea	315,991	$758,978	$2.40
Oyster, Eastern	50,676	$742,558	$14.65
Clam, Soft	102,742	$711,869	$6.93
Butterfish	1,588,842	$680,673	$0.43
Skates	6,455,051	$627,053	$0.10
Bass, Striped	202,593	$540,829	$2.67
Cod, Atlantic	454,363	$511,321	$1.13
Crab, Atlantic rock	952,517	$489,484	$0.51
Crab, Jonah	892,223	$471,098	$0.53
Crab, Red	608,303	$452,849	$0.74
Haddock	336,594	$369,411	$1.10
Crabs, Brachyura	484,718	$242,149	$0.50
Swordfish	85,632	$236,487	$2.76
Flounder, Witch	168,881	$211,958	$1.26
Skate, Little	2,374,344	$196,849	$0.08
Hake, Red	797,796	$191,042	$0.24
Bluefish	553,631	$185,447	$0.33

[22] Species included in the table are those for which the average landings value is over $100,000 for 1999-2008
[23] Shellfish weights are expressed in meat weights

Plaice, American	119,517	$118,531	$0.99
Whelk, Channeled	93,273	$118,367	$1.27

5. Figure 5.36 below shows trends in landings and landings value in Rhode Island for the years 1999-2008. The dollar values here are nominal values only, and not adjusted for inflation, and therefore are weighted toward the more recent years. Landings have decreased over that time period, while the landings values have seen less fluctuation.

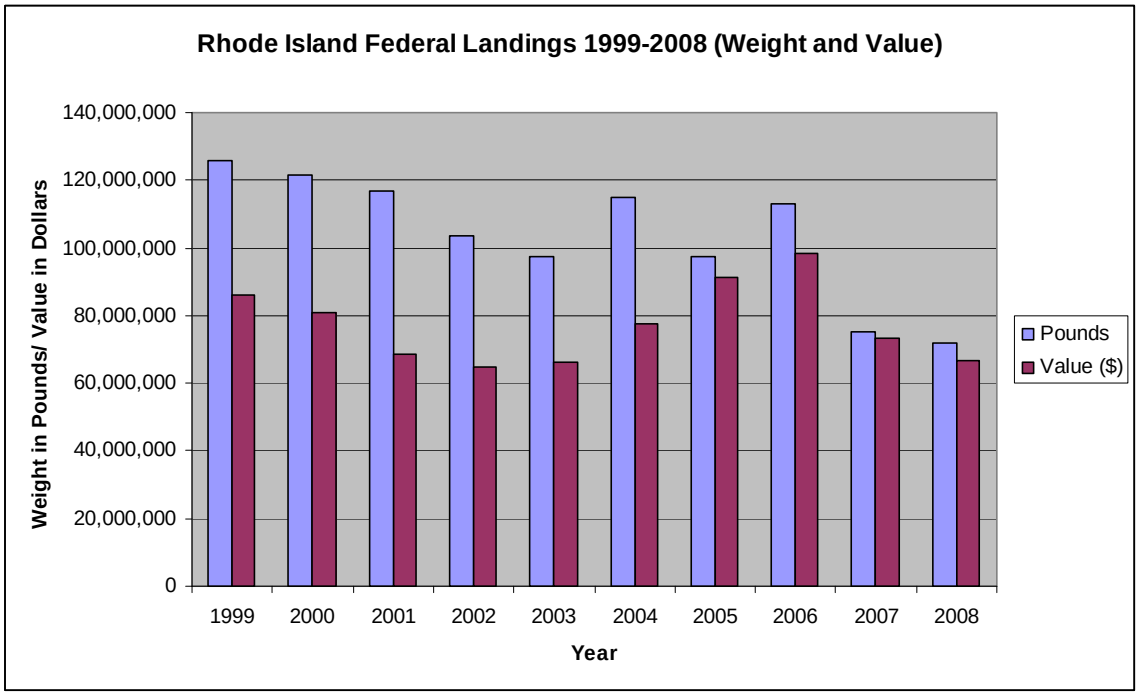


Figure 5.36. Rhode Island commercial landings by value, 1999- 2008 (includes fish caught both within and outside of the Ocean SAMP area). (NMFS, Fisheries Statistics Division 2009a)
Note: dollar values are annual nominal landings values only and are not adjusted for inflation.

540.1.1. Point Judith

1. Clay et al. (2008) report that in 2006, there were 168 vessels with federal permits in Point Judith, and the total federal landings value in Point Judith was $46,947,791 (see Table 5.41). The most valuable federally managed group of species was squid, mackerel, and butterfish (combined into one group for management purposes), with a 2006 landings value of $13,188,211, followed by lobster, with landings of over $8.6 million (see Table 5.42).[24]

[24] Clay et al. 2008 represents the most recently published and best available data on port-specific landings and value.

Table 5.41. Federal vessel permits and landings value between 1997 and 2006 for Point Judith/Narragansett (includes fish caught both within and outside of the Ocean SAMP area). (Clay et al. 2008)

Year	# Vessels	Value of landings in Point Judith ($)
1997	181	$47,529,746
1998	175	$42,614,251
1999	181	$51,144,479
2000	184	$41,399,853
2001	186	$33,550,542
2002	179	$31,341,472
2003	173	$31,171,867
2004	174	$36,016,307
2005	171	$38,259,922
2006	168	$46,947,791

Table 5.42. Dollar value of landings of federally managed groups of species for Point Judith (includes fish caught both within and outside of the Ocean SAMP area). (Clay et al. 2008)

	Average from 1997 – 2006	2006 only
Squid, Mackerel, Butterfish	$11,298,781	$13,188,211
Lobster	$11,022,301	$8,675,086
Summer Flounder, Scup, Black Sea Bass	$4,718,136	$6,495,568
Smallmesh Groundfish[25]	$2,816,677	$1,799,479
Monkfish	$2,687,563	$2,110,227
Largemesh Groundfish[26]	$2,451,647	$3,383,452
Other[27]	$2,056,576	$2,697,425
Scallop	$1,457,702	$7,420,396
Skate	$618,033	$604,990
Herring	$470,065	$376,506
Tilefish	$230,142	$32,985
Bluefish	$112,378	$118,466
Dogfish	$48,031	$45,000
Red Crab	$9,593	$0

2. Figure 5.37 shows Point Judith commercial landings by weight and value from 1999-2008. The dollar values here are nominal values only, and not adjusted for inflation, and therefore are weighted toward the more recent years. The landings by weight indicate that whereas landings declined from 1999-2001, they have since remained fairly consistent.

[25] Smallmesh Multi-Species: red hake, ocean pout, mixed hake, black whiting, silver hake (whiting)
[26] Largemesh groundfish: cod, winter flounder, witch flounder, yellowtail flounder, American plaice, sand-dab flounder, haddock, white hake, redfish, and pollock
[27] "Other" species includes any species not accounted for in a federally managed group, including species managed at the state level

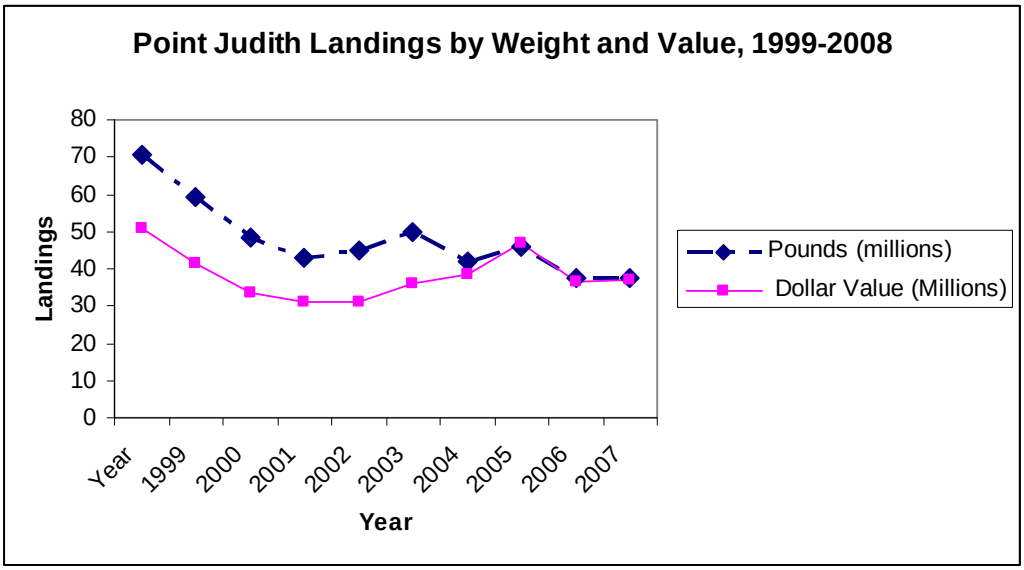


Figure 5.37. Point Judith landings by dollar value and weight, 1999-2008. (NMFS 2009a)
Dollar values are annual nominal landings values only and are not adjusted for inflation.

540.1.2. Newport

1. Clay et al. (2008) report that in 2006, there were 48 vessels with federal licenses listing Newport as their home port, and the total value of landings was $20,837,561 (see Table 5.43).[28] The most valuable species landed in Newport in 2006 was scallops, with a landed value of $13,267,494, followed by lobster, worth just under $3 million (Clay et al. 2008) (see Table 5.43).

Table 5.43. Federal vessel permits and landings value between 1997 and 2006 for Newport (includes fish caught both within and outside of the Ocean SAMP area). (Clay et al. 2008)

Year	# Vessels	Value of landings in Newport ($)
1997	52	7,598,103
1998	52	8,196,648
1999	52	8,740,253
2000	59	8,296,017
2001	52	7,485,584
2002	55	7,567,366
2003	52	9,082,560
2004	52	8,402,556
2005	54	14,281,505
2006	48	20,837,561

Table 5.44. Dollar value for landings of federally managed species for Newport (includes fish caught both within and outside of the Ocean SAMP area). (Clay et al. 2008)

[28] Clay et al. (2008) represents the most recent and best available data on port-specific landings and value.

	Average from 1997-2006 ($)	2006 only ($)
Lobster	2,758,908	2,971,680
Scallop	2,528,448	13,267,494
Squid, Mackerel, Butterfish	1,425,947	1,315,229
Largemesh Groundfish[29]	1,039,962	445,273
Monkfish	878,265	1,068,547
Summer Flounder, Scup, Black Sea Bass	739,880	815,918
Other[30]	334,103	401,779
Smallmesh Groundfish[31]	179,296	43,165
Skate	58,481	224,184
Herring	42,538	267,164
Dogfish	26,441	6,037
Red Crab	15,560	0
Bluefish	11,759	9,878
Tilefish	9,230	1,213

2. Figure 5.38 shows Newport commercial landings and value from 1999-2008. The dollar values are nominal values only and are not adjusted for inflation, and therefore are weighted toward the more recent years. Whereas the value of Newport's landings seems to have fluctuated, the weight of landings stayed relatively consistent from 2004-2007.

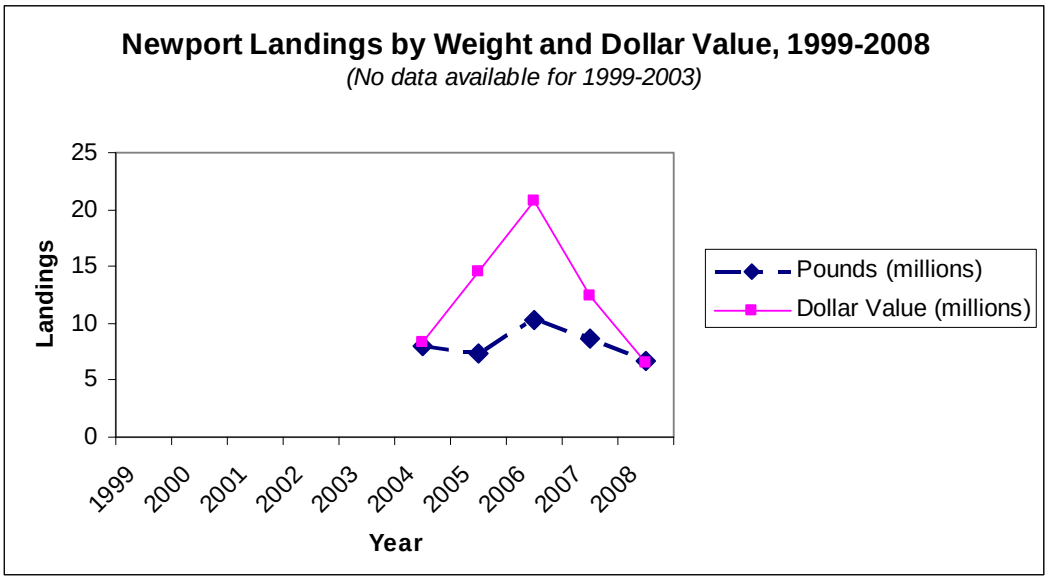


Figure 5.38. Newport landings by dollar value and weight, 1999-2008. (NMFS 2009a)

3. Figure 5.39 and Figure 5.40 track the ranking of Point Judith and Newport amongst all major U.S. fishing ports by both landings value and pounds landed. Point Judith has steadily been declining in ranking of pounds landed since 1998 and in landings value,

[29] Largemesh groundfish: cod, winter flounder, witch flounder, yellowtail flounder, am. plaice, sand-dab flounder, haddock, white hake, redfish, and pollock

[30] "Other" species includes any species not accounted for in a federally managed group, including species managed at the state level

[31] Smallmesh Multi-Species: red hake, ocean pout, mixed hake, black whiting, silver hake (whiting)

although landings value has fluctuated more than pounds. The rank of Point Judith did climb in 2008 from 21st to 18th in value of landings, and from 24th to 21st in pounds. Newport did not appear in the rankings for 1999-2003. Newport climbed significantly in the rankings for both pounds landed and landings value for 2006, but declined again in 2007. Data for Newport for 2008 were not available (NMFS 2009a).

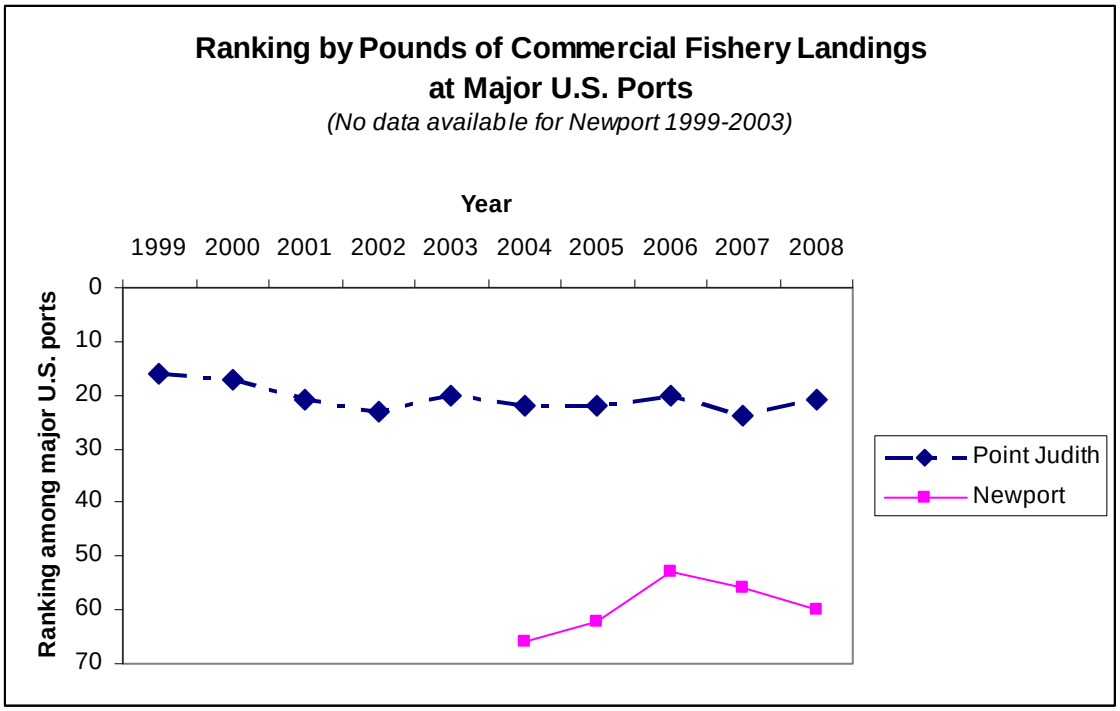


Figure 5.39. Ranking by pounds of commercial fishery landings at major U.S. ports, 1999-2008. (NMFS 2009a)

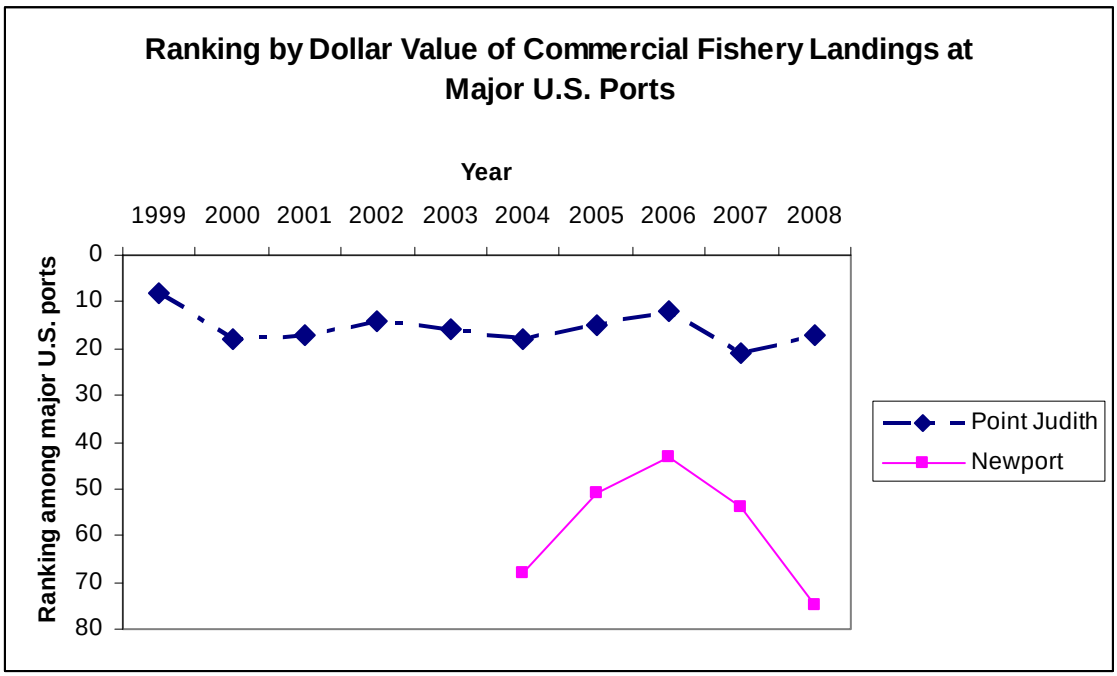


Figure 5.40. Ranking by dollar value of commercial fishery landings at major U.S. ports, 1999-2008. (NMFS 2009a)

4. While commercial fisheries landings have great value in themselves, the commercial fishing industry has a broader effect on Rhode Island's economy through the jobs, income, and sales associated with the commercial fishing industry. However, accurately assessing the economic impact of the state's commercial fishing industry is difficult for a variety of reasons, including the fact that many fishermen are self-employed and fishing vessels do not always land their catch in the same state in which they are home ported. For this reason, estimates of the economic impact of commercial fishing vary by study. One 2008 study analyzed 2006 landings and employment data and determined that the RI commercial fishing industry represents approximately 1700 jobs and nearly $98 million in wages, and accounted for $11-18 million in vessel operation costs and another $9-15 million in vessel maintenance costs. In total, this study found that the state's commercial fishing industry is responsible for at least $100 million in economic activity each year (RI Economic Monitoring Collaborative 2008).

5. A 2008 NMFS fisheries economic study found that the estimated total sales impacts from the Rhode Island commercial fishing industry were approximately $705,938,000, and the estimated income impacts from this industry state-wide totaled $378,396,000 (see Table 5.45). The majority of economic impacts in both areas came from the resulting impacts on the retail sectors of seafood sales. Commercial harvesting itself also provided significant economic impacts to the economy, with more than $75 million in income impacts to the state, and over $3 million in employment impacts (NMFS 2008a).[32] Once again, because it is not feasible to determine the amount or value of landings originating within the Ocean SAMP area, it is impossible to

[32] This NMFS study, *Fisheries Economics of the United States 2006*, is at the time of this writing the most updated and best available data on the economic impact of commercial fishing throughout the region.

determine what percentage of these impacts can be attributed to fishing activity and resources found within the Ocean SAMP area.

Table 5.45. Economic impacts of commercial fishing industry in Rhode Island, 2006. (NMFS 2008a)

	Sales Impacts	**Income Impacts**	**Employment Impacts**
Commercial Harvesters	$171,075,000	$75,223,000	$3,308,000
Seafood Processors and Dealers	$50,924,000	$18,474,000	$465,000
Seafood Wholesalers and Distributors	$97,988,000	$50,549,000	$947,000
Retail Sectors	$385,951,000	$234,149,000	$10,246,000
Total Impacts	**$705,938,000**	**$378,396,000**	**$14,966,000**

6. A 2009 NMFS economic study of marine-related industries (Thunberg 2009) provides additional insight into the broader economic impacts of commercial fishing. According to this study, the number of establishments in Rhode Island involved in seafood commerce was 112 in 1999, and declined to 92 in 2005 (see Table 5.46).[33] Seafood commerce includes commercial fishing, seafood dealers, seafood processors, and retail seafood markets. The number of employees in these establishments was 2,291 in 1999, and fell to 1,925 by 2005 (see Table 5.46). In 2005, 68.0% of employment in the seafood commerce sector was made up of commercial fishing employees, 16.2% was made up of seafood dealers, 14.0% was in the processing sector, and 7.3% was in seafood retail. There were a total of 1,211 sole proprietors engaged in fishing in Rhode Island in 2005, and Rhode Island fishermen in sole proprietorships earned more than the average for the Northeast region. At the same time, wage-based income was higher for fishermen than income earned through a sole proprietorship in Rhode Island, but lower in many other Northeast states. The consumer price index adjusted annual fishing wages in Rhode Island in 2005 averaged $31,546, while the adjusted average receipts for sole proprietorships in 2005 were $27,954 (Thunberg 2009).

Table 5.46. Total number of Rhode Island seafood commerce establishments and employees, 1999-2005. (Thunberg 2009)

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Year	**Number of Establishments**	**Number of Employees**
1999	112	2,291
2000	110	2,240
2001	112	2,235
2002	104	2,057
2003	104	2,225
2004	105	2,057
2005	92	1,925

7. This 2009 NMFS study also analyzed fishing-related employment in Rhode Island and found Bristol, Newport, and Washington Counties all had a fishing quotient higher than

[33] This NMFS study, *Trends in Northeast Region Marine Industries* (Thunberg 2009) is based on data through 2005 and provides the most recent and best available data on commercial fishing-related businesses in RI.

one, meaning fishing employment in these counties is higher than average, and these three counties would be disproportionately affected by a reduction in fishing employment. In 2005, the number of fishing employees and sole proprietorships in Bristol County was 76; in Newport County, 198; and in Washington County, 176 (Thunberg 2009).

8. NMFS further analyzed employment at seafood dealer establishments and found that in 2005, total employment in Rhode Island in the seafood dealer sector was 206 at 32 seafood dealer establishments. Rhode Island had as many as 66 seafood dealer establishments in 1993, but this number declined steadily through the 1990s and early 2000s. Overall, Rhode Island had more residents employed by seafood dealers as a percentage of all employment state-wide than the average for most Northeast states, and Newport and Washington Counties had the highest dependence on seafood dealer employment, with 61 employees in eight establishments in Newport County, and 70 employees in 12 establishments in Washington County in 2005 (Thunberg 2009) (see Table 5.47).

9. NMFS also investigated seafood processing establishments and found that Rhode Island had seven such businesses in 2005, employing 270 people. Like for seafood dealers, the percentage employment in seafood processing is generally higher in Rhode Island than the average employment in the sector for the Northeast. In 2005, Bristol County had two seafood processors with 192 employees, Newport County had two seafood processors with 63 employees, and Washington County had one processor with two employees. Rhode Island had 31 retail seafood markets in 2005 with 140 employees, which, again, was higher than the average employment for the Northeast (Thunberg 2009) (see Table 5.47).

Table 5.47. Fisheries sector employment impacts, 2005. (Thunberg 2009)

Sector		**Bristol County**	**Newport County**	**Washington County**	**RI Total**
Seafood Dealers	Number of Establishments	N/A	8	12	32
	Employees	N/A	61	70	206
Seafood Processors	Number of Establishments	2	2	1	7
	Employees	192	63	2	270
Retail Seafood Market	Number of Establishments	3	3	5	31
	Employees	5	23	34	140

540.2. Economic Impact of Recreational Fishing

1. While recreational fishing is different than commercial fishing in that fish caught are not landed and sold on the market, it nonetheless has a significant economic impact in the state of Rhode Island. Unlike commercial fishing, the value of recreational fishing lies in the act of fishing itself, and the expenditures associated with that act. As noted above in Section 530.7.2, recreational fishing catch, effort, and associated economic impact are generally more difficult to characterize because of the lack of data collected by state and

federal regulatory agencies. Estimates of the economic impact of recreational fishing are typically based on surveys administered to a sampling of recreational fishermen and extrapolated to a larger population, combined with analysis of the businesses (e.g. tackle shops and boat manufacturers) associated with recreational fishing. Results of these studies tend to vary widely depending on the sample size and location, methods, and data sources used. For these reasons, all recreational fishing data should be regarded with caution and should be viewed as estimates, rather than verifiable facts.

2. Several studies have attempted to extrapolate from survey results to create estimates of the economic impact of recreational fishing in Rhode Island. One such study was conducted by NMFS in connection with the Marine Recreational Fisheries Statistics Survey (MRFSS) program, discussed above in Section 530.7.2. Economic data on fishing expenditures were gathered from an economic survey added on to the traditional MRFSS survey; this was performed in 2006 (Gentner and Steinback 2008).[34] Other economic impact studies of RI recreational fishing include one commissioned by the Rhode Island Saltwater Anglers Association (RISAA) which incorporated 2006 angler intercept survey results as well as MRFSS and other pre-existing data sets (Ninigret Partners 2007), and one conducted by the U.S. Fish and Wildlife Service in 2006. Together, these studies represent the best available and most up-to-date recreational fishing economic impact data for Rhode Island; results of each study are summarized below. As is the case for commercial fishing data, it is infeasible to directly apportion a percentage of recreational fishing activity to within the Ocean SAMP area based on the available data. In addition it should be noted that the discrepancy between surveys and the lack of clear survey methods make recreational fisheries economic data difficult to compare with commercial fisheries economic data.

3. The most recent available recreational fishing economic data from NMFS are summarized in *Fisheries Economics of the United States, 2006* (NMFS 2008a) and detailed in Gentner and Steinback (2008). In this study, economic intercept surveys were added onto the traditional MRFSS survey methodology discussed above in Section 530.7.2. This survey includes direct impacts, which occur when anglers spend money at fishing-related businesses, indirect impacts, based on expenditures by the fishing-related businesses on supplies and operating costs for their business, and inducted impacts, which occur when employees in the direct and indirect sectors make purchases as a part of normal household consumption. The resulting estimates of the multiplier effects from these activities represent the impacts from saltwater sportfishing expenditures to the economy (Gentner and Steinback 2008). The data include expenditures by both residents and non-residents; expenditures by non-residents are higher in Rhode Island than those for residents, typically because they have to travel further and are more likely to stay overnight in the state, producing an overall net increase in economic impacts from saltwater recreational fishing to the state (Gentner and Steinback 2008).

4. This study found that in 2006, recreational anglers spent an estimated $182,606,000 on recreational fishing. This figure includes both trip expenditures and durable equipment expenditures. This study estimated that fishermen spent an estimated $60,412,000 on

[34] A prior study was conducted in 1998 and published in 2004 (Steinback, Gentner, and Castle 2004). NMFS has conducted an updated study based on 2008 data, but at the time of this writing, study results are not yet available.

fishing trips; Rhode Island residents fishing in-state spent $18,727,000, and non-residents fishing in Rhode Island spent $41,685,000. This study also found that total durable equipment expenditures for recreational fishing in Rhode Island, including fishing tackle, other equipment, boats, and the vehicles and second home expenses related to recreational fishing, at $122,194,000. At over $55 million, fishing tackle represents the greatest expenditure for recreational fishermen. In addition, because of the costs associated with owning and operating a boat, boat-based fishing is a significant economic driver within the state, with $11 million in expenses by residents and an additional $12 million by non-residents. See Tables 5.48 and 5.49 for more information.

Table 5.48. Angler trip expenses, 2006. (NMFS 2008a)

Fishing Mode	Expenditures- non-residents	Expenditures – residents
Private Boat	$11,858,000	$11,130,000
Shore	$25,522,000	$6,634,000
For-Hire	$4,305,000	$963,000
Total	**$41,685,000**	**$18,727,000**

Table 5.49. Durable equipment expenditures, 2006. (NMFS 2008a)

Durable Equipment	Expenditure
Fishing Tackle	$55,326,000
Other Equipment	$17,367,000
Boat Expenses	$22,042,000
Vehicle Expenses	$25,660,000
Second Home Expenses	$1,799,000
Total Durable Equipment Expenditures	**$122,194,000**

5. This study also estimated that in 2006, the total impact from RI marine recreational fishing was $166,869,000 (see Table 5.50). This includes both resident and non-resident activity. The 2006 estimated value added for Rhode Island based on expenditures was roughly $82 million, and the 2006 income impact was estimated at over $52 million. This survey further estimated that 1,476 jobs in Rhode Island are the result of expenditures on marine recreational fishing, of which 1,001 are the result of direct expenditures (Gentner and Steinback 2008).

Table 5.50. Economic impacts from recreational fishing in Rhode Island, 2006. (Gentner and Steinback 2008)

Impact Type	Resident Status	Expenditures	Direct Impact	Indirect Impact	Induced Impact	Total Impact
Output ($1,000)	Resident	$75,823	$50,586	$14,441	$13,688	**$78,684**
	Non-Resident	$106,783	$57,765	$14,913	$15,506	**$88,184**
	Total	**$182,606**	**$108,351**	**$29,324**	**$29,194**	**$166,869**
Value Added ($1,000)	Resident	$75,823	$21,312	$8,261	$8,394	**$37,967**
	Non-Resident	$106,783	$26,535	$7,916	$9,628	**$44,079**
	Total	**$182,606**	**$47,847**	**$16,177**	**$18,022**	**$82,046**

Income ($1,000)	Resident	$75,823	$15,247	$4,964	$4,503	**$24,714**
	Non-Resident	$106,783	$17,588	$4,834	$5,285	**$27,707**
	Total	**$182,606**	**$32,836**	**$9,798**	**$9,787**	**$52,422**
Employment (jobs)	Resident	$75,823	414	102	123	**639**
	Non-Resident	$106,783	587	110	140	**836**
	Total	**$182,606**	**1,001**	**212**	**263**	**1,476**

6. A prior NMFS study using 1998 survey data (Steinback et al. 2004) also assessed the economic impact of recreational fishing in RI. This study indicated that recreational fishing supported 1,068 jobs and the total economic impact of recreational fishing expenditures exceeded $93 million (2000 dollars). Note that this figure is not inflation-adjusted and therefore cannot be directly compared with the 2006 data presented above. While small methodological changes make it difficult to compare between this and the current study on a state-by-state basis, Gentner and Steinback (2008) indicate that for the nation as a whole, recreational fishing expenditures have increased 79% in comparison to inflation-adjusted estimates for 2000 (Gentner and Steinback 2008).

7. Another survey based on 2006 survey data, the U.S. Fish and Wildlife Service (FWS) National Survey of Fishing, Hunting, and Wildlife Associated Recreation, estimated a total of 158,000 anglers fishing in Rhode Island, of which 82,000 were from out of state[35]. These figures, which are much more conservative estimates than those provided by the MRFSS program (see Section 530.7.2 above), include both saltwater and freshwater fishing – saltwater fishing only had an estimated 122,000 anglers. This survey places the total recreational fishing-related expenditures in the state of Rhode Island at $153,694,000 for both fishing trip and equipment expenses. This total includes both saltwater and freshwater fishing for an average of $968 per angler. When only saltwater fishing is considered, the total expenditures are placed at $115,913,000, a considerably lower estimate than for the MRFSS program (U.S. Fish & Wildlife Service 2006). There are a few reasons why the NMFS estimates are so much higher than the USFWS survey. The NMFS survey estimates much higher rates of participation in marine recreational fishing, in part because of differences in sampling procedures. The NMFS survey targets marine anglers specifically, as opposed to both salt and freshwater fishing. Additionally, the NMFS survey contains many more expenditure categories than does the USFWS survey (Gentner and Steinback 2008).

8. A 2007 recreational fishing economic impact study commissioned by RISAA incorporated results from an intercept study as well as pre-existing datasets from numerous other sources including NMFS (1998 data summarized in Steinback et al. 2004) and a 2001 survey conducted by the FWS. This study found that the annual direct expenditures of RI recreational saltwater anglers are $70 million, and that RI recreational fishing has a total economic impact of $160 million (Ninigret Partners 2007). These figures are more conservative than those included in the NMFS and FWS studies described above; this may be due to the fact that this study included older survey data than was included in the above-mentioned studies.

[35] This U.S. Fish and Wildlife Service survey is conducted every five years.

Section 550. Impacts of Existing Activities and Trends on Fisheries Resources and Habitats

1. By definition, fishing impacts fisheries resources, and in some instances, habitats. Other existing activities that will affect fisheries and fish habitat include, but are not restricted to: coastal development; introduced species; marine transportation; and marine fisheries diseases (Johnson et al. 2008). These impacts are discussed below.[36]

2. Potential future uses of the Ocean SAMP area, which may include offshore renewable energy development or other activities, may also have impacts on fisheries resources. See Chapter 8, Renewable Energy and Other Offshore Development, and Chapter 9, Other Future Uses for further discussion of these issues.

550.1. Fisheries and Overfishing

1. A significant impact on fisheries resources in the Ocean SAMP area comes from fishing activity. Fishing of any kind will have an effect on the ecosystem. Fishing can have both primary and secondary impacts on fish populations and species assemblages, including population declines from overfishing (defined in the Magnuson Stevens Fishery Conservation and Management Act as fishing at a rate or level or mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis) and from shifts in community dynamics.

2. At present, seven of the species of importance to commercial and recreational fisheries are either listed as overfished or overfishing is occurring on the stock (Atlantic cod, American lobster, bluefin tuna, tautog, winter flounder, winter skate, and yellowtail flounder – see Table 5.2 for a list of all species of importance and their status). Many of the other species found with in the Ocean SAMP area have been in the past or are in danger of becoming overfished. Overfishing can lead to a reduction in recruitment, or of fish growing large enough and old enough to spawn, as well as to a decline in the average size of targeted species (e.g. Collie et al. 2008; Fogarty and Murawski 1998).[37]

3. Fishing can change the species composition in the food web. The intense harvest of certain stocks will change the ecological balance of an area by causing the decline of that stock; that stock's decline may in turn have an impact on species which relied on the depleted stock for food, or have an impact on other species which become the new food source for hungry predators. For example, on Georges Bank, as groundfish populations have declined, dogfish and skate populations, which target similar prey, exploded (Fogarty and Murawski 1998). Likewise, a decline in cod populations in the North Atlantic has led to increased abundance of certain invertebrates such as lobster and crab that are commonly eaten by cod. Overfishing may also have indirect ecosystem effects,

[36] Johnson et al. (2008) also list coastal-based issues including the alteration of freshwater systems, agriculture, and the chemical and physical effects from water intake and discharge facilities. These issues are not enumerated here because they primarily impact the near-shore environment, and are less relevant to the offshore areas of the Ocean SAMP. Additionally, Johnson et al. (2008) have listed energy-related activities and dredging and disposal activities as potentially impacting fish habitat. These activities are discussed further in Chapter 9: *Other Future Uses*.

[37] It should be noted that a stock can be overfished with overfishing not occurring, or conversely, overfishing can occur on a stock that has not yet been found to be overfished.

as smaller species may proliferate when their predators are reduced through fishing pressure (Piet and Jennings 2005). In Narragansett Bay and in at least some parts of the Ocean SAMP area, it has been demonstrated that the species composition has shifted from one dominated by benthic fish species to one dominated by pelagic fish and benthic invertebrates, in part because of the impact of fishing on benthic fish species (Collie et al. 2008). See Chapter 2, Ecology of the Ocean SAMP Region for further discussion of this shift.

4. Bycatch, including the incidental and regulatory discard of species in commercial and recreational fisheries, can negatively alter the species composition inhabiting the ecosystems of the Ocean SAMP area, and additionally is a waste of valuable fisheries resources.

5. Fishing activity can also impact fish habitat, particularly through the use of bottom fishing gear. Trawls and dredges physically damage the sediment surface, and a large portion of the epifaunal species living there (such as sponges, corals, and tube worms) are damaged or removed (Olsgard et al. 2008). Collie et al. (2000) found that one trawling pass may reduce the abundance of fauna by as much as 55%. These benthic communities provide habitat for other species, as well as providing food for fish species and shelter for juveniles (Collie et al. 2004). This loss of habitat complexity may have important consequences for fish species (Collie et al. 2000). Bottom fishing may also reduce the abundance of prey species important to commercially and recreationally important fish species. The particular effects, both initial and long-term, will depend on the sediment type, the sensitivity of benthic organisms to disturbance, the level of natural disturbance, and the type of fishing gear being used. The impact of trawling will be higher at locations that experience low levels of natural disturbance, such as sites in deeper water, than those areas frequently subject to natural disturbance such as wave action (Hiddink et al. 2006). Some soft-sediment habitats, such as sand and mud, may be able to recover fully within a year, while other bottom types may take longer (Collie et al. 2004). Intensively fished areas may remain in a permanently altered state (Collie et al. 2000). Some areas are trawled repeatedly; the initial impact of trawling on pristine habitat will be much larger than further trawling activity in previously fished areas (Hiddink et al. 2006). Areas that are frequently trawled may be dominated by small-bodied, opportunistic species (Olsgard et al. 2008), as they can withstand higher rates of mortality, as opposed to large invertebrates, whose abundance may be reduced through trawling disturbance because of their slow life history (Hiddink et al. 2008). This loss of large invertebrates may lead to a loss of local biodiversity (Hiddink et al. 2006). Trawling may have some positive secondary effects for fish species that primarily feed on small invertebrates by increasing food production of these species; this does not necessarily mean the net effects of trawling are positive for these species, however, because of the undesirable ecosystem-level effects (Hiddink et al. 2008). These impacts to habitat can have secondary effects on fish stocks and on the ecosystem as a whole.

6. Overall, there is a lack of adequate methods to assess trawling impacts at the fishery scale, and the problem has not been addressed at an ecosystem level. These impacts to habitat can have secondary effects on fish stocks and on the ecosystem as a whole. To address this problem, the New England Fishery Management Council is in the process of

developing an Omnibus Habitat Amendment that will address the effects of fishing on Essential Fish habitat. The Council is also in the process of developing the Swept Area Seabed Impact (SASI) Model. The model includes ten different categories of fishing gear, and will be used to quantitatively assess the effects of fishing to Essential Fish Habitat. The SASI model may be available for use sometime in 2011 (Bachman pers. comm.).

550.2. Coastal Development

1. Threats to fish habitat in the Ocean SAMP area from coastal development primarily result from the discharge of nonpoint source pollution and urban runoff, and specifically the introduction of pathogens, petroleum products, heavy metals, pesticides, and other pollutants that can affect marine organisms, even in offshore environments. These pollutants may sometimes have direct toxic effects on fish, but are more likely to have sublethal effects that may inhibit the development and reproduction of marine organisms. Metals, for example, including mercury, lead, copper, and cadmium, can be lethal to fish at high concentrations, and may also produce effects such as reduced hatch rates of eggs, increased larval mortality, developmental problems in larvae, and endocrine disruption. While many of these problems may not have a significant effect on many marine organisms, metals as well as other compounds bioaccumulate, moving up the food chain through trophic levels resulting in higher and more damaging concentrations in top predators, as well as causing health problems in human consumers of fish (Johnson et al. 2008).

2. Eutrophication resulting from nutrient loading can also be a threat, particularly to the inshore portions of the Ocean SAMP area. These threats can also impact sensitive estuarine nursery and spawning areas, including Narragansett Bay, of the fish species found in the Ocean SAMP area (Johnson et al. 2008).

550.3. Introduced Species

1. The introduction of nonnative species is another threat to fish and fish habitat. Introduced species may include finfish, shellfish, plankton, bacteria, viruses, and pathogens. Introduced species can cause alterations to habitat, species communities, species diversity, and food webs, as well as introducing diseases, affecting the health of native species, and affecting water quality. For example, the green crab, one of the most common crustaceans in New England waters, is an introduced species from Europe that grazes on submerged aquatic vegetation and preys on newly settled winter flounder. *Didemnum* is an invasive tunicate that has colonized parts of Georges Bank as well as many coastal areas in New England. This benthic filter-feeder forms dense mats along the seafloor that prevent the settlement of other benthic organisms, smother benthic organisms beneath it, and reduce food availability for juvenile scallops and groundfish. *Didemnum* also has the ability to change the benthic community structure; it has been observed to transform heterogeneous gravel habitat into a homogeneous tunicate mat, reducing important habitat for species such as cod, haddock, and scallops. The changes to the benthic habitat that occur from bottom trawling and scallop dredging are likely to contribute to the spread of *Didemnum* (Lengyel et al. 2009). Nonnative species are likely

to be introduced through the ballast water of ships coming into or passing through the area from elsewhere, or through aquaculture operations (Johnson et al. 2008).

2. Introduced species are discussed in more detail in Chapter 2, Ecology of the Ocean SAMP Region.

550.4. Marine Transportation

1. There is a great deal of commercial shipping through the Ocean SAMP area, and this activity may have a variety of impacts on fisheries resources. Commercial shipping may create habitat disturbances by disturbing sediment when operating close to shore, in shallow waters, or when anchoring. It may also increase underwater noise, which may affect some fish species (see Chapter 8, Renewable Energy and Other Offshore Development for further discussion). Vessel operations may also increase the likelihood that invasive species or pollutants, such as petroleum products, are introduced into the environment. Much of the Ocean SAMP area shipping traffic involves the movement of petroleum products. While oil spills are infrequent, such spills can have a major impact on marine species and on habitat. These impacts can disrupt benthic community composition and oil can persist in sediments for years after a spill. In addition, the noise generated by commercial ship traffic can adversely affect fishery resources, impacting fish spawning, migration, and recruitment behaviors (Johnson et al. 2008). In January 1996, the *North Cape* barge ran aground off South Kingstown, in the Ocean SAMP area, and spilled approximately 828,000 gallons of home heating oil into Block Island Sound and the South County coastal salt ponds. The result was a significant loss of lobster, finfish, surf clams, seabirds, and other species, and significant impacts on the commercial fishing and lobstering as well as recreational fishing industries in the state (NOAA General Counsel for Natural Resources 2010). See Chapter 7, Marine Transportation, Navigation, and Infrastructure for further discussion.

550.5. Dredged Material Disposal

1. The disposal of dredged materials offshore involves environmental effects beyond those produced in the dredging process. The U.S. Army Corps of Engineers disposes approximately 65% of its dredged materials in open waters. For dredged material to be disposed of offshore, it must be demonstrated that the sediment is compatible with the sediment at the disposal site, and that the disposal will not disrupt the benthic habitat or communities (Johnson et al. 2008). Yet the disposal of dredged material can still have a significant impact. Benthic organisms may be buried in the process, and more mobile species may leave the area. Recolonization may increase the occurrence of opportunistic species. These processes may affect fish by reducing prey availability. Dumping may change the biological and chemical characteristics of the sediment, and will temporarily increase the turbidity of the water column. The increased volume of suspended sediments is likely to push some fish out of the area, may affect foraging patterns, and can even cause injury or death. Sedimentation may also affect the viability of fish eggs and larvae. On the other hand, some species, including lobster and winter flounder, have been found to be attracted to dredge disposal sites (Johnson et al. 2008). The disposal of dredged material can also result in a release of contaminants, making contaminants biologically

available to organisms in the water column or through the food chain. However, this is only likely to occur in trace amounts, as generally the disposal of toxic materials through offshore dumping is prohibited (Johnson et al. 2008).

550.6. Marine Debris

1. Marine debris is an issue in the Ocean SAMP area as it is in the rest of the world's oceans. Marine debris may be anything accidentally or intentionally discarded that makes its way into the ocean, and can include various types of plastics, such as bags, bottles, or fishing gear. One of the major impacts from marine debris is the entanglement of marine wildlife, including fish, causing injury or death. A particularly relevant problem for the Ocean SAMP area may also be the impact of ghost gear, or lost or abandoned fishing gear, that continues to catch fish long after it has been lost. Marine debris, including ghost gear, can also damage benthic habitats.

550.7. Marine Fisheries Diseases

1. Marine diseases, including lobster shell disease and mycobacteriosis in striped bass, are another factor affecting fisheries resources within the Ocean SAMP area. Marine diseases are discussed further in Chapter 2, Ecology of the Ocean SAMP Region.

550.8. Global Climate Change

1. Global climate change is having, and will likely continue to have, significant impacts on fisheries resources. Temperature changes can affect the location and timing of spawning, as well as the timing of plankton blooms and the availability of food, which in turn can impact the growth and survival of commercially important fish species. The warming water temperatures are also likely to cause shifts in distribution, with species moving further north or into deeper waters. Some species important to Rhode Island commercial fisheries, such as cod and lobster, may shift their range out of the Ocean SAMP area, while other species found more typically to the south may become more abundant off Rhode Island. See Chapter 3, Global Climate Change for further discussion.

Section 560. Policies and Standards

560.1. General Policies

1. The commercial and recreational fishing industries, and the habitats and biological resources of the ecosystem they are based on, are of vital economic, social, and cultural importance to Rhode Island's fishing ports and communities. Commercial and recreational fisheries are also of great importance to Rhode Island's economy and to the quality of life experienced by both residents and visitors. The Council finds that other uses of the SAMP area could potentially displace commercial or recreational fishing activities or have other adverse impacts on commercial and recreational fisheries.

2. The Council recognizes that finfish, shellfish, and crustacean resources and related fishing activities are managed by a host of different agencies and regulatory bodies which have jurisdiction over different species and/or different parts of the SAMP area. Entities involved in managing fish and fisheries within the SAMP area include, but are not limited to, the Atlantic States Marine Fisheries Commission, the RI Department of Environmental Management, the RI Marine Fisheries Council, the NOAA National Marine Fisheries Service, the New England Fishery Management Council, and the Mid-Atlantic Fishery Management Council. The Council recognizes the jurisdiction of these organizations in fishery management and will work with these entities to protect fisheries resources. The Council will also work in coordination with these entities to protect priority habitat areas.

3. The Council's policy is to protect commercial and recreational fisheries within the SAMP area from the adverse impacts of other uses, while supporting actions to make ongoing fishing practices more sustainable. It should be recognized that scientific knowledge of the impacts of fishing on habitats and fish populations will advance. Improvements in more sustainable gear technology, fishing practices, and management tools may improve the state of fisheries resources. A general goal of the Council is to constantly improve the health of the Ocean SAMP area ecosystem and the populations of fish and shellfish it provides. Cooperative research, utilizing the unique skills and expertise of the fishing community, will be a cornerstone to this goal.

4. Commercial and recreational fisheries activities are dynamic, taking place at different places at different times of the year due to seasonal species migrations and other factors. The Council recognizes that fisheries are dynamic, shaped by these seasonal migrations as well as other factors including shifts in the regulatory environment, market demand, and global climate change. The Council further recognizes that the entire Ocean SAMP area is used by commercial and recreational fishermen employing different fishing methods and gear types. Changes in existing uses, intensification of uses, and new uses within the area could cause adverse impacts to these fisheries. Accordingly, the Council shall:

    i. In consultation with the Fishermen's Advisory Board, as defined in section 560.2.1, identify and evaluate prime fishing areas on an ongoing basis through an adaptive framework.

ii. Review any uses or activities that could disrupt commercial and recreational fisheries activities.

5. The Council shall work together with the U.S. Coast Guard, the U.S. Navy, the U.S. Army Corps of Engineers, NOAA, fishermen's organizations, marine pilots, recreational boating organizations, and other marine safety organizations to promote safe navigation, fishing, and recreational boating activity around and through offshore structures and developments, and along cable routes, during the construction, operation, and decommissioning phases of such projects. The Council will promote and support the education of all mariners regarding safe navigation around offshore structures and developments and along cable routes.

6. Discussions with the U.S. Coast Guard, the U.S. Department of Interior Bureau of Ocean Energy Management, Regulation, and Enforcement, and the U.S. Army Corps of Engineers have indicated that no vessel access restrictions are planned for the waters around and through offshore structures and developments, or along cable routes, except for those necessary for navigational safety. Commercial and recreational fishing and boating access around and through offshore structures and developments and along cable routes is a critical means of mitigating the potential adverse impacts of offshore structures on commercial and recreational fisheries and recreational boating. The Council endorses this approach and shall work to ensure that the waters surrounding offshore structures, developments, and cable routes remain open to commercial and recreational fishing, marine transportation, and recreational boating, except for navigational safety restrictions. The Council requests that federal agencies notify the Council as soon as is practicable of any federal action that may affect vessel access around and through offshore structures and developments and along cable routes. The Council will continue to monitor changes to navigational activities around and through offshore developments and along cable routes. Any changes affecting existing navigational activities may be subject to CZMA Federal Consistency review if the federal agency determines its activity will have reasonably foreseeable effects on the uses or resources of Rhode Island's coastal zone.

7. The Council recognizes that commercial and recreational fishermen from other states, such as the neighboring states of Connecticut, New York, and Massachusetts, often fish in the Ocean SAMP area. The Council also recognizes that many fish species that are harvested in adjacent waters may rely on habitats and prey located within the Ocean SAMP area. Accordingly, the Council will work with neighboring states to ensure that Offshore Development and other uses of the Ocean SAMP area do not result in significant impacts to the fisheries resources or activities of other states.

8. The Council shall appoint a standing Fishermen's Advisory Board (FAB) which shall provide advice to the Council on the siting and construction of other uses in marine waters. The FAB is an advisory body to the Council that is not intended to supplant any existing authority of any other federal or state agency responsible for the management of fisheries, including but not limited to the Marine Fisheries Council and its authorities set forth in R.I.G.L. 20-3-1 *et. seq*. The FAB shall be comprised of nine members, one representing each of the following six Rhode Island fisheries: bottom trawling; scallop

dredging; gillnetting; lobstering; party and charter boat fishing; and recreational angling; and three members, including two commercial fishermen and one recreational fisherman, who are Massachusetts fishermen who fish in the Ocean SAMP area. FAB members shall serve four-year terms and shall serve no more than two consecutive terms. The Council shall provide to the FAB a semi-annual status report on Ocean SAMP area fisheries-related issues, including but not limited to those of which the Council is cognizant in its planning and regulatory activities, and shall notify the FAB in writing concerning any project in the Ocean SAMP area. The FAB shall meet not less than semi-annually with the Habitat Advisory Board and on an as-needed basis to provide the Council with advice on the potential adverse impacts of other uses on commercial and recreational fishermen and fisheries activities, and on issues including, but not limited to, the evaluation and planning of project locations, arrangements, and alternatives; micro-siting (siting of individual wind turbines within a wind farm to identify the best site for each individual structure); access limitations; and measures to mitigate the potential impacts of such projects on the fishery. In addition the FAB may aid the Council and its staff in developing and implementing a research agenda. As new information becomes available and the scientific understanding of the Ocean SAMP planning area evolves, the FAB may identify new areas with unique or fragile physical features, important natural habitats, or areas of high natural productivity for designation by the Council as Areas of Particular Concern or Areas Designated for Preservation.

560.2. Regulatory Standards

1. Any Large-Scale Offshore Development, as defined in section 1160.1.1, shall require a meeting between the Fisherman's Advisory Board (FAB), the applicant, and the Council staff to discuss potential fishery-related impacts, such as, but not limited to, project location, construction schedules, alternative locations, project minimization and identification of high fishing activity or habitat edges. For any state permit process for a Large-Scale Offshore Development this meeting shall occur prior to submission of the state permit application. The Council cannot require a pre-application meeting for federal permit applications, but the Council strongly encourages applicants for any Large-Scale Offshore Development, as defined in Section 1160.1.1, in federal waters to meet with the FAB and the Council staff prior to the submission of a federal application, lease, license, or authorization. However, for federal permit applicants, a meeting with the FAB shall be necessary data and information required for federal consistency reviews for purposes of starting the CZMA 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930, subpart E, pursuant to 15 C.F.R. § 930.58(a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project.

2. The Council shall prohibit any other uses or activities that would result in significant long-term negative impacts to Rhode Island's commercial or recreational fisheries. Long-term impacts are defined as those that affect more than one or two seasons.

3. The Council shall require that the potential adverse impacts of Offshore Developments and other uses on commercial or recreational fisheries be evaluated, considered, and mitigated as described in section 560.2.4.

4. For the purposes of Sections 560.1-560.2, mitigation is defined as a process to make whole those fisheries user groups that are adversely affected by proposals to be undertaken, or undertaken projects, in the Ocean SAMP area. Mitigation measures shall be in consonance with the purposes of duly adopted fisheries management plans, programs, strategies and regulations of the agencies and regulatory bodies with jurisdiction over fisheries in the SAMP area, including but not limited to those set forth above in 560.1.2. Mitigation shall not be designed or implemented in a manner that substantially diminishes the effectiveness of duly adopted fisheries management programs. Mitigation measures may include, but are not limited to, compensation, effort reduction, habitat preservation, restoration and construction, marketing, and infrastructure improvements. Where there are potential impacts associated with proposed projects, the need for mitigation shall be presumed. Negotiation of mitigation agreements shall be a necessary condition of any approval or permit of a project by the Council. Mitigation shall be negotiated between the Council staff, the FAB, the project developer, and approved by the Council. The reasonable costs associated with the negotiation, which may include data collection and analysis, technical and financial analysis, and legal costs, shall be borne by the applicant. The applicant shall establish and maintain either an escrow account to cover said costs of this negotiation or such other mechanism as set forth in the permit or approval condition pertaining to mitigation. This policy shall apply to all Large-Scale Offshore Developments, underwater cables, and other projects as determined by the Council.

5. Glacial moraines are important habitat areas for a diversity of fish and other marine plants and animals because of their relative structural permanence and structural complexity. Glacial moraines create a unique bottom topography that allows for habitat diversity and complexity, which allows for species diversity in these areas and creates environments that exhibit some of the highest biodiversity within the entire Ocean SAMP area. The Council also recognizes that because glacial moraines contain valuable habitats for fish and other marine life, they are also important to commercial and recreational fishermen. Accordingly, the Council shall designate glacial moraines as identified in Chapter 11, Figures 11.3 and 11.4, as Areas of Particular Concern. For further information on Areas of Particular Concern see Chapter 11, The Policies of the Ocean SAMP.

6. The Council recognizes that moraine edges, as illustrated in Figure 11.3 and Figure 11.4 in Chapter 11, The Policies of the Ocean SAMP, are important to fishermen. In addition to these mapped areas, the FAB may identify other edge areas that are important to fisheries within a proposed project location. The Council shall consider the potential adverse impacts of future activities or projects on these areas to Rhode Island's commercial and recreational fisheries. Where it is determined that there is a significant adverse impact, the Council will modify or deny activities that would impact these areas. In addition, the Council will require assent holders for Offshore Developments to employ micro-siting techniques in order to minimize the potential impacts of such projects on these edge areas.

7. The finfish, shellfish, and crustacean species that are targeted by commercial and recreational fishermen rely on appropriate habitat at all stages of their life cycles. While all fish habitat is important, spawning and nursery areas are especially important in providing shelter for these species during the most vulnerable stages of their life cycles. The Council shall protect sensitive habitats where they have been identified through the Site Assessment Plan or Construction and Operation Plan review processes for Offshore Developments as described in Section 1160.5 in Chapter 11, The Policies of the Ocean SAMP.

8. The Council shall consult with the U.S. Coast Guard, the U.S. Navy, marine pilots, the FAB, fishermen's organizations, and recreational boating organizations when scheduling offshore marine construction or dredging activities. Where it is determined there is a significant conflict with season-limited commercial or recreational fisheries activities, recreational boating activities or scheduled events, or other navigation uses, the Council shall modify or deny activities to minimize conflict with these uses.

9. The Council shall require the assent holder to provide for communication with commercial and recreational fishermen, mariners, and recreational boaters regarding offshore marine construction or dredging activities. Communication shall be facilitated through a project website and shall complement standard U.S. Coast Guard procedures such as Notices to Mariners for notifying mariners of obstructions to navigation.

10. For all Large-Scale Offshore Developments, underwater cables, and other development projects as determined by the Council, the assent holder shall designate and fund a third-party fisheries liaison. The fisheries liaison must be knowledgeable about fisheries and shall facilitate direct communication between commercial and recreational fishermen and the project developer. Commercial and recreational fishermen shall have regular contact with and direct access to the fisheries liaison throughout all stages of an offshore development (pre-construction; construction; operation; and decommissioning).

11. Where possible, Offshore Developments should be designed in a configuration to minimize adverse impacts on other user groups, which include but are not limited to: recreational boaters and fishermen, commercial fishermen, commercial ship operators, or other vessel operators in the project area. Configurations which may minimize adverse impacts on vessel traffic include, but are not limited to, the incorporation of a traffic lane through a development to facilitate safe and direct navigation through, rather than around, an Offshore Development.

12. The items listed below shall be required for all Offshore Developments:

    i. A biological assessment of commercially and recreationally targeted species shall be required within the project area for all Offshore Developments. This assessment shall assess the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. Such an assessment shall be performed at least four times:

pre-construction (to assess baseline conditions); during construction; and at two different intervals during operation (i.e. 1 year after construction and then post-construction). At each time this assessment must capture all four seasons of the year. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site. The Council will not require this assessment for proposed projects within the Renewable Energy Zone that are proposed within two years of the adoption of the Ocean SAMP.

ii. An assessment of commercial and recreational fisheries effort, landings, and landings value shall be required for all Offshore Developments. Assessment shall focus on the proposed project area and alternatives. This assessment shall evaluate commercial and recreational fishing effort, landings, and landings value at three different stages: pre-construction (to assess baseline conditions); during construction; and during operation. At each stage, all four seasons of the year must be evaluated. Assessment may use existing fisheries monitoring data but shall be supplemented by interviews with commercial and recreational fishermen. Assessment shall address whether fishing effort, landings, and landings value has changed in comparison to baseline conditions. The Council will not require this assessment for proposed projects within the Renewable Energy Zone that are proposed within 2 years of the adoption of the Ocean SAMP.

Section 570. Works Cited

Allen, G. 2010. Bluefin tuna in Narragansett Bay – A look back. RI Saltwater Anglers Association newsletter, April 2010.

Atlantic Coastal Cooperative Statistics Program. 2010. Commercial Catch and Effort Data. Accessed May 26, 2010 from: http://www.accsp.org/dataware.htm

Atlantic Menhaden Technical Committee. 2006. *2006 Stock Assessment Report for Atlantic Menhaden*. Online at: www.asmfc.org.

Atlantic States Marine Fisheries Commission. 2009a. *American Lobster Stock Assessment Report for Peer Review*. Online at: www.asmfc.org/americanLobster.htm. Last accessed June 21, 2010.

Atlantic States Marine Fisheries Commission. 2009b. Species Profile: Black Sea Bass. Online at: www.asmfc.org/blackseabass.htm. Last accessed March 25, 2010.

Atlantic States Marine Fisheries Commission. 2009c. Species Profile: Atlantic Sturgeon. Online at www.asmfc.org/Atlanticsturgeon.htm. Revised April 2009. Last accessed June 21, 2010.

Atlantic States Marine Fisheries Commission. 2008a. *ASMFC Stock Status Overview*.

Atlantic States Marine Fisheries Commission. 2008b. Annual Coast Striped Bass Landings, 1982-2008. Online at http://www.asmfc.org/stripedbass.htm. Last accessed March 23, 2010.

Atlantic States Marine Fisheries Commission. 2008c. Species Profile: Summer Flounder. Online at: www.asmfc.org/sumerflounder.htm. Last accessed March 25, 2010.

Atlantic States Marine Fisheries Commission. 2008d. Interstate Fishery Management Plan for Atlantic Coastal Sharks. Online at http://www.asmfc.org/speciesDocuments/coastalSharks.htm.

Bachman, Michelle. 2010. New England Fishery Management Council. Personal communication, May 26, 2010.

Atlantic States Marine Fisheries Commission. 2007. Species Profile: Shad & River Herring. Online at: www.asmfc.org. Revised October 2007.

Bellavance, Rick. 2010. Rhode Island Party and Charter Boat Association. Personal communication, April 28, 2010.

Bigelow, H.B.; Schroeder, W.C. 1953. Fishes of the Gulf of Maine. Volume 53: Fishery Bulletin of the Fish and Wildlife Service. Washington: United States Government Printing Office.

Blount, Frank, Frances Fleet. Personal communication, July 13, 2009.

Bohaboy, E., Collie, J., Malek, A. 2010. Baseline Characterization. *Appendix A* to Ocean SAMP Chapter 5, *Commercial and Recreational Fisheries Resources and Uses*.

Bowman, R.E., Stillwell, C.E., Michaels, W.L., Grosslein, M.D. 2000. Food of Northwest Atlantic fishes and two common species of squid. NOAA Tech. Memo. NMFS-F/NE-155, 138 pp.

Buckley, L., Collie, J., Kaplan, L.A.E., Crivello, J. 2008. Winter flounder larval genetic population structure in Narragansett Bay, RI: Recruitment to juvenile young-of-the-year. *Estuaries and Coasts,* 31: 745-754.

Convention on International Trade in Endangered Species (CITES). 2009. Proposal to include Atlantic Bluefin Tuna (*Thunnus thynnus*) on Appendix I of CITES in accordance with Article II 1 of the Convention. October 2009. Available online from: http://www.cites.org/common/cop/15/raw_props/E-15%20Prop-MC%20T%20thynnus.pdf. Last accessed June 21, 2010.

CITES. 2010. CITES conference ends without new sharks in its net. Press release, March 25, 2010, online at http://www.cites.org/eng/news/press_release.shtml. Last accessed June 21, 2010.

Clay, P., Colburn, L., Olsen, J., Pinto da Silva, P., Smith, S., Westwood, A., Ekstrom, J. 2008. *Community Profiles for the Northeast US Fisheries*. Northeast Fisheries Science Center, NOAA. Available at: http://www.nefsc.noaa.gov/read/socialsci/community_profiles/

Cobb, J.S., Wahle, R.A. 1994. Early Life History and Recruitment Processes of Clawed Lobsters. *Crustaceana, 67*(1): 1-25.

Collette, B.B., Klein-MacPhee, G., eds. 2002. *Bigelow and Schroeder's Fishes of the Gulf of Maine*. Third Edition. Washington, D.C.: Smithsonian Institute Press.

Collie, J.S., Hall, S.J., Kaiser, M.J., Poiner, I.R. 2000. A Quantitative Analysis of Fishing Impacts on Shelf-Sea Benthos. *Journal of Animal Ecology,* 69 (5): 785-798.

Collie, J.S., Hermsen, J.M., Valentine, P.C., Almeida, F.P. 2004. Effects of fishing on gravel habitats: assessment and recovery of benthic megafauna on Georges Bank. In: *Benthic habitats and the effects of fishing.* Barnes, P. and Thomas, J., (eds). American Fisheries Society, Bethesda, MD. In press.

Collie, J.S., Wood, A.D., Jeffries, H.P. 2008. Long-term shifts in the species composition of a coastal fish community. *Canadian Journal of Fisheries and Aquatic Sciences,* 65: 1352-1365.

Collie, Jeremy. 2009. URI Graduate School of Oceanography. Personal communication, December 4, 2009.

Conley, P. 1986. *An Album of Rhode Island History, 1636 – 1986*. Virginia Beach, VA: Donning Company Publishers.

Crocker, Julie. 2010. NMFS Northeast Regional Office Protected Resources Division. Personal Communication a, February 3, 2010.

Crocker, Julie. 2010. NMFS Northeast Regional Office Protected Resources Division. Personal Communication b, March 23, 2010.

DeAlteris, J.T., Gibson, M., Skrobe, L.G. 2000. *Fisheries of Rhode Island* (Working Draft). Narragansett Bay Summit 2000: White Paper.

Donilon, Charlie. 2009. Rhode Island Party and Charter Boat Association, Personal communication, June 23, 2009.

Fogarty, M.J., Murawski, S.A. 1998. Large-scale disturbance and the structure of marine systems: Fishery impacts on Georges Bank. *Ecological Applications,* 8(1) Supplement: S6-S22.

Gentner, B., Steinback, S. 2008. *The Economic Contribution of Marine Angler Expenditures in the United States, 2006.* U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-94.

Griffith, D., Dyer, C.L. 1996. *An Appraisal of the Social and Cultural Aspects of the Multispecies Groundfish Fishery in the New England and the Mid-Atlantic Regions*. Report prepared under Contract Number 50-DGNF-5-00008, National Oceanic and Atmospheric Admin and Aguirre International [cited Jan 2007]. Available at: http://www.nefsc.noaa.gov/clay/overvue.htm

Hall-Arber, M., Dyer, C., Poggie, J., McNally, J., Gagne, R. 2001. *New England's Fishing Communities*. Cambridge (MA): MIT Sea Grant 01-15. Available from: http://seagrant.mit.edu/cmss/marfin/index.html. Last accessed June 21, 2010

Hiddink, J.G., Jennings, S., Kaiser, M.J., Queirós, A.M., Duplisea, D.E., Piet, G.J. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. *Canadian Journal of Fisheries and Aquatic Sciences*, 63: 721-736.

Hiddink, J.G., Rijnsdorp, A.D., Piet, G. 2008. Can bottom trawling disturbance increase food production for a commercial fish species? *Canadian Journal of Fisheries and Aquatic Sciences*, 65: 1393-1401.

Hittinger, Richard. 2010. Rhode Island Saltwater Anglers Association, Personal communication, April 8, 2010.

Hittinger, Richard. 2010. Rhode Island Saltwater Anglers Association, Personal communication,

April 26, 2010.

Incze, L., Xue, H., Wolff, N., Xu, D., Wilson, C., Steneck, R., Wahle, R., Lawton, P., Pettigrew, N., Chen, Y. 2010. Connectivity of lobster (*Homarus americanus*) populations in the coastal Gulf of Maine: part II. Coupled biophysical dynamics. *Fisheries Oceanography*, 19(1): 1-20.

Intergovernmental Policy Analysis Program, University of Rhode Island. 1989. *The Commercial Fishing Industry in Rhode Island: An Inventory, Analysis, and Assessment*. Prepared for: The Rhode Island Port Authority and Economic Development Corporation.

Johnson, M.R., Boelke, C., Chiarella, L.A., Colosi, P.D., Greene, K., Lellis-Dibble, K., Ludemann, H., Ludwig, M., McDermott, S., Ortiz, J., Rusanowsky, D., Scott, M., Smith, J. 2008. *Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States*. NOAA Technical Memorandum NMFS-NE-209.

King, John. 2009. URI Graduate School of Oceanography. Personal communication, December 4, 2009.

Lengyel, N.L., Collie, J.S., Valentine, P.C. 2009. The invasive colonial ascidian *Didemnum vexillum* on Georges Bank: Ecological effects and genetic identification. *Aquatic Invasions, 4* (1): 143-152.

Little Compton Harbor Commission. 2008. *Sakonnet Harbor Management Plan*.

Lobster Conservancy. 2004. Lobster Biology. Accessed May 4, 2010 from: http://www.lobsters.org/tlcbio/biology.html

Macy, W.K., Brodziak, J. 2001. Seasonal maturity and size at age of *Loligo pealeii* in waters of southern New England. *ICES Journal of Marine Science*, 58: 852-864.

Malek, A., Collie, J., LaFrance, M., and King, J. 2010. Fisheries Ecology and Benthic Habitat in Rhode Island and Block Island Sounds for the Rhode Island Ocean Special Area Management Plan. University of Rhode Island, June 25, 2010.

Mayo, R., O'Brien, L. 2006. *Atlantic Cod. Status of Fishery Resources off the Northeastern U.S.* NEFSC – Resource Evaluation and Assessment Division. Available online from: http://www.nefsc.noaa.gov/sos/spsyn/pg/cod/. Last accessed June 21, 2010.

Mid-Atlantic Fishery Management Council (MAFMC). June 2009. Amendment 10 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan.

Mullen, D.M., Moring, J.R. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic). Sea Scallop.

Ninigret Partners. 2007. *Rhode Island Recreational Saltwater Fishing Industry Trends and Economic Impact.* Prepared for the RI Saltwater Anglers Association.

NOAA National Marine Fisheries Service Northeast Fisheries Science Center (NEFSC). 2008. *Assessment of 19 Northeast Groundfish Stocks through 2007*. Online at: http://nefsc.noaa.gov/nefsc/publications/crd/crd0815/. Last accessed June 21, 2010.

NEFSC. 2007. Essential Fish Habitat Source Document: Black Sea Bass, *Centropristis striata*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-200.

NEFSC. 2006a. The Status of Fishery Resources off the Northeastern United States. Accessed September 2009. Available from: http://www.nefsc.noaa.gov/sos/

NEFSC. 2006b. Essential Fish Habitat Source Document: Bluefish, *Pomatumus saltatrix*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-198.

NEFSC. 2005a. Essential Fish Habitat Source Document: Atlantic Herring, *Clupea harengus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-192.

NEFSC. 2005b. Essential Fish Habitat Source Document: Longfin Inshore Squid, *Loligo pealeii*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-193.

NEFSC. 2004a. Essential Fish Habitat Source Document: Atlantic Cod, *Gadus morhua*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-190.

NEFSC. 2004b. Essential Fish Habitat Source Document: Sea Scallop, *Placopecten magellanicus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-189.

NEFSC. 2004c. Essential Fish Habitat Source Document: Silver Hake, *Merluccius bilinearis*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-186.

NEFSC. 2003a. Essential Fish Habitat Source Document: Little Skate, *Leucoraja erinacea*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-175.

NEFSC. 2003b. Essential Fish Habitat Source Document: Winter Skate, *Leucoraja ocellata*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-179.

NEFSC. 1999a. Essential Fish Habitat Source Document: Atlantic Mackerel, *Scomber scombrus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-141.

NEFSC. 1999b. Essential Fish Habitat Source Document: Butterfish, *Peprilus triacanthus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-145.

NEFSC. 1999c. Essential Fish Habitat Source Document: Goosefish, *Lophius americanus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-127.

NEFSC. 1999d. Essential Fish Habitat Source Document: Scup, *Stenotomus chrysops*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-149.

NEFSC. 1999e. Essential Fish Habitat Source Document: Summer Flounder, *Paralichthys dentatus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-151.

NEFSC. 1999f. Essential Fish Habitat Source Document: Winter Flounder, *Pseudopleuronectes americanus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-138.

NEFSC. 1999g. Essential Fish Habitat Source Document: Yellowtail flounder, *Limanda ferruginea*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-140.

NEFSC. N.d. Fisheries Technical Terms. Accessed June 8, 2010 from: http://www.nefsc.noaa.gov/techniques/tech_terms.html.

NOAA National Marine Fisheries Service (NMFS). 2010a. Species of Concern. Online at: http://www.nmfs.noaa.gov/pr/species/concern/#list. Updated February 2, 2010. Last accessed March 24, 2010.

NMFS. 2010b. Fish Watch: U.S. Seafood Facts. Available online from: http://www.nmfs.noaa.gov/fishwatch/ Last accessed March 26, 2010.

NMFS. 2010c. Atlantic Sturgeon. Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/atlanticsturgeon_detailed.pdf. Updated February 23, 2010. Last accessed June 22, 2010.

NMFS. 2010d. Porbeagle Shark. Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/porbeagleshark_detailed.pdf. Revised February 23, 2010. Last accessed June 22, 2010.

NMFS. 2010e. Northeast Region Permit Database, updated April 6, 2010.

NMFS. 2009a. Fisheries Statistics Division. Annual Commercial Landings Statistics. Online at: http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html.

NMFS. 2009b. Atlantic Halibut. Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/atlantichalibut_detailed.pdf. Revised May 2009.

NMFS. 2009c. Atlantic Wolffish. Online at:

http://www.nmfs.noaa.gov/pr/pdfs/species/atlanticwolffish_detailed.pdf. Revised May 11, 2009.

NMFS. 2009d. Dusky Shark. Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/duskyshark_detailed.pdf. Revised May 19, 2009.

NMFS. 2009e. River Herring (Alewife & Blueback Herring). Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/riverherring_detailed.pdf. Revised May 19, 2009.

NMFS. 2009f. Sand Tiger Shark. Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/sandtigershark_detailed.pdf. Revised May 11, 2009.

NMFS. 2009g. Thorny Skate. Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/thornyskate_detailed.pdf. Revised May 19, 2009.

NMFS. 2008a. *Fisheries Economics of the United States 2006*. Online at http://www.st.nmfs.noaa.gov/st5/publication/economics_communities.html.

NMFS. 2008b. Fisheries of the United States 2007. Online at: http://www.st.nmfs.noaa.gov/st1/fus/fus07/02_commercial2007.pdf.

NMFS. 2007a. Rainbow Smelt. Online at: http://www.nmfs.noaa.gov/pr/pdfs/species/rainbowsmelt_detailed.pdf. Revised November 1, 2007. Accessed June 21, 2010.

NMFS. 2007b. A Guide to the Tunas of the Western Atlantic Ocean. Online at: https://hmspermits.noaa.gov/other/tunaguide%202007%20waterproof%20version%20new%20pic.pdf. Last accessed May 5, 2010.

NMFS. 2007c. Magnuson-Stevens Fishery Conservation and Management Act. Public Law 94-265. Online at: http://www.nmfs.noaa.gov/msa2005/docs/MSA_amended_msa%20_20070112_FINAL.pdf

NMFS. 2006. Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Online at: http://www.nmfs.noaa.gov/sfa/hms/hmsdocument_files/sharks.htm.

NMFS, Office of Habitat Conservation. 2010. Essential Fish Habitat. Available from: http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/index.htm. Last accessed June 22, 2010.

National Marine Fisheries Service, Fisheries Statistics Division. 2010. Marine Recreational Fisheries Statistics Survey (MRFSS). Personal communication, May 5, 2010.

NMFS. n.d. Essential Fish Habitat and Critical Habitat: A Comparison. Available from: http://www.nmfs.noaa.gov/habitat/habitatprotection/pdf/efh/factsheets/EFH_CH_Handout_Final_3107.pdf. Last accessed June 22, 2010.

NOAA General Counsel for Natural Resources. 2010. Case: North Cape, RI. Available from: http://www.darrp.noaa.gov/northeast/north_cape. Accessed January 28, 2010.

Olsen, S., Robidue, D., Lee, V. 1980. *An Interpretive Atlas of Narragansett Bay*. Coastal Resources Center, Marine Bulletin 40, University of Rhode Island.

Olsen, S., Stevenson, D. 1975. *Commercial Marine Fish and Fisheries of Rhode Island*. Coastal Resources Center, University of Rhode Island: Marine Technical Report 34.

Olsgard, F., Schaanning, M.T., Widdicombe, S., Kendall, M.A., Austen, M.C. 2008. Effects of bottom trawling on ecosystem functioning. *Journal of Experimental Marine Biology and Ecology*, 366: 123-133.

Oviatt, C.A., Kremer, P.M. 1977. Predation on the ctenophore, *Mnemiopsis leidyi*, by butterfish, *Peprilus triacanthus*, in Narragansett Bay, Rhode Island. *Chesapeake Sci.*, 18: 236-240.

Oviatt, C., Olsen, S., Andrews, M., Collie, J., Lynch, T., Raposa, K. 2003. A Century of Fishing and Fish Fluctuations in Narragansett Bay. *Reviews in Fisheries Science* 11 (3) 221-242.

Piet, G.J., Jennings, S. 2005. Response of potential fish community indicators to fishing. *ICES Journal of Marine Science*, 62: 214-225.

Poggie, J., Gersuny, C. 1974. *Fishermen of Galilee: The Human Ecology of a New England Coastal Community.* Kingston (RI): University of Rhode Island Marine Bulletin, Series no. 17.

Poggie, J.J., Pollnac, R.B., eds. 1981. *Small Fishing Ports in Southern New England*. NOAA/Sea Grant. University of Rhode Island: Marine Bulletin 39.

Pogsay, J. A. 1979. Population assessment of the Georges Bank sea scallop stocks. *Rapp P.-V. R eu n. Cons. Int. Explor. Mer* 175:109-113.

Rago, P.J., Sosebee, K.A. 2010. Biological Reference Points for Spiny Dogfish. Northeast Fisheries Science Center Reference Doc. 10-66, 52p.

Rainone, John. 2009. Rhode Island Party and Charter Boat Association. Personal communication, July 4, 2009.

Rathjen, W.F. 1973. Northwest Atlantic squids. *Marine Fisheries Review*, 35 (12): 20-26.

Read, A.J., Brownstein, C.R. 2003. Considering other consumers: Fisheries, predators, and Atlantic herring in the Gulf of Maine. *Conservation Ecology*, 7(1): 2.

RI Coastal Resources Management Council (CRMC). 2010. CRMC funds 10 habitat restoration projects. Press release, March 22, 2010, online at: http://www.crmc.ri.gov/news/2010_0322_habrest.html. Last accessed June 22, 2010.

R.I. Department of Environmental Management (RIDEM). 2010a. 2010 Management Plan for the Finfish Fishery Sector. Available online at: http://www.dem.ri.gov/pubs/regs/regs/fishwild/fishamnd.htm. Last accessed June 22, 2010.

RIDEM. 2010b. Raw data on Rhode Island Marine Fisheries provided by RIDEM Division of Fish and Wildlife, June 2010.

RIDEM. 2009. Abstract of Marine Fisheries Rules and Regulations. Available online at: http://www.dem.ri.gov/programs/bnatres/fishwild/pdf/saltabs.pdf. Last accessed June 22, 2010.

RIDEM, Division of Planning and Development. 2006. Public Access to Shoreline Recreational Fishing in Narragansett Bay. Prepared by Gordon R. Archibald, Inc.

RIDEM, Division of Coastal Resources. N.d. Coastal resources index page. Accessed December 15, 2009 from: http://www.dem.ri.gov/programs/bnatres/coastal/

RI Economic Monitoring Collaborative. 2008. Fiscal Year 08 Economic Monitoring Report.

Rhode Island Saltwater Anglers Association (RISAA). 2010. Tournaments. Rhode Island Saltwater Anglers Association homepage. Available online at: http://www.risaa.org/tournaments/tournaments.html. Last accessed January 26, 2010.

Ross, M.R. 1991. *Recreational Fisheries of Coastal New England.* Amherst, MA: University of Massachusetts Press.

Saila, S.B., Flowers, J.M. 1968. Movements and behavior of berried female lobsters displaced from offshore areas to Narragansett Bay, Rhode Island. *Journal du Conseil,* 31: 342-351.

Sedgwick, S., Collins, C., Olsen, S. 1980. *Commercial Fishing Facilities Needs in Rhode Island*. Coastal Resources Center, University of Rhode Island: Marine Technical Report 80.

Steinback, S., Gentner, B., Castle, J. 2004. *The Economic Importance of Marine Angler Expenditures in the United States*. NOAA Professional Paper NMFS 2.

Thunberg, E. 2009. *Trends in Selected Northeast Region Marine Industries*. NOAA Technical Memorandum NMFS-NE-211.

US Fish and Wildlife Service. 2006. *2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation – Rhode Island*.

Wahle, R.A. 1992. Body-size dependent anti-predator mechanisms of the American lobster. *Oikos* 65: 52-60.

Chapter 6: Recreation and Tourism

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Section 600. Introduction

1. As the Ocean State, one of Rhode Island's greatest economic, environmental, and cultural assets is its connection to the water. Whether through boating, sailing, diving, wildlife viewing, or shore-based activities such as surfing or beach going, Rhode Island residents and tourists alike enjoy the natural beauty of the state and the Ocean SAMP area. Recreational fishing is also a very important recreational use of the Ocean SAMP area and is discussed separately in Chapter 5, Commercial and Recreational Fisheries Resources and Uses. These recreational uses not only provide enjoyment but also generate major economic benefits for the state of Rhode Island. The objective of this chapter is to provide information on the types, locations, and value of marine recreational and coastal tourism activities within the Ocean SAMP area. In addition, this chapter outlines policies for managing these uses.

2. While there are many different definitions for recreation and tourism, for the purposes of this chapter, recreation is defined as any type of leisure activity carried out for enjoyment, by either Rhode Island residents or visitors to the Ocean SAMP area. By contrast, tourism refers only to the activities of visitors to the Ocean SAMP area. Of course, not all marine recreational users are tourists, and conversely not all tourists engage in marine recreation. These two categories are presented jointly within this chapter because of their close relationship, especially in Rhode Island, and not because they are viewed as synonymous.

3. As is illustrated by the Ocean SAMP boundary (see Chapter 1, Introduction), the Ocean SAMP document and policies are focused on the offshore environment, not on adjacent upland areas. This offshore focus is due to the fact that the CRMC already has a regulatory program, including a zoning program, in place for coastal lands and waters out to the 3-nautical mile boundary. Accordingly, this chapter focuses on offshore, water-based recreation and tourism activities. Discussion of upland areas is focused on the facilities that make these water-based uses possible, as well as the economic impact of these water-based uses on coastal communities.

Section 610. History of Recreation and Tourism in the Ocean SAMP Area

1. The Ocean SAMP area and adjacent coastal communities have a long history as centers of marine recreational activity and as seaside tourism destinations. Since the mid-19th century, tourists have traveled to Rhode Island to enjoy the natural beauty of the South County beaches and to enjoy widely popular seaside resorts such as Newport, Block Island, Narragansett, and Watch Hill. Rhode Islanders and visitors alike have engaged in shore-based and marine recreational activities including boating, fishing, diving, yacht racing, and sight-seeing. Many of these recreational activities that take place on or adjacent to Rhode Island's offshore waters have contributed greatly to the economic growth and culture of coastal communities like Newport, Point Judith, and Block Island.

2. Both recreation and tourism in New England, and throughout the U.S., did not exist in their current forms until the mid- to late 19th century, when increased leisure time and disposable income enabled wealthier urban residents to travel to tourist locations and engage in recreational pursuits. Throughout the latter part of the 19th century, coastal areas were increasingly viewed as desirable destinations for vacation and recreation, and new forms of transportation enabled access to such locations. Coastal transport was flourishing at this time, and much of this trade was in the transport of passengers via steamboat between urban centers and seaside resort locations (Labaree et al. 1998). Companies such as the Fall River Line provided overnight steamboat service from New York, via the protected waters of Long Island, Block Island, and Rhode Island Sounds, to resort towns such as Newport, or to Fall River to connect with a Boston-bound train (Labaree et al. 1998). Passenger steamships also provided transport to Block Island, and to Narragansett Bay coastal camps and amusement parks such as Rocky Point in Warwick and Bullock's Point in Riverside (Albion et al. 1970).

3. Newport, dubbed the "City by the Sea," is considered by some sources to be the oldest summer resort in the nation. This coastal city was a destination as early as the 1720s (Kellner and Lemons 2004), and grew dramatically in popularity in the late 19th century through the establishment of steamboat companies like the Fall River Line, as well as the increased popularity of yachting (Albion et al. 1970). Wealthy New Yorkers, such as Cornelius Vanderbilt, traveled by steamboat to Newport, where they entertained at their seaside mansions and sailed aboard their yachts (Labaree et al. 1998). Others cruised to Newport by yacht to enjoy what were considered the ideal sailing waters of Block Island Sound and Narragansett Bay. The New York Yacht Club began to hold its annual regatta in Newport waters, which laid the groundwork for the relocation of the club to Newport nearly a century later (Albion et al. 1970). As such, Newport's rise as a resort community was due in part to its location adjacent to the Ocean SAMP area waters.

4. Much of Newport's late 19th century rise in popularity was tied to the rise of yachting. Yachting and recreational boating had expanded dramatically in popularity in the late 19th and early 20th centuries throughout the U.S. due to the increase in discretionary income and leisure time amongst the upper classes. Narragansett Bay and the adjacent ocean waters have been popular locations for yacht racing activities and regattas since 1860. One historian describes the waters directly south of Narragansett Bay as "the most

favored spot on the coast for yacht racing" because "the winds off Newport are usually fresh and constant, and the tidal currents are moderate" (Albion et al. 1970).

5. Newport's reputation as a center of yacht racing was solidified in 1930 when the defending champion, the New York Yacht Club, brought to the city the America's Cup,, an international sailing trophy dating to 1851. The New York Yacht Club successfully defended the America's Cup 24 times between 1870 and 1980, which is widely considered one of the greatest winning streaks in sports history (Levitt 2008). From 1930 to 1983, America's Cup racing was based out of Newport, and the races were held just outside of Narragansett Bay off Brenton Point. In the 1930s, defender and challenger raced in large, iconic "J-Boats"; in 1957, when racing resumed after World War II, racers competed in 12-meter sloops that were roughly half the size of the original J Boats (Labaree et al. 1998). By the 1970s and 1980s, America's Cup racing had attained significant, widespread popularity among sailors and non-sailors alike, and attracted large numbers of spectators. Increasingly large crowds of visitors came to Newport and the adjacent waters; by one count, 100,000 people converged on Newport for the 1983 race (Kellner and Lemons 2004). Although the America's Cup was lost to Australia in 1983, in 1987, the New York Yacht Club established a permanent base in Newport and continues its prominent role in yacht racing, both in Rhode Island and throughout the world. The Club also continues to run yacht racing events in the same waters historically used by America's Cup competitors (Levitt 2008).

6. Many other historic and internationally renowned yacht races continue to take place in Ocean SAMP area waters. Many are long-distance races that saw their beginning in the 1920s; the Bermuda Race, or Newport-Bermuda Race, is one such race (Albion et al. 1970). The modern history of the Newport-Bermuda race dates back to 1923, and in 1936 the race start was moved to Newport from New London, Conn. The race is organized by the Cruising Club of America, one of the more prominent national organizations of yacht racing sailors (Connett 1948). Another long-running prestigious yacht racing event is Block Island Race Week, which has been organized biennially by the Storm Trysail Club since 1965 (Storm Trysail Club 2009a). Other long-running races based out of Newport include the New York Yacht Club Annual Regatta and Sail Newport's annual regatta.

7. Though Newport is best-known throughout recent history as a nationally recognized center of coastal tourism and recreation, other Rhode Island communities adjacent to the Ocean SAMP area have historically been popular destinations and centers of recreational activity. Narragansett flourished as a coastal resort in the mid- to late 19th century. The Narragansett Pier and Casino (of which the Towers are the only remaining structure) were the center of this popular seaside resort that drew wealthy tourists from throughout the country (Conley 1986). In Westerly, Watch Hill was another coastal resort that attained prominence in the late 19th century (Conley 1986). Little Compton and Jamestown were also seaside resort destinations (Kellner and Lemons 2004). Block Island also became a popular tourist destination at this time, though unlike Newport and Watch Hill, it attracted visitors of more modest means (Conley 1986; Manheim and Tyrell 1986). In these and other locations, tourists stayed in large, Victorian-style hotels and enjoyed swimming and recreating on Rhode Island's expansive beaches (Conley 1986).

8. In addition to seaside tourism, Block Island has historically been a popular destination for recreational boaters and sailors. A 1948 cruising guide, *Yachting in North America*, identifies Block Island as a recommended destination and directs boats to anchor in the Great Salt Pond, rather than Old Harbor on the east side of the island. It identifies Block Island as "a place where you'll meet every cruising yacht and yachtsman between Cape Cod and New York. It's the goal of many a small boat's cruise from both the western end of Long Island Sound and the ports to the eastward, the place where bigger yachts almost always stop in when bound either east or west, and the scene of many a yacht club rendezvous and cruising-race finish" (Connett 1948).

9. Though modern seaside recreation and tourism, both in Rhode Island and throughout the nation, originated as an activity for the wealthier classes, coastal recreation and tourism activities became increasingly popular activities for the emergent middle class during the early to mid-20th century. The rise of the automobile coupled with the development of roads made coastal destinations accessible by car, which drew middle class tourists and residents to Rhode Island's seaside resorts (Thompson 2006). Similarly, throughout the 20th century, recreational boating and sailboat racing became an activity available to Americans of all classes (Labaree et al. 1998). Today, the Ocean SAMP area waters and adjacent seaside resorts are actively utilized by a wide range of residents and tourists. For additional information on the history of the Ocean SAMP area and adjacent communities, see Chapter 4, Cultural and Historic Resources, and Chapter 7, Marine Transportation, Navigation, and Infrastructure.

Section 620. Marine Recreation in the Ocean SAMP Area

1. Rhode Island's close association with the ocean has made marine recreation a large part of the state's culture and appeal. Rhode Island has approximately 420 miles of shoreline, and because of the state's geography and small size, all Rhode Islanders live within 25 miles of the shore. The bay, ocean, and shoreline are, consequently, Rhode Island's most cherished natural features, and offer opportunities for swimming, boating, fishing, diving, wildlife observation and other recreational pursuits enjoyed by both residents and tourists (R.I. Department of Administration Statewide Planning Program and R.I. Department of Environmental Management 2003).

620.1. Recreational Boating

1. Recreational boating is one of the most popular uses of the Ocean SAMP area, attracting Rhode Island residents and tourists to the water for sailing, power boating, and fishing and diving activities. Sailors and power boaters use the Ocean SAMP area to cruise between recreational harbors and other destinations, sightsee, race, fish, or participate in other recreational activities. Recreational fishing (which includes recreational fishing aboard private boats and party and charter boats) is one of the most popular recreational boating activities in the Ocean SAMP area and is discussed in detail in Chapter 5, Commercial and Recreational Fisheries Resources and uses. Organized sailboat racing is another popular recreational use of the Ocean SAMP area and is discussed in detail below in Section 620.3. Recreational boating activity within the Ocean SAMP area varies seasonally, with the peak times occurring during warmer months (approximately May through October). According to the U.S. Coast Guard, the majority of recreational boating takes place within three miles of shore (U.S. Coast Guard 2006).

2. As of September 2009, there were 41,985 boats registered in the state of Rhode Island, a portion of which are owned by non-residents (R.I. Department of Environmental Management Office of Boat Registration and Licensing 2009). In 2006, out-of-state boat owners represented 14 percent of the total registered boats in Rhode Island (R.I. Economic Monitoring Collaborative 2008). In addition, boats registered in other states use Rhode Island waters; the Department of Environmental Management has estimated that 10,000 boats registered out-of-state visit Rhode Island each year (R.I. Department of Environmental Management 2004).

3. Much recreational boating within the Ocean SAMP area originates in and/or is supported by Rhode Island's recreational port and harbor facilities and marine trades businesses. These include marinas, boatyards, and boat ramps in Point Judith, Newport, Portsmouth, and in New Harbor on Block Island. See Section 640 below for further discussion of Rhode Island marinas, boat ramps, and recreational ports and harbors.

4. Local economies benefit from the influx of out-of-state recreational boaters through the use of marina services, fuel expenditures, and revenue generated from dining, entertainment, and accommodations. See Section 650 below for further discussion.

5. This chapter is focused on recreational activities in the Ocean SAMP area, which excludes Narragansett Bay. However it should be noted that recreational activities or events that take place outside the Ocean SAMP area, within Narragansett Bay, may sometimes generate increased recreational boating activity outside of the Bay in or adjacent to the Ocean SAMP area. Such activities include organized sailboat races and sailing school activities run by organizations like Sail Newport, or events that draw boat-based spectators such as the Quonset Air Show or Tall Ships parades.

6. Recreational boating activity in the Ocean SAMP area, excluding organized sailboat races and recreational fishing, largely constitutes cruising between recreational harbors and other destinations. Both sail and power boats, ranging widely in size, cruise between such destinations. Cruising activity within the Ocean SAMP area typically follows a number of general routes connecting destinations and bodies of water. Block Island and Newport are particularly popular destinations for cruising sailors and boaters. Most cruising occurs through the protected waters of Long Island, Block Island, and Rhode Island Sounds and is less common further offshore, though some cruisers travel between Newport and the Chesapeake, the Canadian Maritimes, Bermuda, the Caribbean, and Europe. See Figure 6.1 for a map of typical cruising routes within the Ocean SAMP area. This map was created through the input of recreational boating stakeholders. Many cruising routes follow similar preferred traffic routes used by commercial vessels; see Chapter 7, Marine Transportation, Navigation, and Infrastructure, for further discussion. It should be noted that this map represents typical recreational cruising routes only, and does not represent the entirety of recreational boating traffic patterns in the Ocean SAMP area.

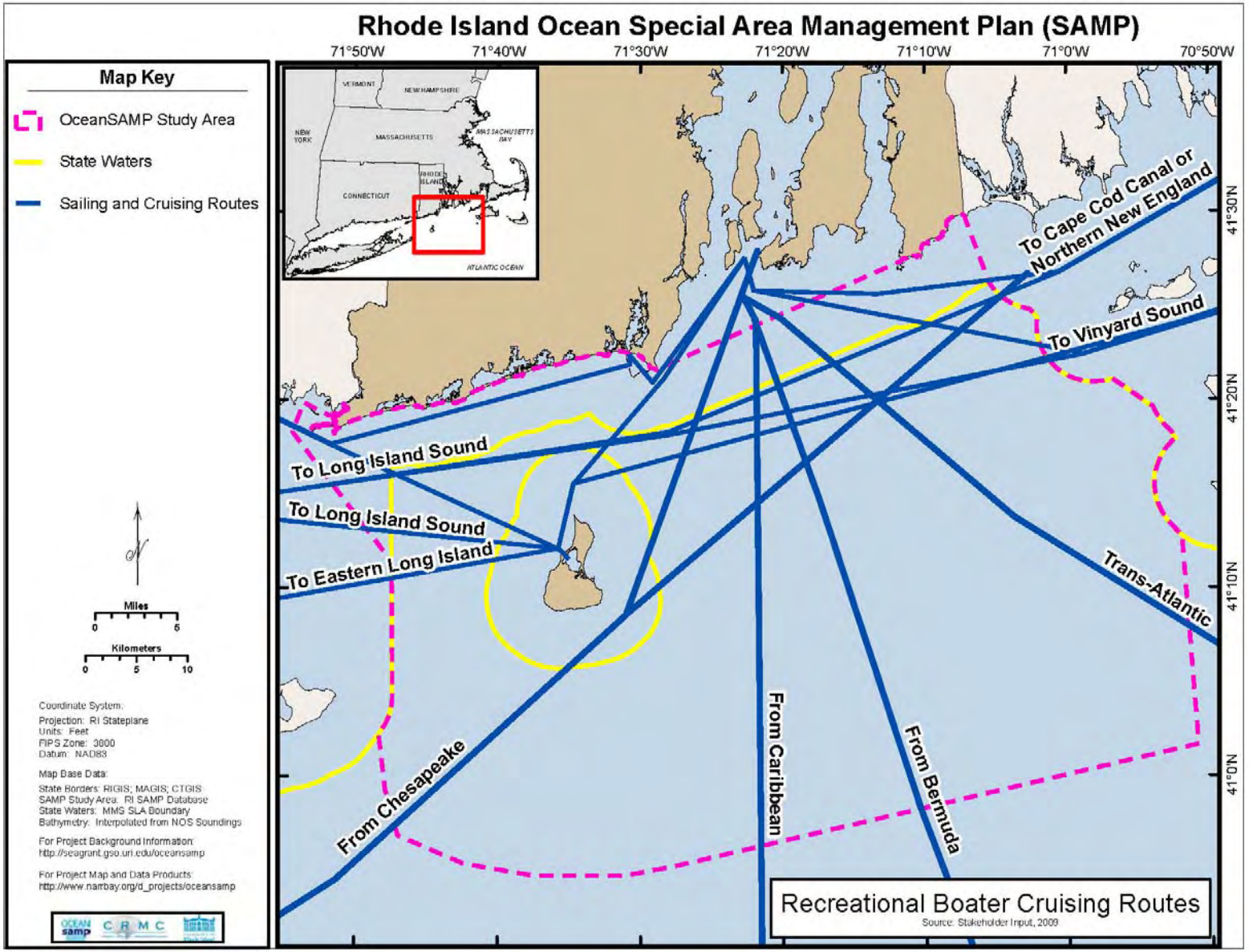


Figure 6.1. Recreational boater cruising routes.

7. Some recreational power boaters may occasionally take part in official or informal power boat racing events, also described as poker runs, in waters in or adjacent to the Ocean SAMP area. The U.S. Coast Guard has indicated that poker runs take place very infrequently within the Ocean SAMP area, and are generally problematic due to safety concerns (LeBlanc, pers. comm.).

620.2. Recreational Fishing

1. Recreational fishing (which includes recreational fishing aboard both private boats and party and charter boats), is one of the most popular activities among recreational boaters within the Ocean SAMP area. A 2002 U.S. Coast Guard Boaters Survey found that fishing was the most prevalent activity when boating. Approximately 182,000 anglers fish in Rhode Island's waters each year, making 1.2 million trips; fifty percent of these anglers come from out of state (Ninigret Partners 2007). Recreational fishing is addressed separately in extensive detail in Chapter 5, Commercial and Recreational Fisheries. Recreational fishing is discussed within the context of fisheries because commercial and recreational fishermen target many of the same species. Additionally, activities such as charter boat fishing make it difficult to distinguish between commercial and recreational fishing because charter boat clients are recreational anglers, while charter boat captains are licensed professionals who manage fishing businesses.

620.3. Offshore Sailboat Racing

1. Much of the recreational sailing that takes place within the Ocean SAMP area is within the context of offshore sailboat races, or regattas. While it is likely that the majority of Rhode Island-based sailboat racing takes place within Narragansett Bay, many such races, primarily those involving larger vessels, ranging in length from 30 to 90 feet, occur offshore within the Ocean SAMP area each year.

2. Sailboat racing is a time-honored tradition in the Ocean SAMP area and a significant part of Rhode Island's history and culture. Some of the world's most famous and most competitive sailboat races, including the America's Cup and the Newport-Bermuda Race, have been held in the Ocean SAMP area since the early 20th century. From 1930 to 1983, America's Cup races were held in the waters south of Brenton Point, and the Newport-Bermuda Race has been held in Newport on a biennial basis since 1936. See Section 610 for further discussion.

3. Sailboat racing in the Ocean SAMP area may be categorized as either buoy racing or distance racing. Many races occur on a regular basis as annual or biennial events, and some have been taking place since the early 20th century. Tables 6.1 and 6.2, below, together list races that occur wholly or partly within the Ocean SAMP area and that were identified and mapped through the Ocean SAMP stakeholder process. It is important to note that this is only a selection of regularly-occurring races in the area, and is not intended to be all-inclusive. Descriptions and course information for each of these races

were obtained from race organizers, official race documents such as Notices of Race or Sailing Instructions, or U.S. Coast Guard marine event permit applications.[1]

4. Buoy races typically take place in inshore, protected areas and involve racing one or more laps around a small linear or triangular course marked by special racing buoys. Examples in the Ocean SAMP area include the many races comprising Block Island Race Week, as well as the many different races hosted by Newport-based clubs that take place in the waters south of Brenton Point. See Table 6.1 below. Detailed descriptions of these races are included below.

[1] The Coast Guard requires marine event permit applications per 33 C.F.R. 100.15: "an individual or organization planning to hold a regatta or marine parade which, by its nature, circumstances or location, will introduce extra or unusual hazards to the safety of life on the navigable waters of the United States, shall submit an application to the Coast Guard District Commander having cognizance of the area where it is intended to hold such regatta or marine parade. Examples of conditions which are deemed to introduce extra or unusual hazards to the safety of life include but are not limited to: an inherently hazardous competition, the customary presence of commercial or pleasure craft in the area, any obstruction of navigable channel which may reasonably be expected to result, and the expected accumulation of spectator craft."

Table 6.1. Select buoy sailboat races occurring within the Ocean SAMP area.

Event	Organizer	Month	Frequency	Course Description	Avg. No. of Vessels	Avg. Vessel Length (ft)
Block Island Race Week	Storm Trysail Club (odd years); Ted Zuse (even years)	June	Annual	Week of buoy races west of Block Island.*	100+	30 - 90
New York Yacht Club Annual Regatta	New York Yacht Club	June	Annual	Buoy races south of Brenton Point.	110	30 - 90
New York Yacht Club Invitational Cup	New York Yacht Club	Sept	Biennial	Buoy races south of Brenton Point.	20	42
New York Yacht Club Race Week	New York Yacht Club	Sept	Biennial	Buoy races south of Brenton Point.	150	30 - 90
Swan 42 National Championship	New York Yacht Club	July	Annual	Buoy races south of Brenton Point.	20	42
Sail Newport Coastal Living Newport Regatta	Sail Newport	July	Annual	Buoy races south of Brenton Point.	varies	varies
world championship regattas (vary)**	various	Sept	Annual	Buoy races south of Brenton Point.	varies	varies

**Event may also include one around-the-island race.*

***The Newport sailing community hosts at least one "world championship" regatta each September. In 2009 it was both the Six Meter World Cup and the Twelve Meter World Championships.*

5. Distance races may take place inshore or offshore and range in duration from part of a day to several weeks. A distance race may start and end in the same location, such as the Ida Lewis Distance Race, which starts and ends in Newport and covers up to 177 nautical miles (Ida Lewis Yacht Club 2009a). Other distance races may start and end in different locations; one example is the Newport—Bermuda Race, which starts in Newport, ends in Bermuda, and covers approximately 635 nautical miles (McCurdy 2009). See Table 6.2 below. It should be noted that other long-distance transoceanic races periodically start or end in Newport and pass through the Ocean SAMP area. A recent example is the 2007 HSH Nordbank Blue Race (Dellenbaugh, pers. comm.).

Table 6.2. Select distance sailboat races occurring within the Ocean SAMP area.

Event	Organizer	Month	Frequency	Course Description	Avg. No. of Vessels	Vessel Length (ft)
Annapolis to Newport Race	Annapolis Yacht Club	June	Biennial	Annapolis, MD, to Newport.	61	34+
Bermuda One-Two	Goat Island Yacht Club and Newport Yacht Club	June	Biennial	Singlehanded (one crew member): Newport to Bermuda; Doublehanded (two crew members): Bermuda to Newport.	38	28-60
Block Island Race	Storm Trysail Club	May	Annual	Stamford, CT, around Block Island and back to Stamford.	60	30-75
Corinthians Stonington to Boothbay Harbor Race	Corinthians Association, Stonington Harbor Yacht Club, and Boothbay Harbor Yacht Club	July	Biennial	Stonington, CT, to Boothbay, ME.	14	
Earl Mitchell Regatta	Newport Yacht Club	Oct	Annual	Newport to Block Island.	15	30-50
Ida Lewis Yacht Club Distance Race	Ida Lewis Yacht Club	August	Annual	Multi-legged course through Rhode Island Sound and adjacent offshore waters.	40	30-90
Marion to Bermuda Cruising Yacht Race	Marion-Bermuda Cruising Yacht Race Association	June	Biennial	Marion, MA, to Bermuda.	48	32-80
New England Solo-Twin Championships	Newport Yacht Club and Goat Island Yacht Club	July	Annual	Multi-legged course through Rhode Island Sound and adjacent offshore waters; starts/ends in Newport.	35	24-60
Newport Bucket Regatta	Bucket Regattas/ Newport Shipyard	July	Annual	Three multi-legged courses off Brenton Point.	19	68-147
Newport to Bermuda Race	Cruising Club of America	June	Biennial	Newport to Bermuda.	265	30 - 90
New York Yacht Club Annual Cruise	New York Yacht Club	August	Annual*	Varies.	100	30-90

Offshore 160 Single-Handed Challenge	Newport Yacht Club and Goat Island Yacht Club	July	Biennial	Multi-legged course through Rhode Island Sound and adjacent offshore waters; starts/ends in Newport.	15	28-60
Off Soundings Club Spring Race Series	Off Soundings Club	June	Annual	Day 1: Watch Hill to Block Island; Day 2: Around Block Island.	120-150	23-62
Owen Mitchell Regatta	Newport Yacht Club	May	Annual	Newport to Block Island.	31	24-44
Vineyard Race	Stamford Yacht Club	Aug/Sept	Annual	Stamford, CT, to entrance of Vineyard Sound and back to Stamford.	77	30-90
Whaler's Race	New Bedford Yacht Club	Sept	Annual	New Bedford, MA, around Block Island, to Noman's Island, and back to New Bedford.	22	25+

Races start and/or end in Newport unless otherwise noted.
**Course varies widely; event is held within the Ocean SAMP area waters approximately three out of every five years (Dellenbaugh, pers. comm.). Because of this variability, this race is not included in Figure 6.3, Map of Sailboat Race Courses.*

6. Buoy races in the Ocean SAMP area typically take place within the same areas each year and are best represented on a map as circles encompassing the areas where the race courses are traditionally set. It should be noted that the New York Yacht Club, Sail Newport, and other race organizers run multiple buoy racing events and use the same standard areas for all of their events. See Figure 6.2, Sailboat Racing Areas.

7. Long-distance races are best represented on a map as linear race courses; see Figure 6.3, Distance Sailing Race Courses. However it is important to note that racers typically do not race in a straight line, but change course significantly depending on winds, currents, and other factors. It should also be noted that some race courses change from year to year based on the discretion of the race organizer.

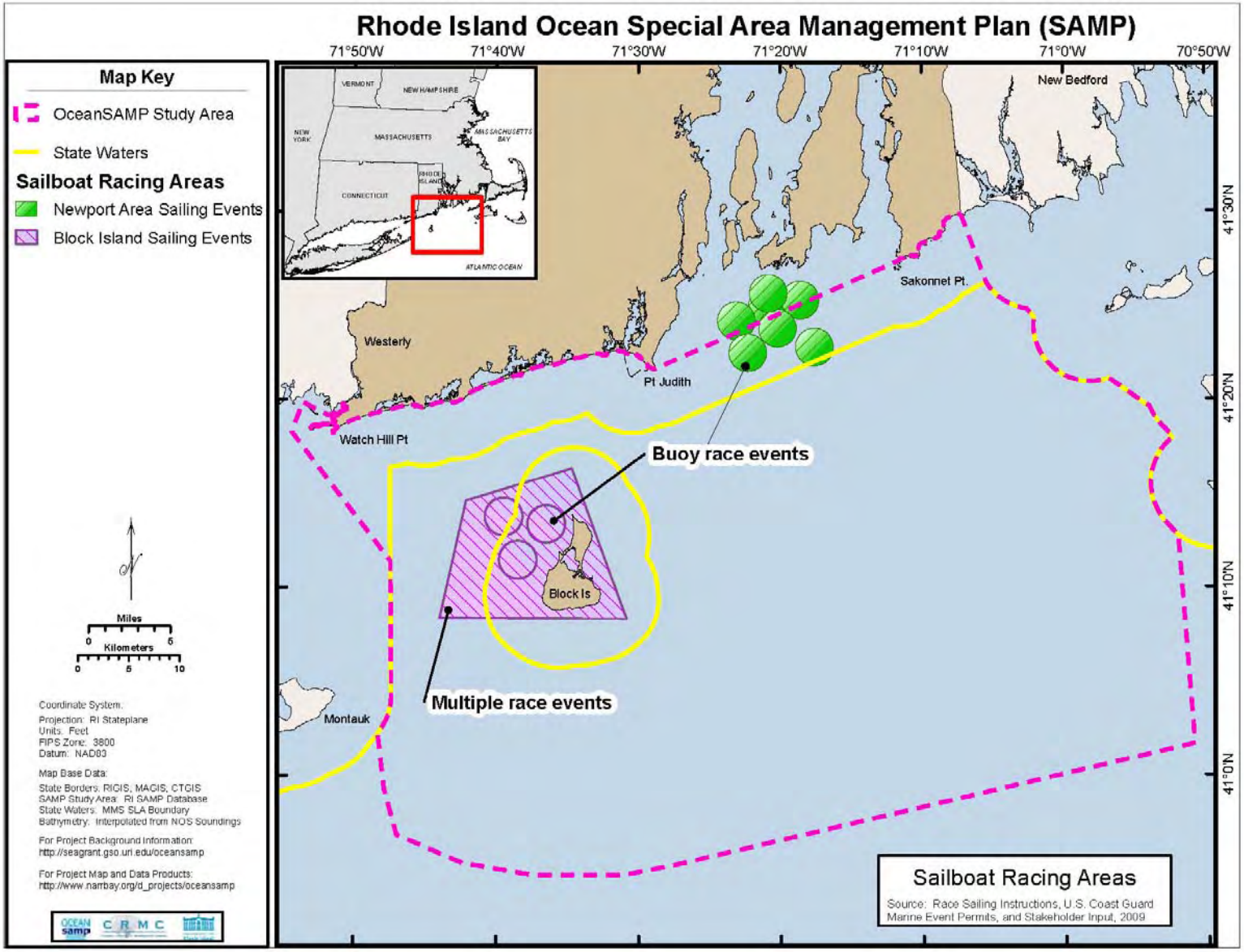


Figure 6.2. Sailboat racing areas.

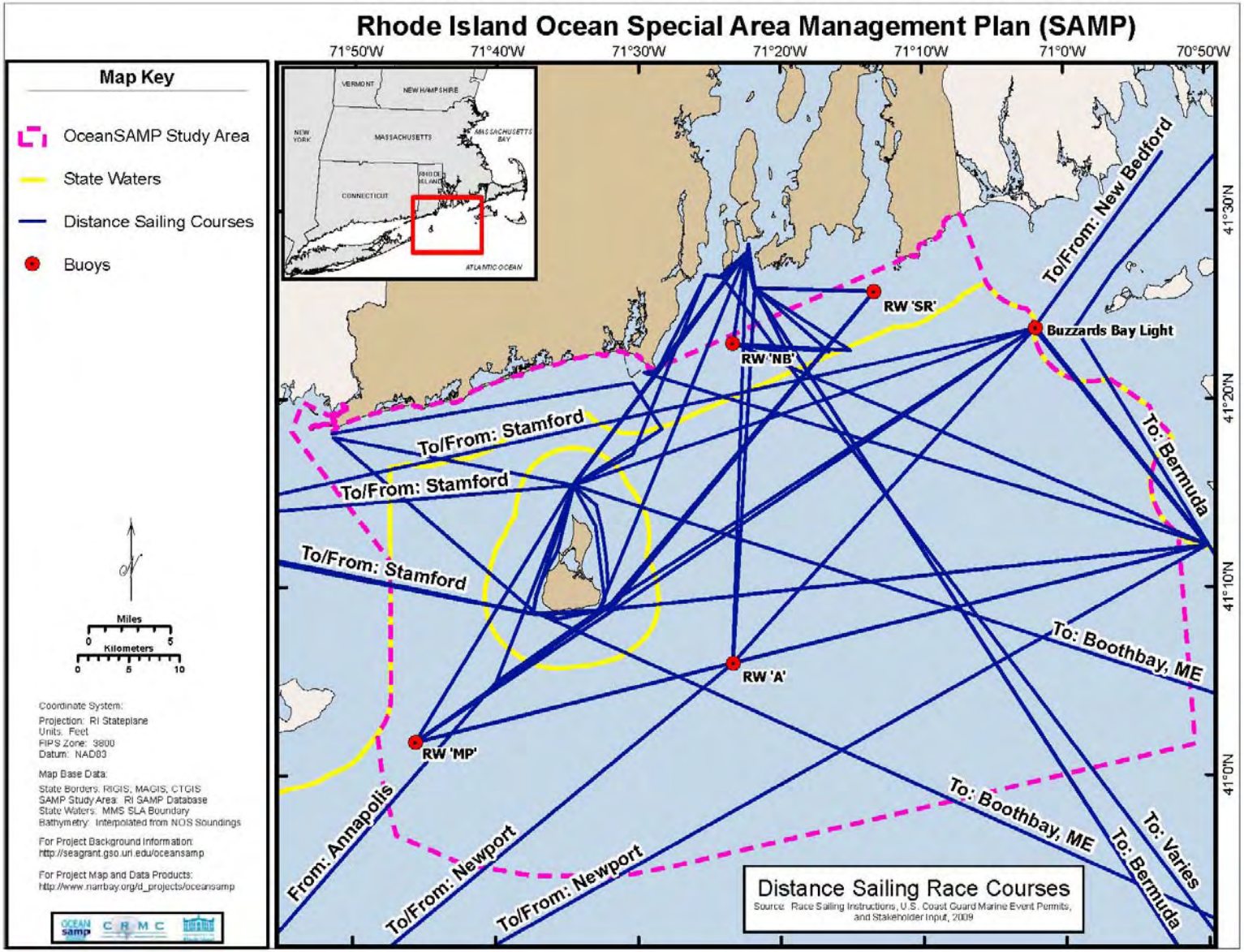


Figure 6.3. Distance sailing race courses.

8. As Figures 6.2 and 6.3 illustrate, sailboat racing within the Ocean SAMP area is widespread, but is also concentrated in two different areas: south of Brenton Point and around Block Island. The waters south of Brenton Point are used for the majority of buoy racing that takes place within the Ocean SAMP area. Many races also start or end in these waters, or just north of them inside Narragansett Bay. It is also important to note that this area is where America's Cup races took place for over 50 years, from 1930 to 1983. Block Island is also a popular destination or waypoint for many of the races that take place within the Ocean SAMP area. In addition to Block Island Race Week, eight other races listed above use Block Island as either a destination or a waypoint. In many cases, Block Island is integral to the challenge of a race in that sailors make strategic decisions about whether to pass to the north or south of the island, or how close to pass near it, in order to gain advantage over competitors. See Figure 6.4, High-Intensity Recreational Boating Areas and Areas of Particular Concern.

9. Figure 6.4 identifies the racing circles south of Brenton Point and west of Block Island as Recreational Boating Areas of Particular Concern. These areas, which are used for buoy racing as well as other uses, are characterized by an especially high concentration of boating activity and as such have been designed as Areas of Particular Concern. See section 660 for further information.

10. Figure 6.5, Sailing Events by Month, illustrates that sailboat racing in the Ocean SAMP area is concentrated in just a few months of the year. June, July, August, and September are particularly active months for sailboat racing.

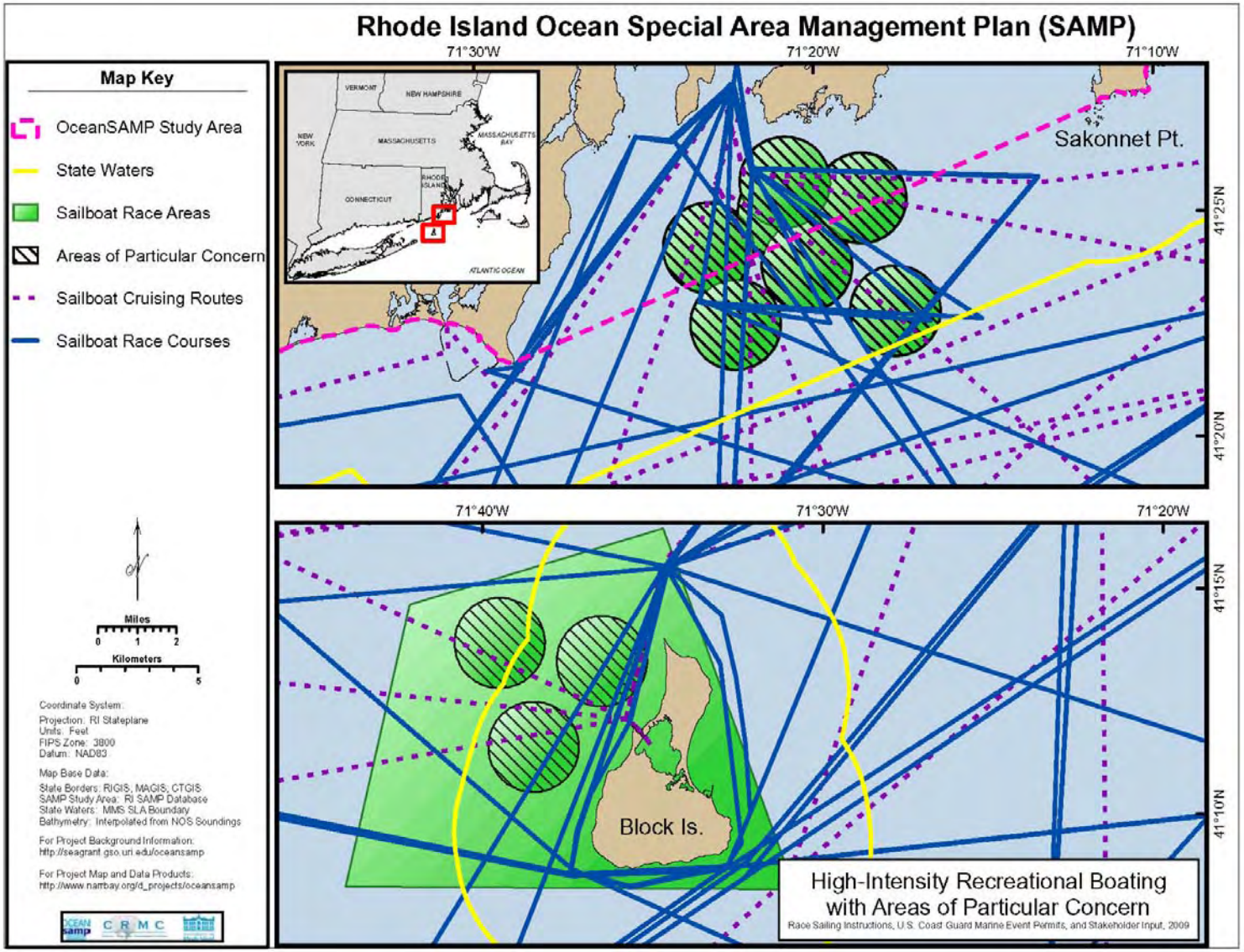


Figure 6.4. High-intensity recreational boating areas with areas of particular concern.

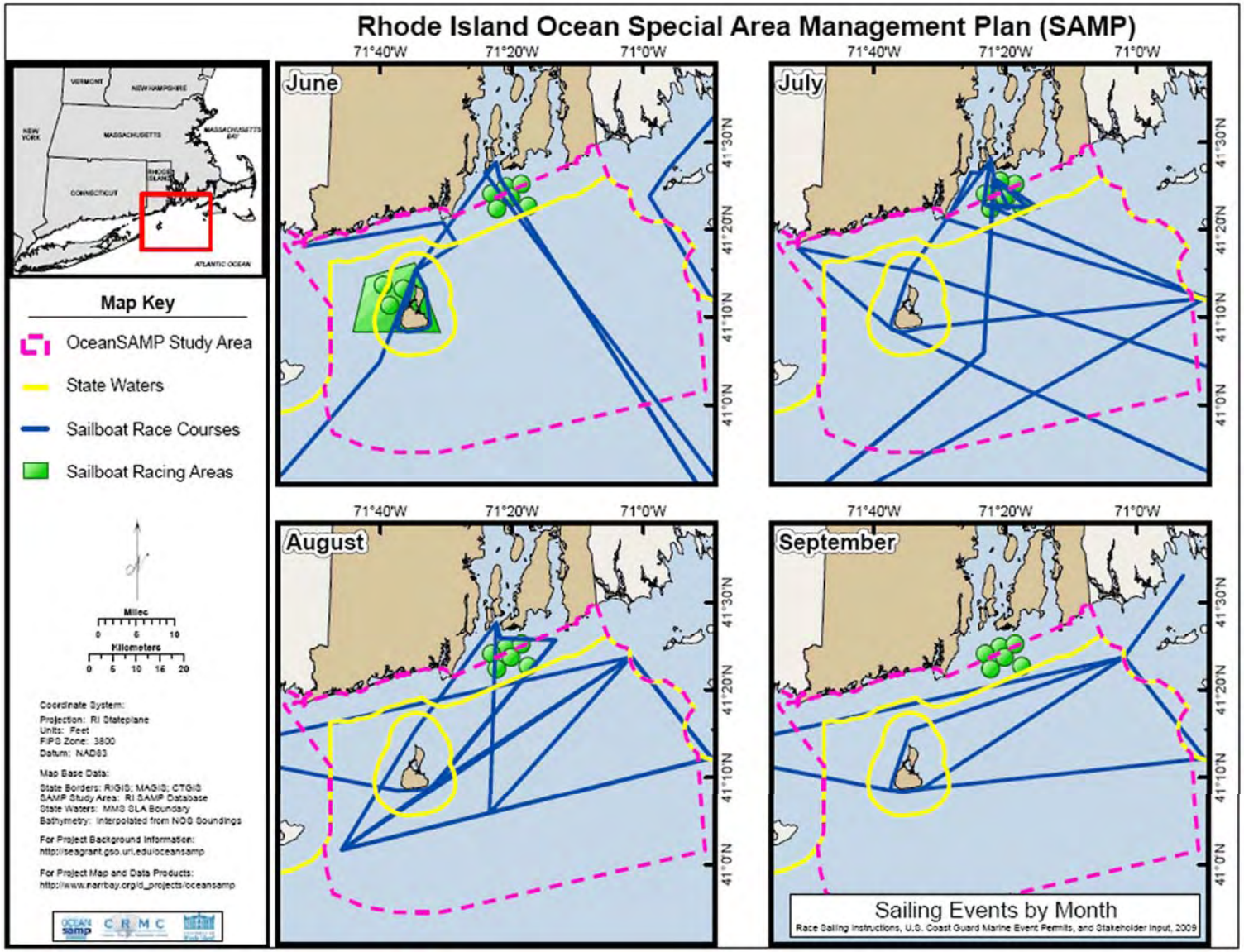


Figure 6.5. Sailing events by month.

Table 6.3. Descriptions of select sailboat races.

BUOY RACES	
Block Island Race Week ***(Storm Trysail Club, Ted Zuse)***	Block Island Race Week is a week-long racing event that takes place annually in approximately the 3rd week of June. In even years a smaller-scale race week is hosted by Ted Zuse; in odd years a larger-scale event is hosted by the Storm Trysail Club. The event comprises five days of races, most of which are buoy races. Race weeks usually also include an around-the-island race. Buoy races are generally held in one of three predetermined areas west and northwest of the island (Storm Trysail Club 2009b). Event size varies; the race typically attracts between 150 and 200 boats ranging in size from 25 to 80 feet, which translates to approximately 1,800-2,500 participants (Trenholm, pers. comm.). In 2009, 153 boats ranging in size from 24 to 65 feet entered the race (Storm Trysail Club 2009c).
New York Yacht Club Annual Regatta **New York Yacht Club Invitational Cup** **New York Yacht Club Race Week** **Swan 42 National Championships** ***(New York Yacht Club)***	*New York Yacht Club Events*: The New York Yacht Club (NYYC) hosts a number of highly competitive buoy races each year. Those that take place within the Ocean SAMP area include the New York Yacht Club Annual Regatta, the New York Yacht Club Invitational, the New York Yacht Club Race Week (biennial), and the Swan 42 National Championships. These events typically last between two and five days and all comprise a series of buoy races south of Brenton Point in Rhode Island Sound within one of several areas traditionally used by the New York Yacht Club (see Figure 6.2) (Dellenbaugh, pers. comm.). Average size and number of participating vessels varies; see Table 6.2 above (Dellenbaugh, pers. comm.). Actual race courses are set each day by the race organizers in order to take advantage of current weather conditions.
Sail Newport Coastal Living Newport Regatta ***(Sail Newport)***	Sail Newport hosts a few buoy races within the Ocean SAMP area each year; one is the Sail Newport Coastal Living Newport Regatta in July. This race is a three-day event including multiple buoy-racing events for multiple types of vessels (Sail Newport 2009a). Races take place south of Brenton Point in Rhode Island Sound within one of several areas traditionally used by Sail Newport (see Figure 6.2). Actual race courses are set each day by the race organizers in order to take advantage of current weather conditions.
world championship regattas (TBD) ***(organizer varies)***	The Newport sailing community hosts at least one "world championship" regatta each year in September. In 2009 two events were held. The International Six Meter World Cup was a six-day event hosted by Sail Newport comprising five days of racing for an international group of competitors (Sail Newport 2009b). The Twelve Meter World Championships was a five-day event hosted by the New York Yacht Club (New York Yacht Club 2009). World championship regattas typically take place south of Brenton Point in Rhode Island Sound within one of several areas traditionally used by Newport-based race organizers (see Figure 6.2). The average size and number of participating vessels varies widely depending on the event.

DISTANCE RACES	
Annapolis to Newport Race ***(Annapolis Yacht Club)***	One of the popular, longer-distance races passing through the Ocean SAMP area is the biennial Annapolis to Newport race organized by the Annapolis Yacht Club in Annapolis, Md. Sailing Instructions for this event do not specify what route racers need to take on their approach to Newport, and as a result, racers may choose to pass north and south of Block Island at their own discretion (Annapolis Yacht Club 2009a). In either case, racers will try to sail as close to the island as possible to minimize the distance to the finish line. Sixty-one boats entered the 2009 race, all of which were at least 34 feet in length (Annapolis Yacht Club 2009b).
Bermuda One-Two ***(Goat Island Yacht Club and Newport Yacht Club)***	The Bermuda One-Two Regatta is held in odd-numbered years and is co-sponsored by the Goat Island Yacht Club and Newport Yacht Club. The race has two legs, the first of which is sailed singlehanded (by one crew member) by any course from Newport to St. George's, Bermuda. The second leg is sailed doublehanded (by two crew members) from Bermuda, by any course, to Newport (Goat Island Yacht Club and Newport Yacht Club 2009a). In 2009, there were 38 entrants in the singlehanded race and 30 in the doublehanded race, and included vessels ranging from 28 to 60 feet in length (Goat Island Yacht Club and Newport Yacht Club 2009b). Entrants into this race qualify by competing in the Offshore 160 Single-Handed Challenge (below) (Newport Yacht Club 2009a).
Block Island Race ***(Storm Trysail Club)***	The annual Block Island Race, sometimes called the Around Block Island Race, starts from Stamford, Conn., on the Friday before Memorial Day. Participating boats race east out of Long Island Sound, round Block Island in a clockwise pattern, and then race back to Stamford. This is a 185-mile race with a 60-year history. Approximately 60 boats ranging in length from 30 to 75 feet participated in the 2009 race (Storm Trysail Club 2009d).
Corinthians Stonington to Boothbay Harbor Race ***(Corinthians Association, Stonington Yacht Club, and Boothbay Harbor Yacht Club)***	The Stonington to Boothbay Harbor Race is a biennial race organized by the Corinthians Association, Stonington Harbor Yacht Club, and Boothbay Harbor Yacht Club. The race starts in Stonington, Conn., and crosses through the Ocean SAMP area en route to Boothbay Harbor, Maine. Racers may pass either north or south of Block Island during the first leg of the race, heading for Nantucket Shoals before turning northward for Maine (Corinthians Association 2008). In 2008, fourteen vessels participated in this race.
Ida Lewis Distance Race ***(Ida Lewis Yacht Club)***	The annual Ida Lewis Distance Race features two multi-legged race courses of between 150 and 177 miles in length that start and end in Newport and travel throughout the Ocean SAMP area (Ida Lewis Yacht Club 2009a, Ida Lewis Yacht Club 2009b). Approximately 40 yachts, ranging in length from 30 to 90 feet, registered for the 2009 event (Ida Lewis Yacht Club 2009c).
Marion to Bermuda	The biennial cruising yacht race from Marion, Mass., to Bermuda is

Cruising Yacht Race ***(Marion-Bermuda Cruising Yacht Race Association)***	organized by the Marion-Bermuda Cruising Yacht Race Association. This 645-nautical-mile race does not start or finish in Rhode Island, though many racers pass through the Ocean SAMP area when exiting Buzzards Bay (Marion Bermuda Cruising Yacht Race Association 2009a). Yachts participating in this race must be between 32 and 80 feet in length (Marion Bermuda Cruising Yacht Race Association 2009b). In 2009, 48 vessels entered the race (Marion-Bermuda Cruising Yacht Race Association 2009c).
Owen L. Mitchell Memorial Day Regatta **Earl Mitchell Columbus Day Regatta** ***(Newport Yacht Club)***	The Newport Yacht Club organizes both the Owen and Earl Mitchell Regattas every year on Memorial Day and Columbus Day, respectively. Both day-long distance races begin in Newport and finish in New Harbor on Block Island along a course set just off the coast of Point Judith (see Figure 6.3). The Mitchell Regattas emphasize fun over competition, and participants who have not finished by 6:00 p.m. are advised to motor to the finish line to join the awards ceremony (Newport Yacht Club 2009b and 2009c). Thirty-one vessels competed in the 2009 Owen Mitchell Regatta, and 15 competed in the Earl Mitchell Regatta. Vessels in these regattas were between 24 and 50 feet in length (Newport Yacht Club 2009d).
New England Solo – Twin Championships ***(Goat Island Yacht Club and Newport Yacht Club)***	The annual New England Solo-Twin Championships are a series of single- and double-handed races. Vessels between 24 and 60 feet in length compete on long-legged courses, from 65 to 125 miles in length, that start and end in Newport and travel through the Ocean SAMP area (Newport Yacht Club and Goat Island Yacht Club 2009a). Thirty-five vessels competed in the 2009 Championships (Newport Yacht Club and Goat Island Yacht Club 2009b).
Newport Bucket Regatta ***(Bucket Regattas/ Newport Shipyard)***	The Newport Bucket Regatta is an annual invitational regatta open to megayachts (very large yachts), largely those over 90 feet in length. The regatta is popular with classic sailing yachts, and event organizers emphasize fun and safety over competition. Vessels race a series of long-legged triangular courses south of Brenton Point (Bucket Regattas 2009a). In 2009, 19 yachts ranging in length from 68 to 147 feet participated in this event (Bucket Regattas 2009b).
Newport to Bermuda Race ***(Cruising Club of America)***	The biennial Newport to Bermuda Race, organized by the Cruising Club of America, takes place in even-numbered years. This 635-mile race lasts from three to six days and takes racers from the waters off of Newport, south through the Ocean SAMP area, to Bermuda (McCurdy 2009). The race was founded in 1906 and has been based out of Newport since 1936. In 2006, a record 265 vessels entered this race (Rousmaniere 2007).

New York Yacht Club Annual Cruise ***(New York Yacht Club)***	The New York Yacht Club Annual Cruise is a week-long event hosted each August that comprises a series of day-long distance races between different northeastern ports. The average cruise involves 100 vessels ranging from 30 to 90 feet in length. Race course and port destinations vary each year and the race takes place wholly or partly within the Ocean SAMP area approximately three out of every five years (Dellenbaugh, pers. comm.). Because of the significant variation in this event's race course, it is not included in Figure 6.3, Map of Sailboat Race Courses.
Offshore 160 Single-Handed Challenge ***(Newport Yacht Club and Goat Island Yacht Club)***	The biennial Offshore 160 Single-Handed Challenge is held during even-numbered years and is sponsored by the Goat Island Yacht Club and the Newport Yacht Club. The 160-mile Offshore 160 is held in the off-years from the biennial Bermuda One-Two Race (above) and is a qualifier for the One-Two (Newport Yacht Club 2009e). This multi-legged course starts and ends in Newport and extends throughout the Ocean SAMP area. Participating vessels must be 28 to 60 feet in length (Newport Yacht Club 2008). In 2008, fifteen vessels participated in this race.
Off Soundings Club Spring Race Series ***(Offsoundings Club)***	The Off Soundings Club Spring Race Series is sponsored by the Off Soundings Club of Madison, Conn., and takes place annually during the second weekend of June. Day 1 of the series comprises a race from Watch Hill to Block Island. Day 2 comprises a race around Block Island. Approximately 120 to 150 vessels ranging in length from 23 to 62 feet participate in this race (Off Soundings Club 2009).
Vineyard Race ***(Stamford Yacht Club)***	The Vineyard Race is a 283-mile race that takes place each year on Labor Day weekend. Racers start in Stamford, Conn., and race eastward through Long Island and Rhode Island Sounds to Buzzard's Bay Tower, near the mouth of Vineyard Sound. Racers then pass to the south of Block Island, re-enter Long Island Sound, and return to Stamford (Stamford Yacht Club 2009a). In 2009, 77 vessels ranging in length from 30 to 90 feet entered this race (Stamford Yacht Club 2009b).
Whaler's Race ***(New Bedford Yacht Club)***	The Whaler's Race is an annual event sponsored by the New Bedford Yacht Club each September. The 105-mile race is open to vessels greater than 25 feet in length. The race course begins and ends in New Bedford and comprises a multi-legged course throughout the Ocean SAMP area (New Bedford Yacht Club 2009a). Twenty-two vessels competed in the 2007 race (New Bedford Yacht Club 2009b).

620.4. Offshore Diving

1. Boat-based scuba diving occurs at a number of sites throughout the Ocean SAMP area, primarily focused around historical ship wrecks or interesting benthic communities. Shark cage diving is another popular activity that is discussed separately, below, under Section 620.5, Offshore Wildlife Viewing. While diving can occur anytime from May through December, visibility underwater is a major factor in selecting the time and location of a dive. In offshore diving areas, visibility improves steadily from May to through September or October, while in diving areas further inshore, good visibility may extend into November (Donilon, pers. comm.). Because visibility within Narragansett Bay is usually poor throughout the year, almost all diving within Rhode Island occurs within the Ocean SAMP area. Many diving excursions are facilitated through professional dive boats that can be chartered by groups of approximately six people, for eight-hour trips. Approximately 10 licensed dive boats operate within the Ocean SAMP area; however, divers may also dive from private boats as well (Bellavance, pers. comm.). The depth of the diving site determines its level of difficulty, with the shallowest sites being used by both beginners and experts, and the deepest sites used only by the more experienced divers.

2. The most important wrecks for diving were identified by dive boat captains operating within the area. Twelve sites were identified as those most commonly used by dive charter operators within the Ocean SAMP area (Bellavance, pers. comm.), and are listed in Table 6.4 and shown in Figure 6.6. In identifying the most popular dive sites within the Ocean SAMP area, only offshore sites were considered. In addition, dive boat captains identified an area that they have considered for potential future dive trips; see Figure 6.6. For a full discussion of historic shipwrecks in the Ocean SAMP area, see Chapter 4, Cultural and Historical Resources.

3. By definition, offshore diving relies on access to shipwrecks and other site-specific ocean features. For further information on ocean features see section 660.

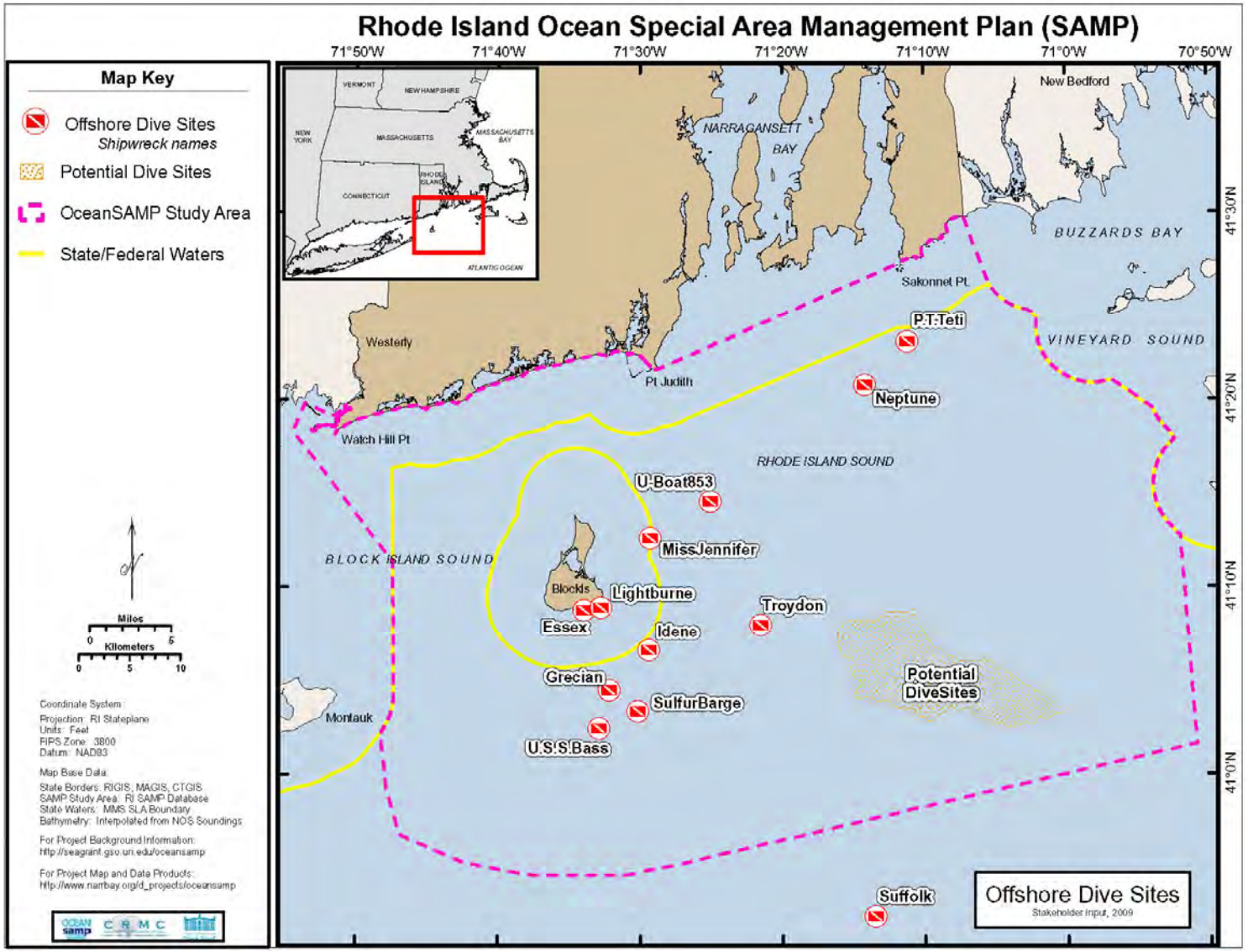


Figure 6.6. Offshore dive sites within the Ocean SAMP area.

Table 6.4. Dive sites within the Ocean SAMP area.

Dive Site	Approximate Position
Suffolk	40° 52.5 N/ 071°13.5 W
U.S.S. Bass	41°02.5 N / 071° 32.9 W
Idene	41°06.65 N/ 071°29.4 W
Sulfur Barge	41°03.4 N/ 071°30.2 W
Grecian	41°04.5 N/ 071°32.2 W
P. T. Teti	41°23.1 N/ 071°11.2 W
Neptune	41°20.8 N / 071° 14.2 W
Troydon	41°08.0 N / 071° 21.55 W
Miss Jennifer	41°12.65 N/ 071°29.3 W
U-Boat 853	41°14.6 N/ 071°25.1 W
Essex	41°08.8 N/ 071°34.0 W
Lightburne	41°08.9 N/ 071°32.9 W

620.5. Offshore Wildlife Viewing

1. Offshore wildlife viewing within the Ocean SAMP area consists mainly of whale, bird, and shark viewing aboard charter vessels of various sizes. Whale watching occurs primarily during July and August when the demand is highest and the whales are most active within the area. During the season, whale watching trips occur most days during the week. Whale watching trips in the Ocean SAMP area are offered by only a couple of Rhode Island-based businesses. The vessels used most frequently for whale watching can carry approximately 100 to 150 people per trip. Assuming roughly 40 trips per season, one whale watching vessel can serve anywhere from 4,000 to 6,000 people per year. A typical whale watching trip lasts for approximately four and a half hours, though there are some overnight charters as well (Blount, pers. comm.). The whale species observed most frequently on whale watching trips within the Ocean SAMP area are finback, minke, and humpback whales. In the early season, right whales are occasionally observed, as well as sperm whales, which chase squid up through the area between Block Island and Long Island (see Figure 6.7). Due to their unpredictable nature, the number of whales observed on these trips can vary greatly from season to season. Areas within the Ocean SAMP area that produce the most frequent whale sighting include the Deep Hole region and an area south of Block Island, both of which are characterized by deeper water (see Figure 6.7).

2. Offshore bird watching charters occur throughout the year, by private charter or in conjunction with whale watching charters. Avian migration patterns dictate what types of species are most prevalent on the bird watching trips. Most trips are day trips, though there are some overnight charters available. Popular times for offshore bird watching are after storms because strong winds can blow rare offshore species closer to shore. Because pelagic bird watching represents a niche market, only a handful of charter boats offer the service. The largest charter vessels involved serve an estimated 400 people per year (Blount, pers. comm.). Areas within the Ocean SAMP area that are used most heavily for bird watching include the waters off the southeast corner of Block Island and the Deep Hole region. However, some trips extend out to the submarine canyons south of the Ocean SAMP area (see Figure 6.7). The areas used for offshore bird watching are often

the same areas used by mobile gear commercial fishermen, as their fishing activity attracts birds.

3. Shark cage diving is another popular offshore wildlife viewing activity. Currently there is one Rhode Island-based charter company running shark cage diving trips within the Ocean SAMP area. Trips are typically eight hours in length, though trips further offshore run from 10 to 12 hours. Divers can choose between using a submersible cage that is lowered approximately seven feet below the surface, or a floating cage platform for those less experienced or who prefer to snorkel rather scuba dive (Snappa Charters 2008). While shark diving trips can occur between June and October, most occur within August and September when visibility is best. The area used for these shark charters can be large (see Figure 6.7) as the boat will usually drift or relocate multiple times to find the best location for the customers (Donilon, pers. comm.).

4. Offshore wildlife viewing areas were identified and mapped through the Ocean SAMP stakeholder process and with particular input from key charter boat operators; see Figure 6.7.

5. It should be noted that offshore wildlife viewing activities rely on the presence and visibility of marine and avian species including fish, whales, sharks, and birds. The site-specific nature of offshore wildlife viewing, as depicted in Figure 6.7, may be due in part to site-specific benthic habitat or other environmental factors. For further discussion of benthic habitat and other natural and physical features, see Chapter 2, Ecology of the SAMP Region.

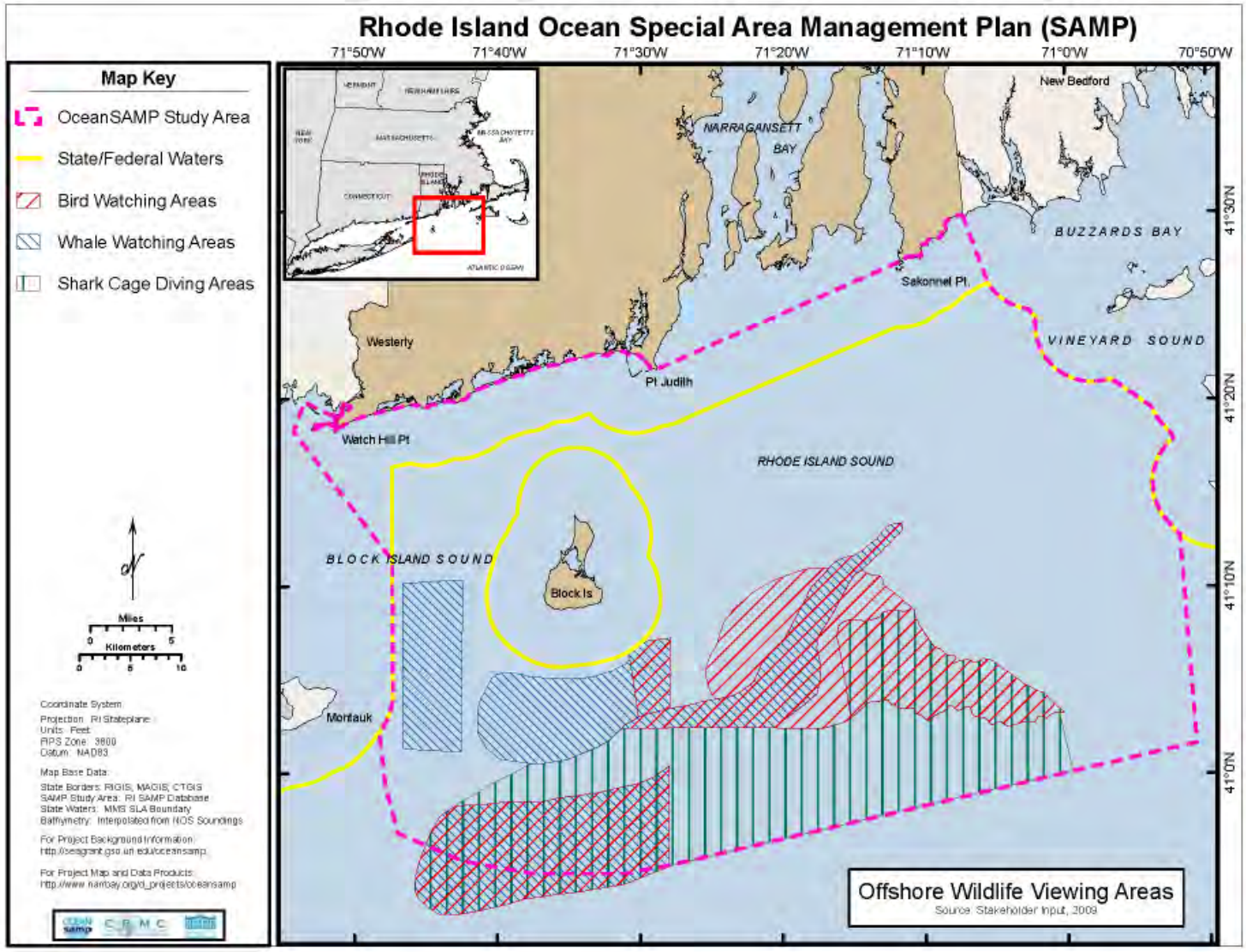


Figure 6.7. Offshore wildlife viewing areas.

620.6. Other Boat-Based Activities

1. Other boat-based activities that may occur within the Ocean SAMP area include parasailing, canoeing, kayaking, sea duck hunting, and other charter boat operations. Parasailing, which requires a specially rigged boat, occurs mainly off the coast of Block Island during the summer months. Canoeing and ocean kayaking activities take place primarily close to shore, in sheltered waters along Rhode Island's south shore and the Block Island coast. Sea duck hunting in Rhode Island is predominately a boat-based activity that takes place in nearshore waters within a mile of the coastline. Hunting is concentrated in waters off of Sachuest Point, Brenton Point, Sakonnet Point, the Point Judith Harbor of Refuge, Green Hill Beach, and Block Island; target species include scoter, eider, and long-tailed ducks (Osenkowski, pers. comm.). Other charter boat activities that may occasionally take place within the Ocean SAMP area include Newport-based sailing charters, and lighthouse viewing tours. Such trips typically take place closer to shore in sheltered waters.

Section 630. Cruise Ship Tourism

1. There are 11 cruise line companies that currently visit Rhode Island coastal communities between April and November (see Table 6.5). These cruise ships pass through the Ocean SAMP area en route to and from Block Island, Newport, Bristol, and Providence. Newport has the largest amount of cruise ship activity. Typically, Newport-bound cruise ships will anchor out in Newport Harbor for eight to 10 hours, allowing passengers to disembark for day trips in the Newport area. Once anchored, passengers are then ferried over to Newport's Perrotti Park in smaller vessels. American Cruise Lines operates smaller ships that dock at Newport's Fort Adams pier. For more information on the routes and anchorages used by cruise ships through the Ocean SAMP area, see Chapter 7, Marine Transportation, Navigation, and Infrastructure.

2. 58 cruise ships were scheduled to visit Newport in 2009 (see Table 6.5), up from 35 ships in 2008 (see Table 6.6) (Newport & Bristol County Convention and Visitors Bureau 2009a). Newport saw its largest amount of cruise ship traffic in 2004, when 76 ships visited between the months of April and November (see Figure 6.8). However, while 2004 had the largest number of ships, 2008 showed the greatest number of cruise ship passengers to Newport, when 68,183 visitors were recorded (see Figure 6.9) (Newport & Bristol County Convention and Visitors Bureau 2009b).

Table 6.5. Cruise ship visits scheduled for Newport in 2009. (Newport & Bristol County Convention and Visitors Bureau 2009a)

Cruise Line	**# of Scheduled Visits**
Carnival	1
Holland America	5
American Cruise Lines	23
Princess	14
P&O	1
Norwegian Cruise Lines	4
Celebrity	1
Cunard	3
Saga	1
Costa	2
Crystal	3
Total	**58**

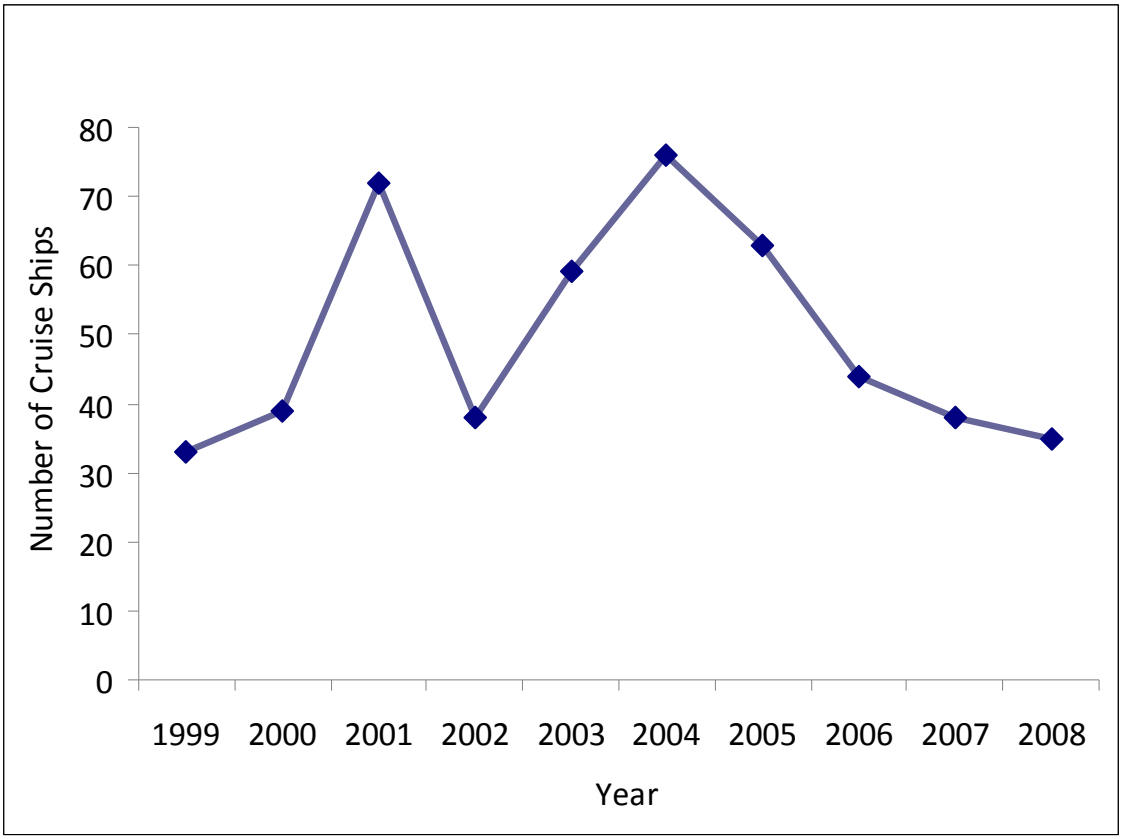


Figure 6.8. Annual cruise ship visits to Newport between 1999 and 2008. (Newport & Bristol County Convention and Visitors Bureau 2009b)

Table 6.6. Number of cruise ships visiting Newport, 1999—2008. (Newport & Bristol County Convention and Visitors Bureau 2009b)

	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
April	0	0	1	0	0	4	0	2	2	1
May	0	0	4	3	8	2	1	2	1	2
June	4	0	9	2	4	4	3	0	1	0
July	4	10	11	2	5	6	10	2	2	1
August	6	9	15	4	10	9	10	5	5	1
September	10	10	17	12	18	23	21	16	11	16
October	9	10	15	15	14	27	15	14	16	14
November	0	0	0	0	0	1	3	3	0	0
Total	**33**	**39**	**72**	**38**	**59**	**76**	**63**	**44**	**38**	**35**

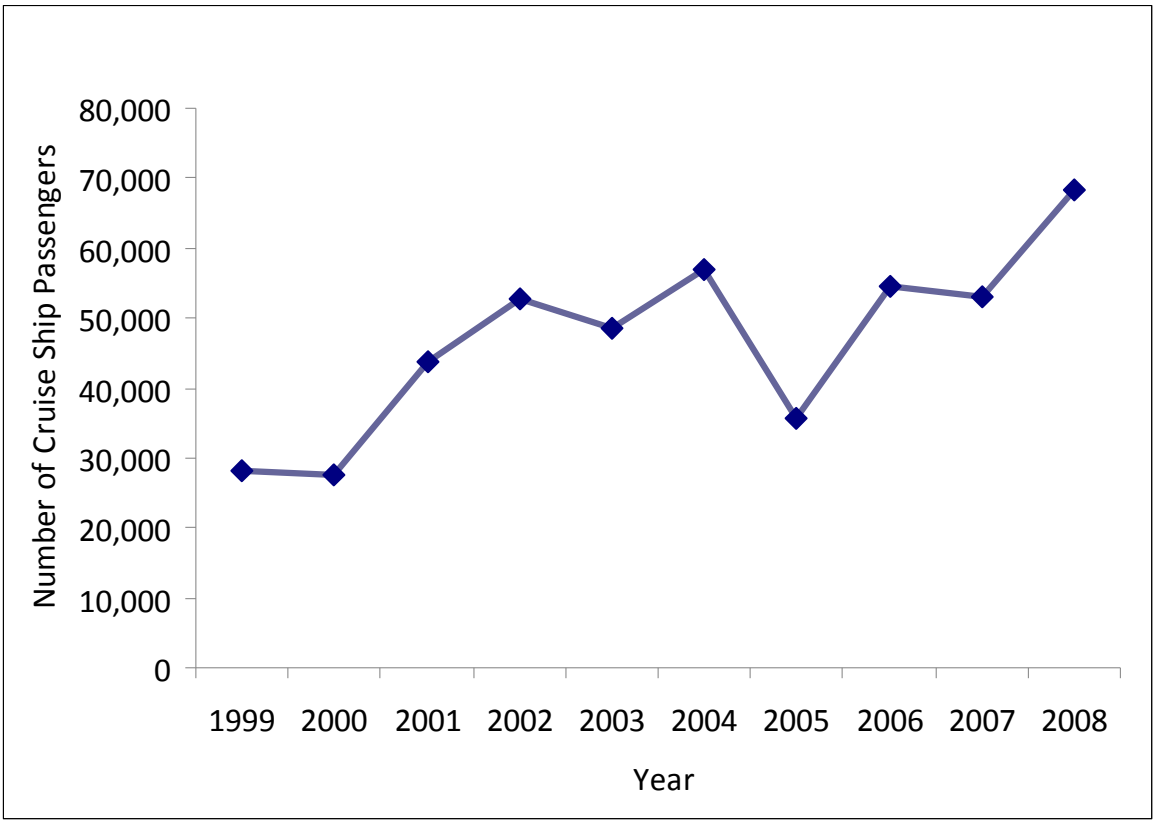


Figure 6.9. Annual number of cruise ship passengers to Newport between 1999 and 2008. (Newport & Bristol County Convention and Visitors Bureau 2009b)

Table 6.7. Number of cruise ship passengers visiting Newport, 1999—2008. (Newport & Bristol County Convention and Visitors Bureau 2009b)

	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
April	0	0	607	0	0	4,650	0	2,333	2,754	2,496
May	0	0	349	3,798	11,088	105	74	588	1,196	1,325
June	2,959	0	7,106	3,080	1,644	186	0	0	1,336	0
July	3,607	6,877	9,471	3,201	205	299	1,468	48	1,422	2,264
August	6,417	7,124	11,386	6,585	2,872	973	268	349	1,561	3,373
September	7,655	4,774	10,641	14,299	15,182	21,519	15,963	21,351	19,000	35,066
October	7,540	8,882	4,085	21,794	17,689	28,986	17,069	25,358	25,733	23,659
November	0	0	0	0	0	333	709	4,492	0	0
Total	**28,178**	**27,657**	**43,645**	**52,757**	**48,680**	**57,051**	**35,551**	**54,519**	**53,002**	**68,183**

Section 640. Shore-Based Recreational Activities Adjacent to the Ocean SAMP Area

1. The shores that surround the Ocean SAMP area attract millions of visitors to the state each year, while also providing invaluable recreational opportunities to residents (R.I. Department of Administration Statewide Planning Program and R.I. Department of Environmental Management 2003). Beaches, parks, open spaces, marinas, and boat ramps all facilitate the direct interaction of people with the Ocean SAMP area. The pristine beaches, parks, and recreational open spaces provide areas for the public to swim, wade, surf, fish from shore, view wildlife, enjoy the scenery, or participate in a number of other recreational activities. In addition, marinas and boat ramps in recreational ports and harbors provide boaters with access to the Ocean SAMP area. Activities taking place in connection with these facilities provide great economic benefits for Rhode Island that are discussed below in Section 650. The location of these types of shore-based facilities shapes access to the Ocean SAMP area by tourists and marine recreational users.

2. The coastal communities of Block Island, Charlestown, Little Compton, Narragansett, and Westerly are directly adjacent to the Ocean SAMP area boundary and are important centers of recreation and tourism activity. Other coastal communities, such as Newport, do not directly adjoin the Ocean SAMP area but are popular recreation and tourism destinations and facilitate Ocean SAMP area recreation and tourism. These communities provide Rhode Island residents and visitors with access to Ocean SAMP area waters through their beaches, parks, open space, marinas, yacht clubs, boat ramps, and other features. These communities rely on Ocean SAMP-area recreation and tourism opportunities as a means of attracting seasonal visitors who, in turn, contribute to these communities' local economies. See below for further information on shore-based recreational facilities and associated activities, and see Section 650 for further information on the economic impact of such activities.

3. Shore-based facilities shown on the following maps are all based on the most current datasets available from Rhode Island Geographic Information Systems (RIGIS). See Table 6.9 for a complete list of datasets used in this section.

640.1. Beaches, Parks, and Open Space

1. Rhode Island's beaches, parks, and open spaces are some of the state's most appealing features. In the summer of 2004, more than 6 million people visited Rhode Island's state parks and beaches, including close to 3 million visitors to Rhode Island state beaches alone (R.I. Department of Environmental Management 2004). Rhode Island parks and beaches currently have the highest park visit per acre ratio in the country, with approximately 750 visitors per acre (R.I. Department of Environmental Management 2001). There are at least 28 public beaches along the southern shore of the state and around Block Island that abut the Ocean SAMP area (see Table 6.8). This list of beaches does not include private beaches and beach clubs. The long sandy ocean beaches of the southern shore draw over 1.9 million visitors each year, including many from out of state (R.I. Department of Administration Statewide Planning Program and R.I. Department of Environmental Management 2003). In addition, it is estimated that approximately

168,000 people visit Block Island beaches each year (Closter, pers. comm). See Figure 6.10 for a map of beaches, parks, and open spaces adjacent to the Ocean SAMP area.

Table 6.8. Public beaches adjoining the Ocean SAMP area. (Allard (ed.) 2004; Closter, pers. comm.; R.I. Department of Environmental Management 2009)

Beach	**Town**
Baby Beach	New Shoreham (Block Island)
Charlestown Beach	New Shoreham
Cow Beach	New Shoreham
Fred Benson Town Beach	New Shoreham
Innisvalle Beach	New Shoreham
Mansion Beach	New Shoreham
Mohegan Bluffs	New Shoreham
Scotch Beach	New Shoreham
State Beach	New Shoreham
Surf Beach	New Shoreham
Misquamicut State Beach	Westerly
Napatree Point	Westerly
New Westerly Town Beach	Westerly
Westerly Town Beach	Westerly
Blue Shutters Town Beach	Charlestown
East Beach	Charlestown
Charlestown Breachway	Charlestown
Charlestown Town Beach	Charlestown
Quonochontaug Breachway	Charlestown
East Matunuck State Beach	South Kingstown
Green Hill Beach	South Kingstown
Moonstone Beach	South Kingstown
Roy Carpenter's Beach	South Kingstown
South Kingstown Town Beach	South Kingstown
Salty Brine State Beach	Narragansett
Roger Wheeler State Beach	Narragansett
South Shore Beach	Little Compton

** New Shoreham beaches are reported by the Town of New Shoreham. On Block Island there are 2 miles of continuous beach on the east side of the island; this area is broken down into different named beaches: Surf Beach, Baby Beach, South of State, State, North of State, Innisvalle, Scotch, and Mansion. Fred Benson Town Beach is at the center of this area (Closter, pers. comm.).*

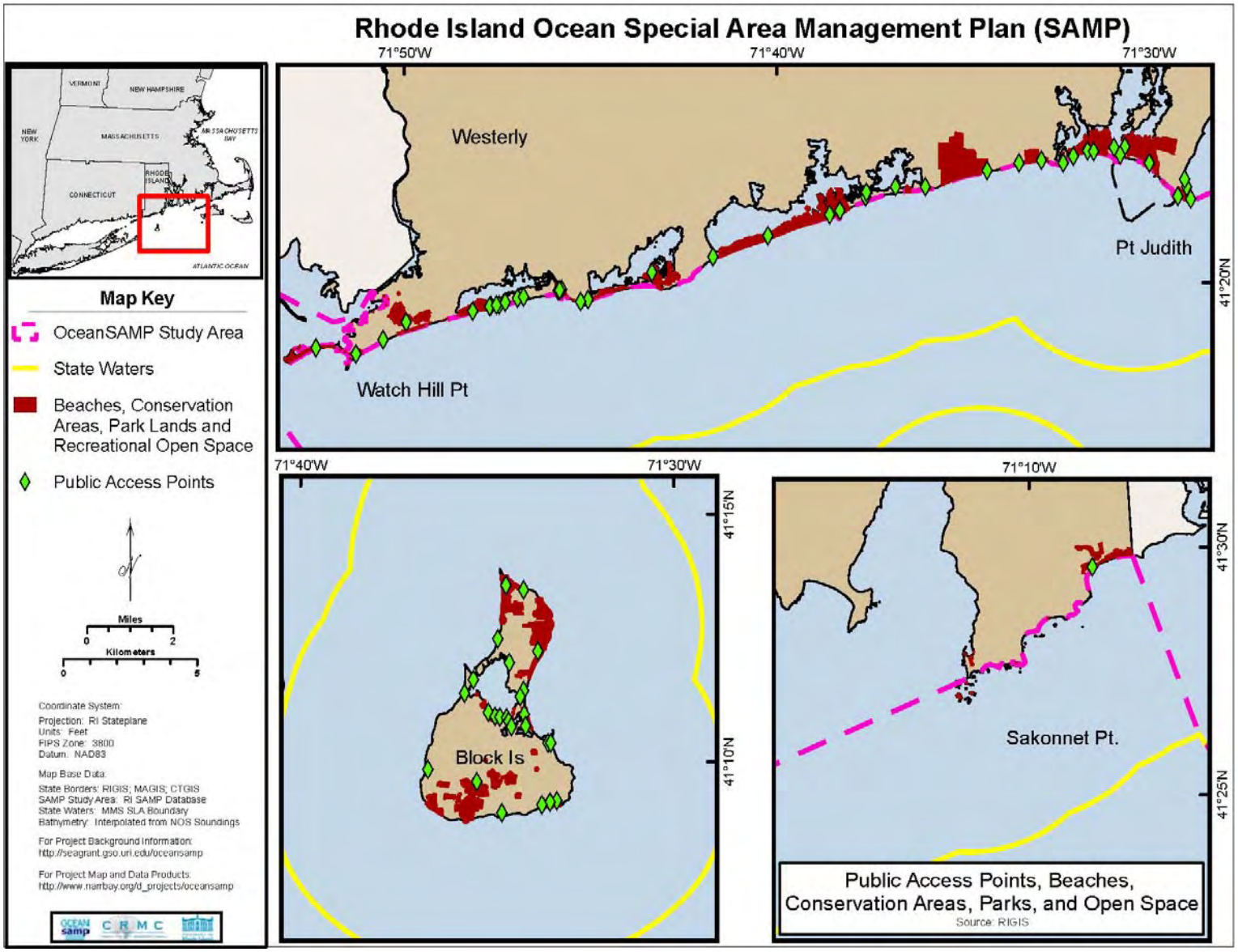


Figure 6.10. Public access points, beaches, conservation areas, parks, and open space adjoining the Ocean SAMP area.

2. According to the R.I. Department of Environmental Management (2001), 40 percent of attendance at beaches along the southern shore is by state residents, and 60 percent is by out-of-state visitors. In Fiscal Year 1999, 58 percent of cars that paid fees at the entrance gate at state beaches were from out-of-state (R.I. Department of Environmental Management 2001).

3. Beach-based activities that occur within or adjacent to the Ocean SAMP area include surfing, wind surfing, kite-boarding, and swimming. Other shore-based activities include fishing, bird-watching, and sight-seeing.

4. Surfing is a popular recreational activity in Rhode Island for both residents and visitors. Rhode Island's coast includes over 30 surfing locations, some of which adjoin the Ocean SAMP area. These include sandy beaches and rocky areas on Block Island and in Point Judith, Matunuck, and Westerly. The most avid surfers will surf year-round, taking advantage of storm swells or surf in the winter months (Allard Cox 2004).

5. Bird-watching is another popular shore-based recreational activity adjacent to the Ocean SAMP area and brings many visitors to coastal communities such as Block Island. New England's Audubon Societies and other conservation organizations travel to Block Island each fall to observe the fall migration of various avian species, often staying for multiple days (Marks, pers. comm.).

6. Rhode Island's lighthouses attract many additional visitors to some coastal recreational destinations. Popular lighthouses adjacent to the Ocean SAMP area include Block Island's Southeast Lighthouse and North Lighthouse; Point Judith Lighthouse, and Watch Hill Lighthouse. All of these lighthouses are listed on the National Register of Historic Places, and Block Island's Southeast Light is designated as a National Historic Landmark (National Park Service 2005). See Chapter 4, Cultural and Historical Resources, for further discussion.

7. Residents and visitors can gain access to the Ocean SAMP area through conservation areas, fishing sites, birding sites, coastal parks and recreation areas, and scenic views and overlooks. Figure 6.10 displays the location of the 67 public access sites along the coast adjacent to the Ocean SAMP area. From these sites, individuals can reach coastal waterways, fish from shore, view wildlife, enjoy a scenic view or participate in a number of other recreational activities. In addition to the public access sites located directly adjacent to the Ocean SAMP area border, the public can also gain access to the Ocean SAMP area from surrounding access points within Narragansett Bay (Allard Cox 2004).

8. An analysis of the most up-to-date RIGIS data on coastal recreational areas shows that in addition to the 67 designated public access sites, there are approximately 3,394 acres of beaches, conservation areas, and recreational open space adjacent to the Ocean SAMP area (as illustrated in Figure 6.10). It should be noted that this is an approximate calculation only, based on the best available data, and may overstate the acreage of such areas. See Table 6.9 for a list of the RIGIS datasets used in this analysis.

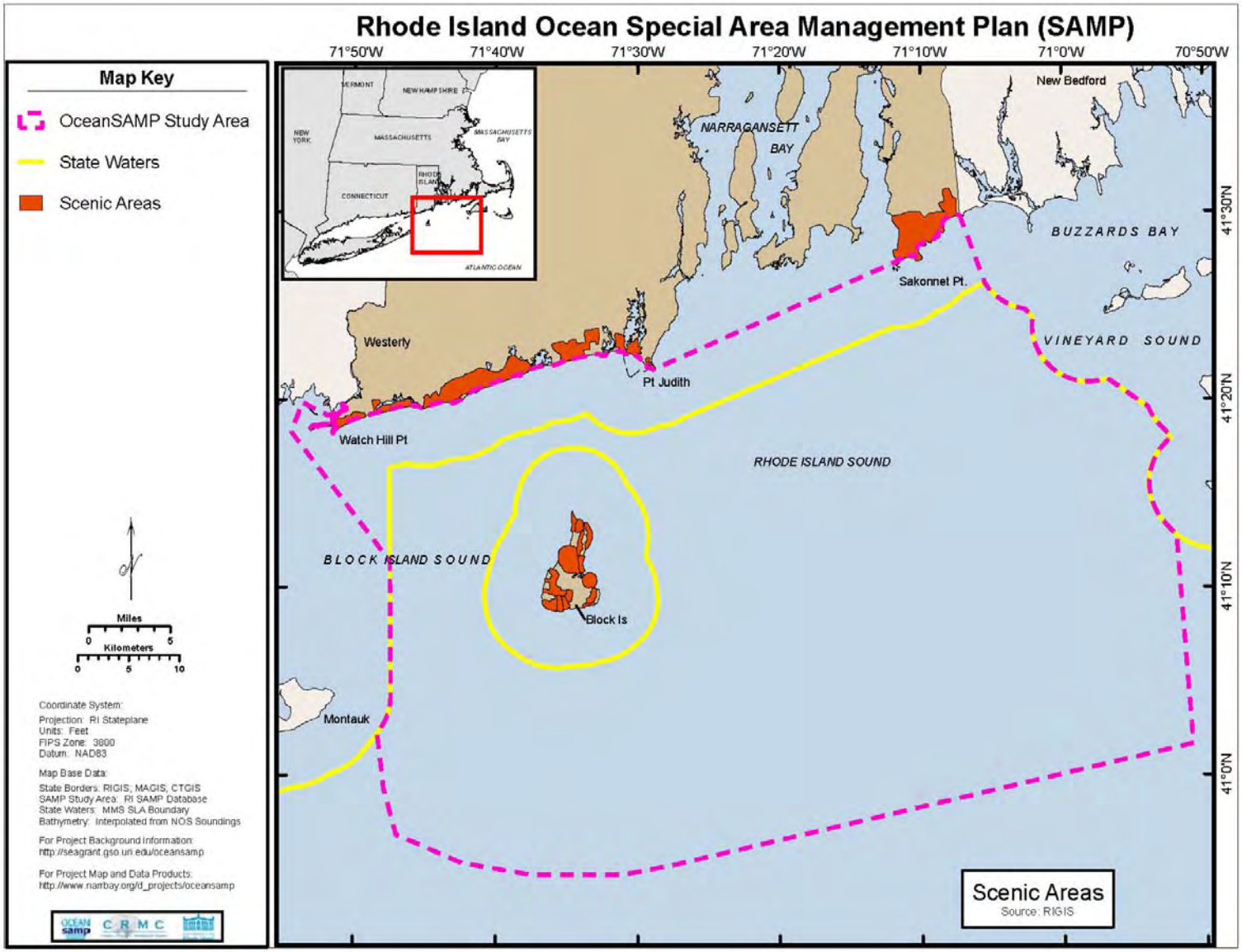


Figure 6.11. Scenic areas adjoining the Ocean SAMP area.

640.2. Marinas and Boat Ramps

1. Marinas and boat ramps provide boaters access to the Ocean SAMP area waters. According to the most current RIGIS data available, Rhode Island has a total of 20 marinas directly adjacent to the Ocean SAMP area (see Figure 6.12 and Table 6.9 below) and many others throughout the state. According to the most current RIGIS data available, there are nine boat ramps directly adjacent to the Ocean SAMP area available for public use (see Figure 6.12 and Table 6.9 below). Boat ramps throughout Narragansett Bay may also facilitate recreational use of the Ocean SAMP area by providing access to connecting waterways. In addition to marinas and boat ramps, boaters can also gain access to the Ocean SAMP area via private yacht clubs, though a current count of all yacht clubs adjacent to the Ocean SAMP boundary is not available.

2. Marinas, boat ramps and yacht clubs are instrumental in the use of the Ocean SAMP area, especially by tourists or out-of-state visitors. Non-resident boats represent a key market for marinas, especially for marinas located along Rhode Island's south shore. Nearly all (96 percent) of all out-of-state boats in Rhode Island are kept at marinas, and nearly 50 percent of those are kept along the state's southern coast, providing direct access to the Ocean SAMP area (R.I. Economic Monitoring Collaborative 2008).

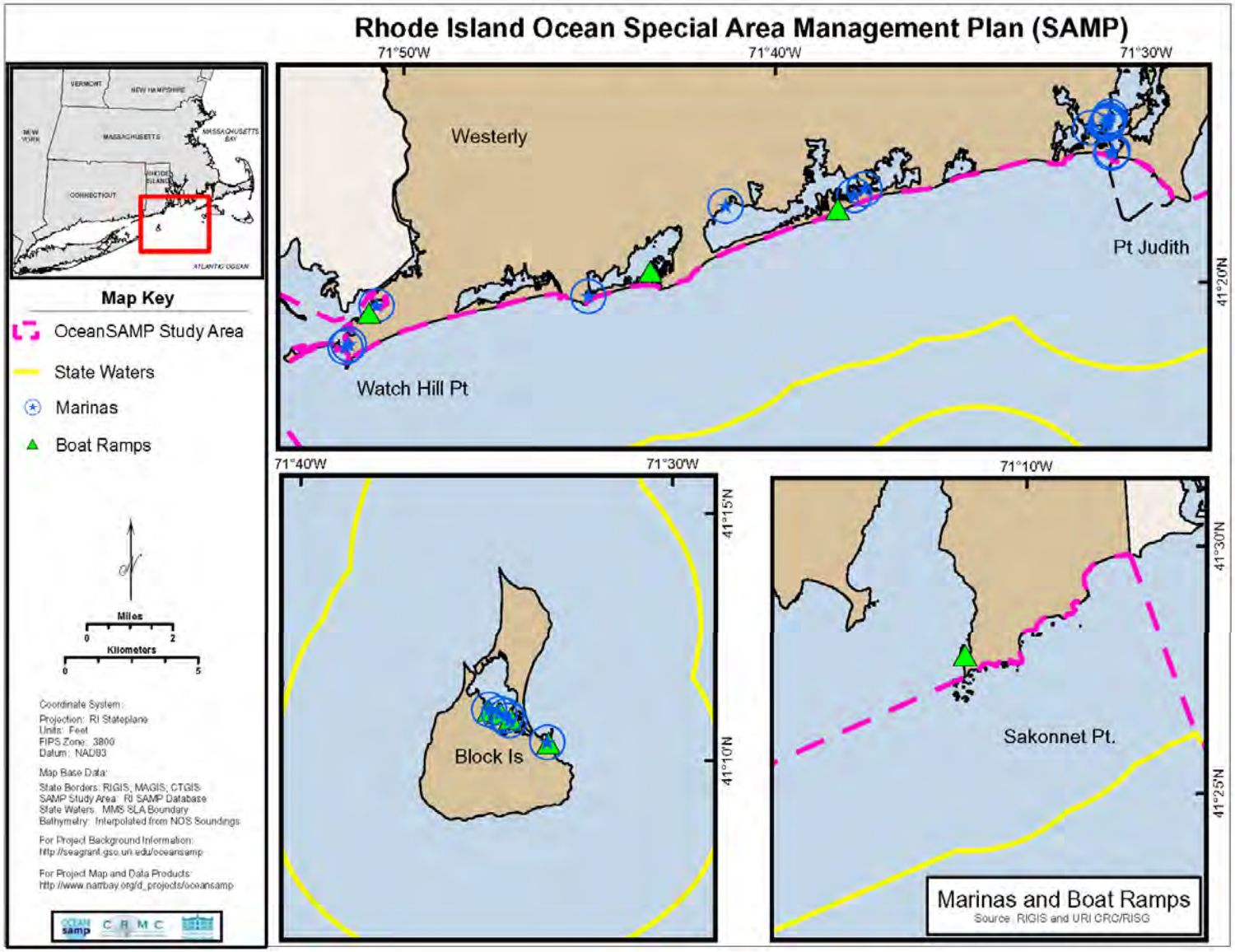


Figure 6.12. Marinas and boat ramps adjoining the Ocean SAMP area.

640.3. Recreational Ports and Harbors

1. Recreational activities in the Ocean SAMP area, and recreational boating in particular, are supported by boating-related infrastructure throughout the state of Rhode Island. Most recreational sail and power boats that use the Ocean SAMP area for recreation are either based in or will pass through one of the state's many harbors—either those providing direct access to the Ocean SAMP area, such as Newport Harbor, Galilee/Point Judith in Narragansett, and Block Island's two harbors, or any of the numerous harbors and marinas located further up Narragansett Bay. These harbors and their shore-side services, including marinas, boat repairs, boat storage, fuel, and supplies, support Rhode Island's recreational boating industry. See Section 620.1 for more discussion on recreational boating in Rhode Island, and Section 650.2 about the economic impact of recreational boating on the state.

Table 6.9. Datasets used to assess shore-based facilities and access points adjoining the Ocean SAMP area.

Data Source	Description of Data Set
Public Access to the Rhode Island Coast (RIGIS 2003)	Public access points to the shoreline of Narragansett Bay and Rhode Island coastal waters to parks, beaches, refuge areas, boat ramps, marinas, and other areas open to the public managed by federal, state, and municipal government, private organizations with interests in land preservation and protection, and rights-of-way that have been designated by the R.I. Coastal Resources Management Council.
State Conservation and Park Lands (RIGIS 2006)	Approximate edges of conservation lands protected by the state of Rhode Island through fee title ownership, conservation easement, or deed restriction. Includes: wildlife management areas, drinking water supply watersheds, state parks, beaches, bike paths, fishing access areas, local parks, and recreation facilities that have been developed with state grant funds.
Scenic Areas of Rhode Island (RIGIS 1989)	Areas designated as noteworthy or distinctive scenic landscapes or views by the R.I. Department of Environmental Management.
State Conservation and Recreational Open Space 1990 (RIGIS 2002)	Land in Rhode Island considered as open space for recreational and conservation purposes, including those properties owned or managed by federal, state, or municipal agencies and private sector organizations and individuals.
Marinas in Rhode Island (RIGIS 1996a)	Public and private yacht clubs, marinas, and recreational boating facilities in Narragansett Bay and southern coastal Rhode Island.*
Boat Ramps in Rhode Island (RIGIS 1996b)	Public recreational boat launching ramp and marine pump-out facilities for fresh and salt water bodies in Rhode Island.

Note: these datasets are the most current versions available from RIGIS.
**Marina dataset was updated, based on Rhode Island marina listings and RIGIS orthophotography, to address inaccuracies.*

Section 650. Economic Impact and Non-Market Value of Recreation and Tourism in the Ocean SAMP Area

650.1 . Economic Impact of Recreation and Tourism

1. Tourism and hospitality is Rhode Island's fourth largest industry based on employment, contributing $6.8 billion in spending and generating 12 percent of all state and local tax revenue in 2007 (Global Insight 2008). The growth of this industry has more than doubled in size in recent years from $2.7 billion in 1999 (Rhode Island State Senate Policy Office 2002). While it is difficult to segregate marine-related recreation and tourism from general tourism statistics, these figures provide a general sense of the economic importance of the larger tourism industry to the state. Ocean-based recreational activities and coastal tourist attractions have been described as likely contributing "directly or indirectly to a significant portion of the overall tourism revenues, not to mention the marine image of the state that is a crucial element of Rhode Island's unique 'brand'" (Rhode Island State Senate Policy Office 2002).

2. Although marine recreation and tourism are valuable uses of the Ocean SAMP area, the economic value of these uses is difficult to describe due to a lack of research. In many cases, the economic value of both land- and water-based tourism and recreation are presented jointly, making the value of each impossible to distinguish. Furthermore, much of the most relevant research—which constitutes the best available data—is several years old (e.g. Tyrrell and Johnston 2001; Tyrrell and Harrison 2000). For these reasons, it is difficult to describe the current value of marine recreation and tourism directly associated with the Ocean SAMP area. Figures cited in this section are based on the best available data and represent data from different years and data sources. All dollar values presented here are expressed in the dollar value of the year in which the data was collected, and have not been converted to present dollar values.

3. In 2007, over 5.7 million visitors were determined to have visited the region adjoining the Ocean SAMP area, with a large portion of visitors coming from out of state (see Table 6.10 below). Based on a 2007 survey, approximately two-thirds of visitors to the state's south coast were from out of state. The majority visited from Massachusetts, Connecticut, New York and New Jersey, while others visited from other east coast U.S. and international locations (R.I. Economic Monitoring Collaborative 2008).[2] These visitors support local economies through spending on entertainment, accommodations, transportation, food, and shopping (Global Insight 2008).

[2] Survey included 315 participants, sampled during July 5th and August 18th, 2007. Locations surveyed on the southern coast included Watch Hill; Misquamicut Boardwalk and Beach area; East Matunuck & Charlestown Breachway state parks; Newport – Thames Street and America's Cup Boulevard, Bellevue Ave. Cliff Walk, Bannister's Wharf, Visitor Center; Little Compton / Tiverton Four Corners; Narragansett – Roger Wheeler, Scarborough, Seawall, Point Judith Ferry area; Wickford.

Table 6.10. Number of visitors to coastal destinations in 2007. (Global Insight 2008)

Area	Visitors
Block Island	616,300
Newport County	2,901,400
South County[3]	2,251,000

4. Rhode Island's coastal tourism is very seasonal, with coastal communities doubling and tripling in population during the summer months (Colt et al. 2000). For example, New Shoreham (Block Island) has a year-round population of approximately 1,000 people, though during the summer months residents increase to approximately 10,000 people. A peak summer day could add an additional 10,000 visitors to the island, doubling its summer population level (U.S. Coast Guard 2006). This influx of people during the summer season is vital to local economies, as an average visitor to Rhode Island spent approximately $384 per visit in 2007 (Global Insight 2008). Total tourism expenditures on Block Island in 2007 totaled over $259 million (see Table 6.11). The South County region of the state generated over $751 million tourism expenditures in 2007, and Newport tourism expenditures totaled over $790 million in the same year. (Global Insight 2008) Collectively, coastal tourism in areas adjacent to the Ocean SAMP area generated over $1.8 billion in spending in 2007.

5. The seasonal nature of Rhode Island's coastal tourism is most pronounced on Block Island. As noted above, Block Island's population swells markedly during the summer season. Whereas the tourism data cited above and in Tables 6.10 and 6.11 suggest that Block Island has fewer visitors and therefore a smaller economic impact than other coastal communities, such a comparison may be misleading. The Block Island data represent one destination, not an entire county; moreover, these data primarily represent the Block Island summer season, which is only 10 weeks long (mid-June through the end of August). This is because Block Island, unlike other locations like Newport, is a much more seasonal destination and relies heavily on the summer months for its tourism economy (Willi, pers. comm.).

Table 6.11. Coastal areas' share of state tourism expenditures. (Global Insight 2008)

Area	Expenditures ($)
South County	$751,830,000
Newport County	$790,790,000
Block Island	$259,410,000

6. Rhode Island's marine recreation and tourism industry supports a number of jobs within the state. The National Ocean Economics Program compiles data on coastal recreation and tourism industries from state labor agencies, as well as the federal Bureau of Labor Statistics and the Bureau of Economic Analysis. According to this data set, in 2004 the recreation and tourism industry in both coastal counties adjacent to the Ocean SAMP (Washington County and Newport County) included 779 different establishments and

[3] Global Insight included the following municipalities in South County: Charlestown, Coventry, East Greenwich, Exeter, Hopkinton, Narragansett, North Kingstown, Richmond, South Kingstown, Westerly and West Greenwich.

10,086 employees (see Table 6.12). The industry was also calculated to have paid over $161 million in wages and produced $393 million in gross domestic product (GDP) in 2004 (National Ocean Economics Program 2009). Measurable growth has been seen in this industry between 1997 and 2004, as the number of establishments involved in recreation and tourism (as defined by the National Ocean Economics Program) within the coastal counties surrounding the Ocean SAMP area grew by 128 facilities, 1,964 jobs, over $36 million in wages, and $86 million in GDP (see Table 6.12).[4]

Table 6.12. Recreation and tourism employment numbers, wages and GDP value within all coastal counties adjacent to the Ocean SAMP area, 1997-2004. (National Ocean Economics Program 2009)

Year	Number of Establishments	Number of Employees	Total Wages Paid	GDP
2004	779	10,086	$161,448,672	$393,372,000
2003	746	9,819	$156,908,694	$380,894,000
2002	721	9,815	$163,418,234	$367,731,000
2001	726	9,654	$158,222,225	$372,150,000
2000	725	9,510	$151,382,834	$369,254,000
1999	737	9,414	$148,640,308	$357,012,000
1999	737	9,414	$148,640,308	$357,012,000
1998	720	8,742	$134,918,102	$324,660,000
1997	651	8,122	$122,058,249	$306,648,000
Note: the National Ocean Economics Program converts all dollar values to year 2000 equivalents.				

7. Current estimates for 2007 rank the travel and tourism sector in Rhode Island as the state's fourth largest employer, representing 40,635 jobs (Global Insight 2008). While this figure includes all tourism within the state, regional employment data for areas adjoining the Ocean SAMP area attribute 2,159 jobs on Block Island, 8,127 jobs in Newport, and 5,725 jobs in the South County region directly and indirectly to the tourism industry (Global Insight 2008).

650.2. Economic Impact of Water-Based Recreational Activities

1. Local economies benefit financially from recreational boating within the Ocean SAMP area through boaters' expenditures on marina services and fuel, as well as dining and entertainment. Exact estimates of the current economic impact of recreational boating in the Ocean SAMP area are unknown. However, a state-wide study conducted by Ninigret Partners in 2006 found that the 43,000 boats registered in Rhode Island at that time generated approximately $182 million worth of spending each year (R.I. Economic Monitoring Collaborative 2008). It should be noted that this figure excludes transients, megayachts (very large yachts), and regatta participants and therefore likely underestimates the economic impact of this industry. Of the $182 million spent in 2006 by recreational boaters in the state, approximately a third (or $63 million each year) was

[4] According to the National Ocean Economics Program, the tourism and recreation sector includes: amusement and recreational services, boat dealers, eating and drinking establishments, hotel and lodging, marinas, recreational vehicle parks and campgrounds, scenic water tours, sporting good retailers, zoos and aquaria. Wage and GDP growth, as calculated by the National Ocean Economics Program is expressed in year 2000 dollar values.

spent on trip-related expenses, such as dining, fuel, groceries, and marina services. In contrast, this study calculated that in 2006, $118 million annually was spent on boat ownership, including repairs, dockage fees, insurance, and equipment (R.I. Economic Monitoring Collaborative 2008). These findings illustrate how spending by recreational boaters supports a variety of businesses adjacent to the Ocean SAMP area and throughout the state.

2. In 2007 the Rhode Island Marine Trades Association reported that there are over 2,300 businesses within the state involved in marine-related industries, providing over 6,600 jobs and $260 million in wages (Rhode Island Marine Trades Association 2007). A NOAA study examined the recreational boating sector, focusing only on boat dealers, businesses in boat building and repair, marinas, and scenic and sightseeing transportation, and found that in 2005 there were 176 establishments in the state of Rhode Island, up 20 percent from the number of establishments in 1998 (see Table 6.13 below) (Thunberg 2008).

Table 6.13. Marine recreational boating industry in Rhode Island, 1998-2005. (Thunberg 2008)

Year	Number of Establishments	Number of Employees	Share of State Employment
1998	138	1,702	7.1%
1999	128	1,595	6.4%
2000	127	1,731	6.6%
2001	137	1,981	7.3%
2002	145	1,872	7.1%
2003	159	1,698	5.8%
2004	164	1,934	6.4%
2005	176	2,071	6.9%

3. While it is difficult to estimate the precise economic impact of recreational fishing in Rhode Island, the industry is highly important for the state. An estimated 468,000 saltwater anglers, more than half of whom were from out of state, fished more than one million trips in Rhode Island in 2006. These anglers spent an estimated $182 million on fishing, producing a value-added economic impact to the state of $82 million (National Marine Fisheries Service, Fisheries Statistics Division 2009). For more information on the value of recreational fishing to the state, please see Chapter 5, Commercial and Recreational Fisheries.

4. The impacts of marine events such as sailboat races have long been recognized for the associated benefits they provide to the economies of host cities and towns (R.I. State Senate Policy Office 2002). Participants and spectators of marine events in the Ocean SAMP area support local economies throughout the state through their spending before, during and after a race or other marine event. Past studies on sailing races and other marine events in Rhode Island have suggested that day- or weekend-long events can have considerable economic impacts on the local economy. For example, the 1992 Newport-Bermuda Race was estimated to have approximately $6.5 million gross economic impact and $1.15 million worth of direct sales impact on Rhode Island (see Table 6.14 below) (Tyrrell and Johnston 2001).

Table 6.14. Economic impact of select marine events between 1986-1995. (Tyrrell and Johnston 2001)

Event	Gross Impact	Net Direct Sales Impact on R.I.
1986 Block Island Race Week	$839,000	$667,000
1989 Newport International Sailboat Show	$9,315,000	$2,928,000
1989 Newport International Powerboat Show	$4,178,000	$1,523,000
1990 Volvo Newport Regatta	$770,000	$513,000
1992 Newport-Bermuda Regatta	$6,472,000	$1,150,000
1995 Newport International Boat Show	$21,338,000	$8,054,000
Note: all dollar values presented here are expressed in the dollar value in the year in which the event was held.		

Table 6.15. Average sailboat racing event expenditures per entry (1992 dollars). (Tyrrell 1993 as referenced in Colt et al. 2000)

Expenditure Category	1985 Admirals Cup	1985 Swarovski Maxi Boat Regatta	1986 Block Island Race Week	1990 Volvo Newport Regatta	1992 Newport Bermuda Race
Lodging	$2,609	$12,314	$1,271	$251	$1,010
Food	$3,326	$21,132	$1,059	$407	$1,204
Entertainment	$1,826	$10,097	$294	$152	$263
Transportation	$978	$3,653	$224	$45	$839
Entry Fees			$510	$142	
Gifts and Miscellaneous	$1,826	$3,913	$210	$136	$616
Marina and Docking		$2,635	$286	$185	$430
Cleaning and Repair		$5,870	$82	$101	$846
Equipment and Supplies		$1,174	$193	$156	$5,162
Total Expenditure per Entrant	$10,565	$60,788	$4,129	$1,575	$10,370
Number of Entries	38	5	227	327	119
Total Expenditures per Event	**$401,470**	**$303,940**	**$937,283**	**$515,025**	**$1,234,030**

5. In 2007, Allianz Global Investors sponsored an economic impact study of the relative impacts of holding the America's Cup in a variety of communities around the world, and included Newport in the analysis. It was estimated that holding the 2010 America's Cup in Newport would generate total economic activity of $886 million (expressed in 2007 dollar values) in pre-event and event spending (Allianz Global Investors 2007).

6. A study conducted by Ninigret Partners in 2008 for the R.I. Economic Monitoring Collaborative concluded that the vast majority of marine event spending is tied to race expenditures, through the purchase of sails, vessel repairs, gear, and other boat equipment. The next largest spending category is for food and lodging. See Table 6.16 below.).

Table 6.16. Distribution of expenditures associated with competitive sailboat racing events. (R.I. Economic Monitoring Collaborative 2008)

Expenditures	Average Range of Total Spending Per Event
Race-related costs	60-70%
Lodging	10-15%
Food	10-15%
Transportation	10%
Shopping	3-5%
Entertainment	2%

7. A 2006 national analysis found that on average, a cruise passenger will spend approximately $123.39 per visit in a port of call such as Newport (expressed in 2006 dollar values, Business Research and Economic Advisors 2007). Based on this estimate, in 2008 the 68,183 cruise ship passengers that disembarked in Newport for the day generated over $8.4 million in spending in local establishments (see Figure 6.13). In addition to direct spending, for every cruise ship passenger that disembarks from a vessel in Newport, the city of Newport collects a $4 port tax (Smith, pers. comm.). As a result, the 2008 cruise ship season produced approximately $272,000 in city revenue (see Figure 6.14). Overall, the cumulative impact of cruise ship passengers on Newport's local economy in 2008 totaled over $8.6 million.[5]

8. States also benefit from purchases of goods and services for the ship itself. For example, cruise operations within a state may purchase air transportation, food and beverage goods for the ship, maintenance or refurbishment services, or engineering and travel agent services (Cruise Lines International Association 2007). Research by Cruise Lines International Association showed that in 2007, including all purchases described above, Rhode Island received approximately $25 million from cruise lines operating in the state, and cruise lines supported 377 jobs and contributed $13 million in wages within the state (Cruise Lines International Association 2008).

[5] Based on the national study and additional port tax charged by the City of Newport, 68,183 passengers x ($123.39+$4.00)= $8,685,832 in revenue.

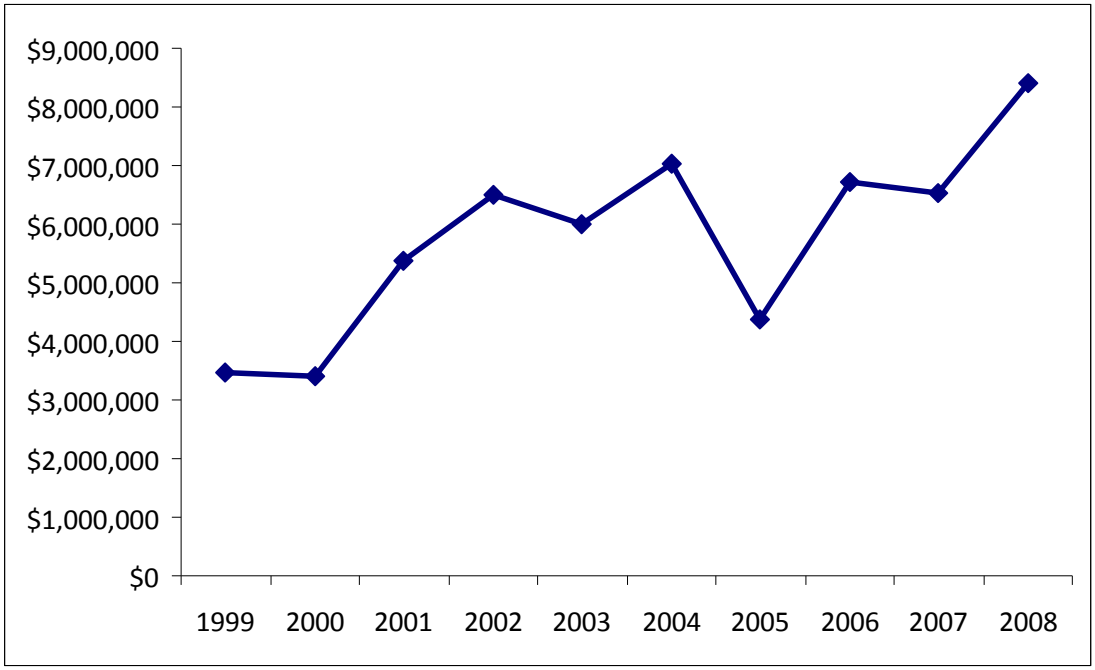


Figure 6.13. Total estimated spending by cruise ship passengers in Newport between 1999 and 2008. (Based on national daily average spending of $123.39 per passenger and passenger counts provided by Newport & Bristol County Convention and Visitors Bureau 2009a)

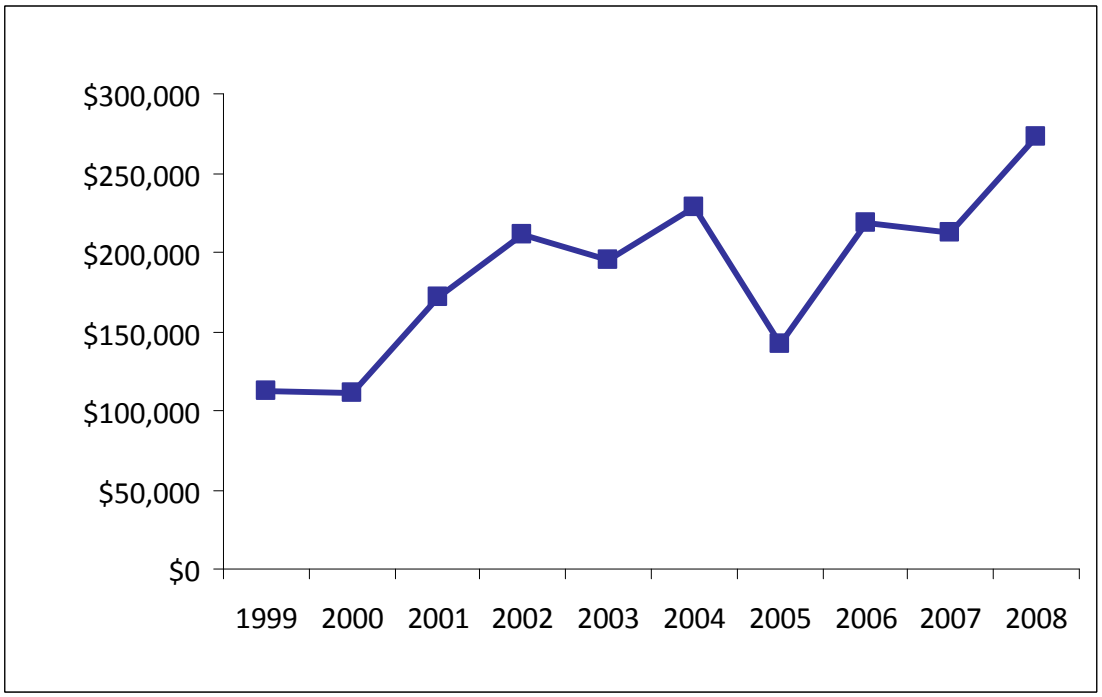


Figure 6.14. Total port tax revenue received from cruise ship passengers visiting Newport between 1999 and 2008. (City of Newport 2009)

650.3. Economic Impact of Shore-Based Recreational Activities

1. Statistics gathered from Rhode Island's state parks and beaches are one indicator of coastal tourism in the state. Rhode Island parks and beaches currently have the highest park visit per acre ratio in the country, with approximately 750 visitors per acre (R.I. Department of Environmental Management 2001).

2. The summer of 2004 brought more than 6 million visitors to Rhode Island's state parks and beaches, including close to 3 million visitors to Rhode Island state beaches (R.I. Department of Environmental Management 2004). More than $4 million in revenue was generated by beach and campground attendance in 2004 (R.I. Department of Environmental Management 2004), up from $3 million in 2000 (R.I. State Senate Policy Office 2002). Tourists frequent coastal hotels, rent summer lodging, visit restaurants and local stores where they spend money, and also contribute revenues from camp and beach fees directly to the state general fund, which in 1999 amounted to $875,000.

3. An analysis performed by the R.I. Department of Environmental Management in 2006 found that Rhode Island's state beaches and coastal campgrounds are vital to the continued operation of the state's entire park system, representing nearly 82 percent of park system revenue. Nearly 79 percent of that revenue is generated during the months of June, July and August. This analysis also demonstrated that while in-state residents represented approximately 57 percent of beach admissions, non-residents generated most of the revenues (64 percent). In fact, more than half (51 percent) of the non-resident revenue stream generated within the state is produced at Misquamicut Beach alone (R.I. Economic Monitoring Collaborative 2008).

650.4. Non-Market Value of Recreation and Tourism

1. The Ocean SAMP area also provides social, cultural, aesthetic, and historic value to users, visitors, and residents. While the non-market value of the Ocean SAMP area, as with all coastal areas, is difficult to quantify and evaluate, it is very important insofar as it is part of the appeal that draws visitors and residents to Rhode Island and adds to the quality of life within the area (e.g. Anthony et al. 2009). Table 6.17 lists some examples of the non-market values of the Ocean SAMP area, though it should not be considered a comprehensive list.

Table 6.17. Examples of the economic impact and non-market value of the Ocean SAMP area.

Examples of the Economic Impact of Recreational and Tourism Uses of the Ocean SAMP Area	1. Total annual value of $4.3 billion for all outdoor recreational activities associated with the marine aquatic and shoreline environments (Colt et al. 2000). 2. Collectively, coastal tourism in areas adjacent to the Ocean SAMP area generated over $1.8 billion in spending (Global Insight 2008). 3. The recreation and tourism industries in coastal counties adjoining the Ocean SAMP area supported over $161 million in wages and produced $393 million in gross domestic product (GDP) in 2004 (National Ocean Economics Program 2009). 4. It was estimated that holding the 2010 America's Cup in the Ocean SAMP area would generate total economic activity of $886 million in pre-event and event spending in Newport (Allianz Global Investors 2007). 5. The cumulative impact of cruise ship passengers on Newport's local economy in 2008 totaled over $8.6 million (see Section 650.2).
Non-market Value of Recreational and Tourism Uses of the Ocean SAMP Area	6. Relaxation benefits provided by Ocean SAMP area and adjacent coastal areas. 7. Aesthetic value of the natural landscape. 8. Spiritual benefits achieved from recreational uses of Ocean SAMP area. 9. Educational value of Ocean SAMP area and surrounding coastal zone. 10. Ocean SAMP area's role in the state and region's maritime history and cultural heritage. 11. Historic and cultural value of marine recreation and tourism. 12. Contribution of recreation and tourism to state's quality of life. 13. Role of the Ocean SAMP area in attracting visitors to the state.

2. One study conducted by Tyrrell and Harrison (2000) attempted to approximate the net benefit of recreation to users after all expenses were accounted for through measuring consumer "total willingness to pay" for various recreational activities (see Table 6.18). Considering only marine-based recreational uses, this study calculated that consumers were willing to pay a total of $4.3 billion annually for all outdoor recreational activities associated with the marine aquatic and shoreline environments (Tyrrell and Harrison 2000). This study attempts to demonstrate the enormous value produced by recreational activities in Rhode Island not easily measured in economic impact. It should be noted that this table does not represent the actual economic impact of these uses to Rhode Island, but rather the additional value provided to consumers not expressed actual expenditures.

Table 6.18. Net willingness to pay for marine-based outdoor recreation (1997 dollars). (Tyrrell and Harrison 2000)

Activity	Net Economic Value Total ($)
Walking for Pleasure	$1,330,917,000
Salt-Water Swimming	$439,986,000
Pleasure Driving/Sightseeing	$396,463,000
Bicycling	$725,966,000
Picnicking	$130,311,000
Jogging or Running	$364,814,000
Nature Observing/ Photography	$412,587,000
Motor boating/ Waterskiing	$177,134,000
Salt-Water Fishing	$323,030,000
Camping	$22,823,000
Sailing/Wind Surfing	$165,541,000
Off-Roading	$186,940,000
Canoeing/Kayaking	$20,105,000
Scuba diving/ Snorkeling	$25,803,000
Hunting	$69,280,000
Total	**$4,393,291,000**

3. All data presented here demonstrate the importance of recreational and tourism uses of the Ocean SAMP area to coastal economies and to Rhode Island as a whole. Coastal and island communities, in particular, rely upon the economic activity generated from recreational and tourism uses of the Ocean SAMP area, as well as the jobs produced from these industries.

Section 660. Policies and Standards

660.1. General Policies

1. The Council recognizes the economic, historic, and cultural value of marine recreation and tourism activities in the Ocean SAMP area to the state of Rhode Island. The Council's goal is to promote uses of the Ocean SAMP area that do not significantly interfere with marine recreation and tourism activities or values.

2. When evaluating proposed Offshore Developments, the Council will carefully consider the potential impacts of such activities on marine recreation and tourism uses. Where it is determined that there is a significant impact, the Council may modify or deny activities that significantly detract from these uses.

3. The Council will encourage and support uses of the Ocean SAMP area that enhance marine recreation and tourism activities.

4. The Council recognizes that the waters south of Brenton Point and within the 3-nautical mile boundary surrounding Block Island are heavily-used recreational areas and are commonly used for organized sailboat races and other marine events. The Council encourages and supports the ongoing coordination of race and marine event organizers with the U.S. Coast Guard, the U.S. Navy, and the commercial shipping community to facilitate safe recreational boating in and adjacent to these areas, which include charted shipping lanes and Navy restricted areas (see Chapter 7, Marine Transportation, Navigation, and Infrastructure). The Council shall consider these heavily-used recreational areas when evaluating Offshore Developments in this area. Where it is determined that there is a significant impact, the Council may modify or deny activities that significantly detract from these uses. The Council also recognizes that much of this organized recreational activity is concentrated within the circular sailboat racing areas as depicted in Figure 6.4, and accordingly has designated these areas as Areas of Particular Concern. See Chapter 11, The Policies of the Ocean SAMP, for requirements associated with Areas of Particular Concern.

5. The Council shall work together with the U.S. Coast Guard, the U.S. Navy, the U.S. Army Corps of Engineers, NOAA, fishermen's organizations, marine pilots, recreational boating organizations, and other marine safety organizations to promote safe navigation, fishing, and recreational boating activity around and through offshore structures and developments and along cable routes during the construction, operation and decommissioning phases of such projects. The Council will promote and support the education of all mariners regarding safe navigation around offshore structures and developments and along cable routes.

6. Discussions with the U.S. Coast Guard, the U.S. Department of Interior Bureau of Ocean Energy Management, Regulation, and Enforcement, and the U.S. Army Corps of Engineers have indicated that no vessel access restrictions are planned for the waters around and through offshore structures and developments, or along cable routes, except for those necessary for navigational safety. Commercial and recreational fishing and

boating access around and through offshore structures and developments and along cable routes is a critical means of mitigating the potential adverse impacts of offshore structures on commercial and recreational fisheries and recreational boating. The Council endorses this approach and shall work to ensure that the waters surrounding offshore structures, developments, and cable routes remain open to commercial and recreational fishing, marine transportation, and recreational boating, except for navigational safety restrictions. The Council requests that federal agencies notify the Council as soon as is practicable of any federal action that may affect vessel access around and through offshore structures and developments and along cable routes. The Council will continue to monitor changes to navigational activities around and through offshore developments and along cable routes. Any changes affecting existing navigational activities may be subject to CZMA Federal Consistency review if the federal agency determines its activity will have reasonably foreseeable effects on the uses or resources of Rhode Island's coastal zone.

7. The Council recognizes that offshore wildlife viewing activities are reliant on the presence and visibility of marine and avian species which rely on benthic habitat, the availability of food, and other environmental factors. The Council shall consider these environmental factors when evaluating proposed Offshore Developments in these areas. Where it is determined that there is a significant impact, the Council may modify or deny activities that significantly detract from these uses.

660.2. Regulatory Standards

1. Offshore dive sites within the Ocean SAMP area, as shown in Figure 6.6, are designated Areas of Particular Concern. The Council recognizes that offshore dive sites, most of which are shipwrecks, are valuable recreational and cultural ocean assets and are important to sustaining Rhode Island's recreation and tourism economy. See Chapter 11, The Policies of the Ocean SAMP, for requirements associated with Areas of Particular Concern.

2. Heavily-used recreational boating and sailboat racing areas, as shown in Figure 6.4, are designated as Areas of Particular Concern. The Council recognizes that organized recreational boating and sailboat racing activities are concentrated in these particular areas, which are therefore important to sustaining Rhode Island's recreation and tourism economy. See Chapter 11, The Policies of the Ocean SAMP, for requirements associated with Areas of Particular Concern.

3. The Council shall consult with the U.S. Coast Guard, the U.S. Navy, marine pilots, the Fishermen's Advisory Board as defined in section 1160.1.6, fishermen's organizations, and recreational boating organizations when scheduling offshore marine construction or dredging activities. Where it is determined that there is a significant conflict with season-limited commercial or recreational fisheries activities, recreational boating activities or scheduled events, or other navigation uses, the Council shall modify or deny activities to minimize conflict with these uses.

4. The Council shall require the assent holder to provide for communication with commercial and recreational fishermen, mariners, and recreational boaters regarding offshore marine construction or dredging activities. Communication shall be facilitated through a project website and shall complement standard U.S. Coast Guard procedures such as Notices to Mariners for notifying mariners of obstructions to navigation.

5. Where possible, Offshore Developments should be designed in a configuration to minimize adverse impacts on other user groups, which include but are not limited to: recreational boaters and fishermen, commercial fishermen, commercial ship operators, or other vessel operators in the project area. Configurations which may minimize adverse impacts on vessel traffic include, but are not limited to, the incorporation of a traffic lane through a development to facilitate safe and direct navigation through, rather than around, an Offshore Development

6. Any assent holder of an approved Offshore Development shall work with the Council when designing the proposed facility to incorporate where possible mooring mechanisms to allow safe public use of the areas surrounding the installed turbine or other structure.

7. The Council shall require where appropriate that project developers perform systematic observations of recreational boating intensity at the project area at least three times: pre-construction; during construction; and post-construction Observations may be made while conducting other field work or aerial surveys and may include either visual surveys or analysis of aerial photography or video photography. The Council shall require where appropriate that observations capture both weekdays and weekends and reflect high-activity periods including the July 4th holiday weekend and the week in June when Block Island Race Week takes place. The quantitative results of such observations, including raw boat counts and average number of vessels per day, will be provided to the Council.

Section 670. Literature Cited

Albion, R. G., Labaree, B. W., and Baker, W. A. 1970. *New England and the Sea*. Mystic, CT: Mystic Seaport Press.

Allard Cox, M. (ed.). 2004. *A Daytripper's Guide to Rhode Island*. Online at: http://seagrant.gso.uri.edu/daytrip.html. Last accessed January 8, 2010.

Allianz Global Investors. 2007. *Allianz Economic Impact Report into the America's Cup: The Economic Impact of the 32nd America's Cup.*

Annapolis Yacht Club. 2009a. Sailing Instructions for Annapolis to Newport Race 2009. Online at http://race.annapolisyc.com/RegattaModules/ViewRegattaDocuments.aspx?RegID=202&mid=218&tabid=10. Last accessed September 30, 2009.

Annapolis Yacht Club. 2009b. List of Entries for Annapolis to Newport Race 2009. Online at http://race.annapolisyc.com/DesktopDefault.aspx?tabid=46. Last accessed September 30, 2009.

Anthony, A., J. Atwood, P. August, C. Byron, S. Cobb, C. Foster, C. Fry, A. Gold, K. Hagos, L. Heffner, D. Kellogg, K. Lellis-Dibble, J. Opaluch, C. Oviatt, A. Pfeiffer-Herbert, N. Rohr, L. Smith, T. Smythe, J. Swift and N. Vinhateiro. 2009. Coastal lagoons and climate change: Ecological and social ramifications in U.S. Atlantic and Gulf Coast Ecosystems. *Ecology and Society* 14 (1): 8.

Bellavance, Cpt. Rick. 2009. Priority Fishing Charters. Personal communication, June 25, 2009.

Blount, Cpt. Frank. 2009. Frances Fleet. Personal communication, June 15, 2009.

Bucket Regattas. 2009a. Notice of Race for 2009 Newport Bucket Regatta. Online at http://www.bucketregattas.com/newport/noticeofrace.html. Last accessed September 30, 2009.

Bucket Regattas. 2009b. Entries for 2009 Newport Bucket Regatta. Online at http://www.bucketregattas.com/newport/entries.html. Last accessed September 30, 2009.

Business Research and Economic Advisors. 2007. *Cruise Line International Association U.S. Economic Impact Analysis.*

City of Newport. 2009. Cruise Ship Annual Passenger Count Comparison. Data provided by the Newport & Bristol County Convention and Visitors Bureau.

Closter, Robert. 2010. Town of New Shoreham. Personal communication, January 8, 2010.

Colt, A. B., Tyrrell, T., and Lee, V. 2000. *Marine Recreation and Tourism in Narragansett Bay: Critical Values and Concerns.* Narragansett Bay Summit 2000 White Paper.

Conley, P. T. 1986. *An Album of Rhode Island History, 1636—1986*. Norfolk, VA: Donning Company Publishers.

Connett, E. V., ed. 1948. *Yachting in North America*. New York: D. Van Nostrand Company, Inc.

Corinthians Association. 2008. Corinthians Stonington to Boothbay Harbor Ocean Race. Online at http://www.stoningtontoboothbayharbor.com/. See also iBoatTrack race tracking of 2008 race at http://charthorizon.com/races/2008_stonington_boothbay/htdocs/. Last accessed September 30, 2009.

Cruise Lines International Association, Inc. 2008. *The Cruise Industry: A $38.0 Billion Partner in the U.S. Economic Growth.*

Dellenbaugh, Brad. 2009. New York Yacht Club. Personal communication, June 16, 2009.

Dellenbaugh, Brad. 2009. New York Yacht Club. Personal communication, September 29, 2009.

Donilon, Cpt. Charlie. 2009. Snappa Charters. Personal communication, June 5, 2009.

Global Insight. 2008. *Rhode Island Tourism: Strength in a Difficult Time: 2007 Tourism Satellite Account.*

Goat Island Yacht Club and Newport Yacht Club. 2009a. Sailing Instructions for Bermuda One-Two Yacht Race. Online at http://www.bermuda1-2.org/. Last accessed September 30, 2009.

Goat Island Yacht Club and Newport Yacht Club. 2009b. Scratch Sheet for 2009 Bermuda One-Two Yacht Race. Online at http://www.bermuda1-2.org/. Last accessed September 30, 2009.

Ida Lewis Yacht Club. 2009a. Sailing Instructions for Ida Lewis Distance Race 2009. Online at http://www.ildistancerace.org/2009/instructions.htm. Last accessed September 30, 2009.

Ida Lewis Yacht Club. 2009b. Notice of Race for 2009 Ida Lewis Distance Race. Online at http://www.ildistancerace.org/2009/notice.htm. Last accessed September 30, 2009.

Ida Lewis Yacht Club. 2009c. Entries for 2009 Ida Lewis Distance Race. Online at http://www.yachtscoring.com/current_event_entries.cfm?eID=243. Last accessed September 30, 2009.

Kellner, G. H. and Lemons, J. S. 2004. *Rhode Island The Ocean State: An Illustrated History*. Sun Valley, CA: American Historical Press.

Labaree, B. W., Fowler, W. M. Jr., Sloan, E. W., Hattendorf, J. B., Safford, J. J., and German, A. W. 1998. *America and the Sea: A Maritime History*. Mystic, CT: Mystic Seaport Press.

LeBlanc, Edward. 2009. U.S. Coast Guard Sector Southeastern New England. Personal communication, October 23, 2009.

Levitt, M. 2008. About the New York Yacht Club, 1844—Present. Available online at http://www.nyyc.org/history/article_3/. Last accessed September 29, 2009.

Manheim, P., and Tyrrell, T.. 1986. *The Social and Economic Impacts of Tourism on Block Island: A Case Study*. NOAA/Sea Grant Marine Technical Report 89.

Marion-Bermuda Cruising Yacht Race Association. 2009a. Sailing Instructions for 2009 Marion to Bermuda Race. Online at http://www.marionbermuda.com/index2009.shtml. Last accessed September 30, 2009.

Marion-Bermuda Cruising Yacht Race Association. 2009b. Notice of Race for 2009 Marion to Bermuda Race. Online at http://www.marionbermuda.com/index2009.shtml. Last accessed September 30, 2009.

Marion-Bermuda Cruising Yacht Race Association. 2009c. Entry List for 2009 Marion to Bermuda Race. Online at http://www.marionbermuda.com/index2009.shtml. Last accessed September 30, 2009.

Marks, Eugenia. 2009. Audubon Society of Rhode Island. Personal communication, November 20, 2009.

McCurdy, S. 2009. Race Description: The Newport Bermuda Race. Online at http://www.bermudarace.com/TheRace/RaceDescription/tabid/164/Default.aspx. Last accessed September 30, 2009.

National Ocean Economics Program. 2009. Ocean Economy Data. Online at: www.oceaneconomics.org. Last accessed September 30, 2009.

National Park Service. 2005. Inventory of Historic Light Stations: Rhode Island Lighthouses. Online at http://www.nps.gov/history/Maritime/light/ri.htm. Last accessed December 28, 2009.

New Bedford Yacht Club. 2009a. Notice of Race for 2009 Whalers Race. Online a http://www.nbyc.com/racing/notice_of_race.htm. Last accessed September 30, 2009.

New Bedford Yacht Club. 2009b. 2007 Race Results for 2007 Whalers Race. Online at http://www.nbyc.com/racing/id185.htm. Last accessed September 30, 2009.

New York Yacht Club. 2009. 2009 12 Metre World Championships. Online at http://www.nyyc.org/12metreworlds/. Last accessed September 30, 2009.

Newport & Bristol County Convention and Visitors Bureau. 2009a. 2009 Cruise Ship Schedule. Online at: http://www.gonewport.com. Last accessed September 30, 2009.

Newport & Bristol County Convention and Visitors Bureau. 2009b. Cruise Ships. Online at: http://www.gonewport.com. Last accessed September 30, 2009.

Newport Yacht Club 2009a. Bermuda 1-2. Online at http://newportyachtclub.org/racing/offshore/bermuda_12/. Last accessed September 30, 2009.

Newport Yacht Club. 2009b. Notice of Race for the 26th Annual Earl Mitchell Columbus Day Regatta. Online at http://newportyachtclub.org/racing/offshore/mitchell_regattas/. Last accessed September 30, 2009.

Newport Yacht Club. 2009c. Notice of Race for the 26th Annual Owen L. Mitchell Regatta. Online at http://newportyachtclub.org/racing/offshore/mitchell_regattas/. Last accessed September 30, 2009.

Newport Yacht Club. 2009d. Results for the 26th Annual Owen L. Mitchell Regatta. Online at http://newportyachtclub.org/fileadmin/user_upload/Race_Results/Mitchell_Regattas/Memorial_Regatta/Memorial_Day_Results2009.html. Last accessed September 30, 2009.

Newport Yacht Club 2009e. Offshore 160 Single-Handed Challenge. Online at http://newportyachtclub.org/racing/offshore/offshore_160/. Last accessed September 30, 2009.

Newport Yacht Club. 2008. Notice of Race for Offshore 160 Single-Handed Challenge. Online at http://newportyachtclub.org/racing/offshore/offshore_160/. Last accessed September 30, 2009.

Newport Yacht Club and Goat Island Yacht Club. 2009a. Entrant List for 2009 New England Solo/Twin Championships. Online at http://newportyachtclub.org/racing/offshore/new_england_solotwin/. Last accessed September 30, 2009.

Newport Yacht Club and Goat Island Yacht Club. 2009b. Notice of Race for 2009 New England Solo/Twin Championships. Online at http://newportyachtclub.org/racing/offshore/new_england_solotwin/. Last accessed September 30, 2009.

Ninigret Partners. 2007. *Rhode Island Recreational Saltwater Fishing Industry Trends and Economic Impact.* Prepared for the Rhode Island Saltwater Anglers Association, January 2007.

National Marine Fisheries Service, Fisheries Statistics Division. 2009. Marine Recreational Fisheries Statistics Survey (MRFSS). Online at: http://www.st.nmfs.noaa.gov/st1/recreational/index.html

Off Soundings Club. 2009. Notice of Race for 72nd Annual Race Series 2009. Online at http://offsoundings.org/Racing/NOR_FP.pdf. Last accessed September 30, 2009.

Osenkowski, Jay. 2009. R.I. Department of Environmental Management Division of Fish & Wildlife. Personal communication, November 20, 2009.

R.I. Department of Administration Statewide Planning Program and R.I. Department of Environmental Management. 2003. *Ocean State Outdoors: Rhode Island's Comprehensive Outdoor Recreation Plan.* Report 105.

R.I. Department of Environmental Management, Office of Boat Registration and Licensing. 2009. Records Database. Accessed September 23, 2009.

R.I. Department of Environmental Management. 2009. *Rhode Island Park Directory*. Online at www.riparks.com. Last accessed October 28, 2009.

R.I. Department of Environmental Management. 2004. *2004 Annual Report*. Online at: www.state.ri.us/dem.

R.I. Department of Environmental Management. 2001. *The Rhode Island Parks and Beach System Study and Asset Management Plan.* R.I. Department of Environmental Management Office of Strategic Planning and Policy, January 2001.

R.I. Economic Monitoring Collaborative. 2008. *FY08 Economic Monitoring Report*. Final Draft. Online at http://www.coordinationteam.ri.gov/econcollab.htm.

R.I. Geographic Information Systems (RIGIS). 2006. *State Conservation and Park Lands.* Data available online at http://www.edc.uri.edu/RIGIS/. Last accessed September 30, 2009.

RIGIS. 2003. *Public Access to the Rhode Island Coast.* Data available online at http://www.edc.uri.edu/RIGIS/. Last accessed September 30, 2009.

RIGIS. 2002. *State Conservation and Recreational Open Space 1990.* Data available online at http://www.edc.uri.edu/RIGIS/. Last accessed September 30, 2009.

RIGIS. 1996a. *Marinas of Rhode Island.* Data available online at http://www.edc.uri.edu/RIGIS/. Last accessed September 30, 2009.

RIGIS. 1996b. *Boat Ramps in Rhode Island.* Data available online at http://www.edc.uri.edu/RIGIS/. Last accessed September 30, 2009.

RIGIS. 1989. *Scenic Areas of Rhode Island.* Data available online at http://www.edc.uri.edu/RIGIS/. Last accessed September 30, 2009.

R.I. Marine Trades Association. 2007. *Report on the Sales Tax Repeal 2007.* Available

online at http://www.rimta.org.

R.I. State Senate Policy Office. 2002. *The Marine Cluster: An Investment Agenda for Rhode Island's Marine Related Economy.*

Rousmaniere, J. 2007. History: 100 Years of Thrashing to the Onion Patch. Online at http://www.bermudarace.com/TheRace/History/tabid/142/Default.aspx. Last accessed September 30, 2009.

Sail Newport. 2009a. Notice of Race for Coastal Living Newport Regatta. Online at http://www.sailnewport.org/npt/m/_general/09newportregattanor.asp. Last accessed September 30, 2009.

Sail Newport. 2009b. Notice of Race for 2009 International Six Meter Worlds. Online at http://www.sailnewport.org/npt/m/_general/09SixMetreWorlds.asp.

Smith, Evan. 2009. Newport & Bristol County Convention and Visitors Bureau. Personal communication, July 16, 2009.

Snappa Charters. 2008. Shark Cage Diving. Online at http://www.snappacharters.com/. Last accessed September 30, 2009.

Stamford Yacht Club 2009a. Sailing Instructions for 75th Vineyard Race 2009. Online at http://yachtscoring.com/emenu.cfm?eID=238. Last accessed September 30, 2009.

Stamford Yacht Club 2009b. Current Entry List for 75th Vineyard Race 2009. Online at http://yachtscoring.com/emenu.cfm?eID=238. Last accessed September 30, 2009.

Storm Trysail Club. 2009a. History of the Club. Online at http://www.stormtrysail.org/Pages/History/History.html. Last accessed December 28, 2009.

Storm Trysail Club. 2009b. Sailing Instructions for 2009 Block Island Race Week XXIII. Online at http://www.yachtscoring.com/emenu.cfm?eID=230. Last accessed September 30, 2009.

Storm Trysail Club. 2009c. Current Entry List for 2009 Block Island Race Week XXIII. Online at http://www.yachtscoring.com/emenu.cfm?eID=230. Last accessed September 30, 2009.

Storm Trysail Club. 2009d. Entry List for 64th Annual Block Island Race 2009. Online at http://www.stormtrysail.org/Pages/2009-BI-Race/2009-BI-Race.html. Last accessed September 30, 2009.

Thompson, R. 2006. Affordable twenty-four hour coastal access: Can we save a working stiff's place in paradise?" *Ocean and Coastal Law Journal* 12 (91) 91-130.

Thunberg, E. 2008. *Trends in Selected Northeast Region Marine Industries*. Woods Hole, MA: National Oceanic and Atmospheric Administration Northeast Fisheries Science Center, July 2008.

Trenholm, Marci. 2009. Storm Trysail Club. Personal communication, December 17, 2009.

Tyrrell, T. 1993. *Economic Impacts of Boating*. TTR Report. Department of Resource Economics, University of Rhode Island.

Tyrrell, T. J. and Johnston, R.J. 2001. A framework for assessing direct economic impacts of tourist events: distinguishing origins, destinations, and causes of expenditures. *Journal of Travel Research*, 40:94-100.

Tyrrell, T. and Harrison, J. 2000. *Assessing the Economic Value of Rhode Island's Natural Resources*. URI Department of Environmental and Natural Resource Economics, December 2000.

U.S. Coast Guard. 2006. *U.S. Coast Guard Captain of the Port Long Island Sound Waterways Suitability Report for the Proposed Broadwater Liquified Natural Gas Facility*. September 2006. Online at http://www.uscg.mil/d1/sectlis/public/broadwater.asp#WSR.

Willi, Jessica. Block Island Tourism Council. Personal communication, December 7, 2009.

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Section 700. Introduction

1. The Ocean SAMP area is an important and highly valuable marine transportation corridor. The Ocean SAMP area represents a crossroads between multiple heavily used waterways: Narragansett Bay, Long Island Sound, Buzzards Bay, and Vineyard Sound. Vessels pass through the Ocean SAMP area when passing between these waterways en route to commercial ports, harbors, and other facilities. These vessels include cargo ships, such as tankers, bulk carriers, and tug and barge units, passenger ferries, naval vessels, government research, enforcement, and search and rescue vessels, and pilot boats. They carry goods, move people, or provide other functions that are essential to Rhode Island, neighboring states, and the entire nation. The Ocean SAMP area is part of the nation's marine transportation system, which is the network of all navigable waterways, vessels, operators, ports, and intermodal landside connections facilitating the marine transport of people and goods in the United States (Marine Transportation System National Advisory Council, 2009). One of the main goals of the Ocean SAMP is to promote and enhance these and other existing uses. Proposed future uses related to marine transportation and other topics are addressed in Chapter 9, Other Future Uses.

2. This chapter focuses on the commercial, military, government, and support vessels and infrastructure that comprise the Ocean SAMP-area elements of the nation's marine transportation system. Other vessels that operate in the Ocean SAMP area and utilize this infrastructure include fishing and recreational craft. Fishing vessels and activities are discussed in Chapter 5, Commercial and Recreational Fisheries. Recreational vessels and activities are discussed in Chapter 6, Recreation and Tourism.

3. Marine transportation in and through the Ocean SAMP area is supported by a network of navigation features including shipping lanes, traffic separation schemes, navigational aids, and other features that facilitate safe navigation. Marine transportation in the Ocean SAMP area also relies on adjacent land-based infrastructure, such as cargo-handling facilities and storage areas in nearby ports. Marine transportation activity in the Ocean SAMP area is shaped by activity at these facilities, in ports such as Providence and Quonset/Davisville, R.I, and Fall River, Mass. Together, these navigation features and port infrastructure provide for the safe passage and operations of a wide range of vessels that provide Rhode Island with essential goods and services.

4. The Ocean SAMP area also includes other infrastructure that does not support navigation. This infrastructure includes existing undersea cables, unexploded ordnance, and other marine debris noted on National Oceanic and Atmospheric Administration (NOAA) nautical charts, as well as designated dredged material disposal sites.

5. As is illustrated by the Ocean SAMP boundary (see Chapter 1, Introduction), the Ocean SAMP document and policies are focused on the offshore environment, not

adjacent upland areas. This offshore focus is due to the fact that the CRMC already has a regulatory program, including a zoning program, in place for coastal lands and waters out to the 3-nautical mile boundary. Accordingly, this chapter focuses on marine transportation activities and infrastructure in the offshore environment, outside of Narragansett Bay. Discussion of upland areas is focused on the Narragansett Bay ports that make these uses possible, as well as the economic impact of these uses on these ports and the state of Rhode Island.

Section 710. History of Marine Transportation in the Ocean SAMP Area

1. Rhode Island's offshore waters have been used for maritime commerce, exploration, transportation, and military purposes for over 400 years. While none of Rhode Island's cargo ports or naval facilities are within the Ocean SAMP area, cargo ships, support vessels, and military craft traverse the Ocean SAMP area en route to the Rhode Island ports of Providence, Quonset/Davisville, and Newport in Narragansett Bay, and the Massachusetts port of Fall River (which includes Fall River and Somerset) in Mount Hope Bay. Maritime commerce in Rhode Island largely began in the 17th century. Rhode Island-based naval activities have also been taking place since the 17th century, but grew to prominence in the late 19th and 20th centuries. Together, these activities have been essential to Rhode Island's economic growth and vitality, and are central to Rhode Island's history.

2. Much of the maritime activity in the Ocean SAMP area was, and still is, fishing. Prior to European contact, Wampanoag and Narragansett Indians fished from shore as well as from dugout canoes, primarily in coastal waters (Hale 1998). See Chapter 4, Cultural and Historical Resources, for further discussion of the Wampanoag and Narragansett Indian tribes' histories. Early Rhode Islanders observed right whales from shore, and rowed out in longboats to hunt and capture them (Albion et al 1970). While whaling never became a major industry in Rhode Island, commercial fishing dates back to the 17th century (Hall-Arber et al. 2001) and has been a viable industry since then, characterized by a diversity of target species and gear types. For a detailed history of fishing activities in the Ocean SAMP area and adjacent ports, see Chapter 5, Commercial and Recreational Fisheries.

3. Before maritime trade came to dominate offshore waters, early European explorers navigated through the Ocean SAMP area, laying the groundwork for future colonization and commerce. In 1524, Italian explorer Giovanni da Verrazano explored Block Island Sound before venturing into Narragansett Bay, and in 1614 Dutch explorer Adriaen Block followed a similar route—and named the offshore island for himself (Albion et al 1970).

4. Rhode Island's maritime commerce first developed in the 17th century while the state was still an English colony. Newport, with its large, deep, well-protected natural harbor, was the center of this early maritime activity. Newport first engaged in trading agricultural goods with the nearby ports of Salem, Boston, and New Amsterdam (later New York). As a result, by the late 17th century Rhode Island had achieved a favorable balance of trade—unlike neighboring colonies, which imported more than they exported (Kellner and Lemons 2004). In the early 18th century, Newport trading ships ventured through what is now the Ocean SAMP area into the Caribbean, trading with Spanish, French, and Dutch colonies, and later began trading with Africa and England. Some of this commerce was based in privateering, in which Rhode Island ships attacked enemy merchant ships during wartime (such as the French-Indian War, 1754–1763) and seized their cargos (Kellner and Lemons 2004).

5. Whereas 17th century trade had focused on agricultural goods, 18th century trade thrived on the re-export business—exporting products that had been made in Rhode Island using goods that had been imported from other locations. Key products were candles made of spermaceti (a wax-like substance found in sperm whales' heads) that came from New Bedford and Nantucket, twine and cordage, and rum distilled from molasses that came from the Caribbean (Kellner and Lemons 2004). Newport was known as a center for spermaceti candle-making and rum distillation (Kellner and Lemons 2004). Spermaceti to make the candles came from the nearby whaling ports of New Bedford and Nantucket (Labaree et al 1998), whereas molasses to make rum originated from the Caribbean (Kellner and Lemons 2004).

6. Rhode Island's early business in distilling and trading rum highlights the state's connection to the slave trade. Rhode Island distilleries imported molasses from Caribbean ports. While much rum was consumed in Rhode Island itself or shipped to ports in Europe, the Caribbean, and South America, Rhode Island merchants traded some rum in African ports in exchange for slaves (Kellner and Lemons 2004). In the early 17th century, some Newport vessels entered the slave trade, followed by ships from Bristol and Providence. One source indicates that between 1725 and 1807 at least 934 vessels left Rhode Island for African ports, and carried away an estimated 106,000 slaves from the continent (Coughtry, cited in Kellner and Lemons 2004). In the late 18th century, the Brown family of Providence entered the slave trade, which led to the growth of the port of Providence as well as the rise of this prominent merchant family (Kellner and Lemons 2004).

7. Newport was the fifth largest town and one of the leading ports in colonial America through the 1760s. However, the Brown family and other Providence merchants actively pursued maritime commerce in the late 18th and early 19th centuries. Due to these merchants' activities, coupled with Providence's geographic advantages and Newport's travails during the American Revolution, Providence soon eclipsed Newport as Rhode Island's main port. Providence ships passed through the Ocean SAMP area en route to European and Caribbean ports, and Providence merchants also pursued opportunities in the newer trades with South America, Australia, and Asian ports. Beginning in the late 18th century, the Brown brothers were major leaders in these newer trades. Nicholas Brown was the first Rhode Islander to trade with Brazil, and John Brown was the first Rhode Islander and the second American to begin trading with both China and Australia. Because of these activities, and in particular the Browns' participation in the highly lucrative trade with China, the port of Providence remained preeminent into the 1820s–1830s (Albion et al 1970; Kellner and Lemons 2004).

8. The height of Rhode Island-based maritime trade lasted only through the 1830s. The whaling activities of nearby ports continued to spur shipbuilding and the spermaceti candle business through the middle of the 19th century, but by mid-century this business also had diminished (Kellner and Lemons 2004). By 1860, Rhode Island's foreign commerce had declined dramatically, as evidenced by a sharp decrease in the number of ship arrivals recorded by Rhode Island ports (Albion et al 1970). In the

mid- to late-19th century, this trade was gradually replaced by a new coastal trade aboard steamboats, many of which were passenger vessels (Albion et al 1970). Late-19th and early-20th century maritime activity in the Ocean SAMP area was characterized largely by passenger steamboats and other recreational craft; see Chapter 6, Recreation and Tourism, for further discussion of the history of recreation in the Ocean SAMP area.

9. Maritime trade, coupled with the Industrial Revolution of the 19th century, required the industrialization of many waterfront areas. Providence became a modern industrial city port, its shoreline lined with warehouses, wharves, and piers. Later, rail service and cargo hoisting equipment were brought to the industrial waterfront so that cargo could be transported from ship to railcar, and wharves were rebuilt to support the weight of this new equipment. In the 20th century, highway construction created additional truck access to these port facilities (R.I. Coastal Resources Management Council, in review). Throughout the 19th and 20th centuries, similar transformations took place at different scales in Quonset/Davisville, Newport, and other ports throughout the state. Rhode Island's industrialized waterfronts continue to provide critical infrastructure that supports maritime commerce and naval activities.

10. In the early 20th century, during the 14 years known as Prohibition, maritime activity in Rhode Island's offshore waters expanded to include the illegal transport of alcoholic beverages. Rum supply vessels typically lined up offshore beyond federal jurisdiction and supplied "rum-runners," small boats that could outrun Coast Guard enforcement vessels while smuggling alcohol back to shore. One source indicates that rum supply vessels serving Rhode Island communities anchored in the Ocean SAMP area about 15 miles southeast of Block Island, and that rum runners used the three entrances to Narragansett Bay to their advantage in attempting to avoid enforcement vessels (Hale 1998).

11. The U.S. Navy became one of the dominant users of the Ocean SAMP area in the late 19th century, though Rhode Island has a long history of ties with the Navy. The U.S. Navy was created, in part, in Rhode Island a century earlier during the American Revolution—the first ship in the Continental Navy was the sloop *Providence*, and the first admiral was Rhode Island native Esek Hopkins. In the late 19th century, Narragansett Bay's deep, protected harbors attracted the Navy to Rhode Island, and as a result the Navy established the Naval Torpedo Station on Goat Island in 1869, the Naval Training Station in Newport in 1883, and the Naval War College in Newport in 1884. During World War II, a large portion of the Atlantic fleet was based out of Newport for a short time, and naval air bases, training centers, and other facilities were established at Quonset/Davisville, Melville, and other locations throughout the state. The Navy's presence had a tremendous impact on the state's economy, especially throughout World War II, providing employment for Rhode Islanders as well as clientele for businesses in Newport and throughout the state (Kellner and Lemons 2004).

12. The Navy's presence made Rhode Island a possible target for attack during the early 20th century. During World War I, a German U-boat sailed directly into Newport Harbor; the next day, the U-boat sank six unarmed cargo ships off Nantucket (Hale 1998). During World War II, the Navy mined the approaches to Narragansett Bay and set out antisubmarine nets to block the passages into the Bay. In 1945, a German U-boat prowling the East Coast torpedoed and sunk an American coal ship off Point Judith, and in retaliation Naval forces hunted and sunk the U-boat, U-853, off Block Island. This represented the final battle of the Atlantic in World War II. The wreck of the U-853 remains in the charted approach to Narragansett Bay and is a popular dive site, and much unexploded ordnance still exists in the waters of Rhode Island Sound in the approaches to the Bay (Kellner and Lemons 2004). See Chapter 6, Recreation and Tourism, for further information on diving; for further information on unexploded ordnance and other features of the Ocean SAMP area see section 750 of this chapter.

13. The Navy's presence in Rhode Island's waters was operationally diminished in early 1973 with the moving of the active fleet from Newport, accompanied by the closing of the Quonset Point Naval Air Station, a drawdown of facilities at Davisville, and a cutback of personnel and activities (Globalsecurity.org 2009). However, the Navy retains several facilities of strategic importance in Newport, which together comprise Naval Station Newport. Naval Station Newport is home to more than 42 commands and is considered the Navy's primary site for training officers and senior personnel as well as developing undersea warfare systems. Newport naval institutions include the Naval Undersea Warfare Center, Division Newport; the Naval War College; the Naval Academy Prep School; and the Surface Warfare Officers School (U.S. Navy 2009).

Section 720. Navigation Features in the Ocean SAMP Area

720.1. Area Overview

1. The Ocean SAMP area is a 1,467-square-mile area of ocean space that is a crossroads for commercial, military, and government vessels traveling between numerous commercial ports, harbors, and recreational destinations. The Ocean SAMP area is bordered by Narragansett Bay to the north; Long Island Sound to the west; and Buzzards Bay and Vineyard Sound to the east; and the Atlantic Ocean to the south. Commercial, military, and government vessels transit through this area when traveling between locations and ports in Narragansett Bay, Long Island Sound, Buzzards Bay, Vineyard Sound, or more distant ports. This section focuses on navigation features located within the Ocean SAMP area only, and does not include discussion of those features located within Narragansett Bay or adjacent waters.

2. Vessels passing through the Ocean SAMP area to or from Narragansett Bay gain access to the commercial port facilities of Quonset/Davisville and Providence, R.I., and Fall River, Mass., as well as to passenger ferry, cruise ship, and Navy port facilities in Newport and Quonset/Davisville. The three entrances to the Bay are the West Passage (between Point Judith and Beavertail Point), the East Passage (between Beavertail Point and Brenton Point), and the mouth of the Sakonnet River (between Sachuest Point and Sakonnet Point); see Figure 7.1. The East Passage offers access to a channel with a depth of about 60 feet (NOAA National Ocean Service 2009), and is used by all deep draft vessels and most tug-and-barge traffic entering and departing Narragansett Bay. The West Passage is used by some tug-and-barge traffic along with some large commercial fishing vessels (Scanlon pers. comm.). The West Passage also serves as a back-up channel for commercial traffic in the event that the East Passage is un-navigable (e.g., after a coastal hazard or other event) (Blount, pers. comm.). Traffic into the Sakonnet River consists largely of recreational vessel traffic (Weavers Cove Energy LLC 2009) and some cruise ship traffic (American Cruise Lines 2009). It is also used as a shortcut by tugs berthed in Fall River and transiting to and from Buzzards Bay to tow or escort barge traffic through the Bay and the Cape Cod Canal.

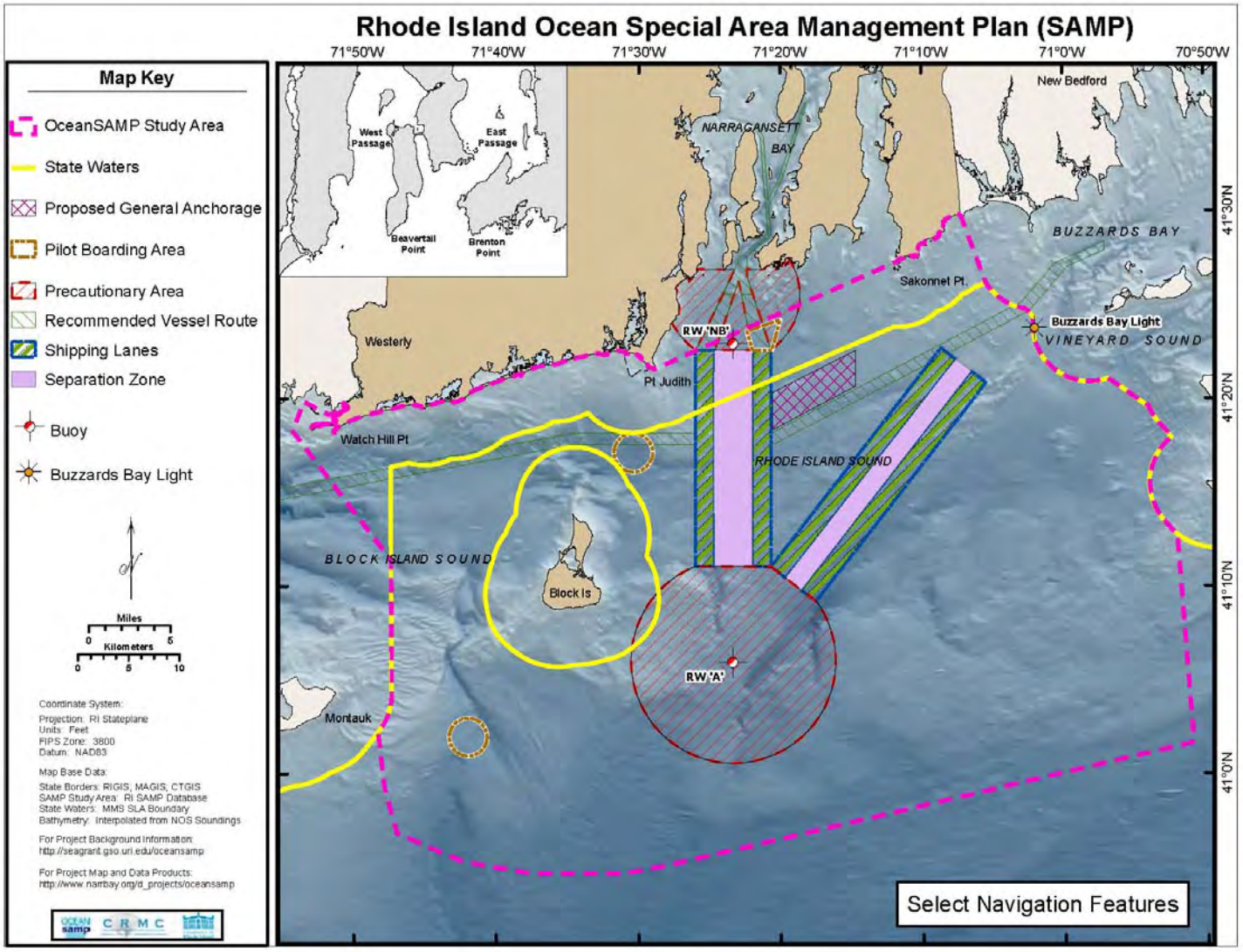


Figure 7.1. Select navigation features.

3. Features described in this section are further detailed on NOAA nautical charts including NOAA Chart No.13205 and Chart No.13218, and in the *U.S. Coast Pilot* Volume 2 (NOAA National Ocean Service 2009); recent updates to these documents may be found in U.S. Coast Guard "Local Notice to Mariners" publications. For further information on navigation within the Ocean SAMP area please consult these documents directly.[1]

4. Taken together, the features described in the remainder of this section (e.g., shipping lanes, recommended vessel routes, pilot boarding areas, anchorages, etc.) comprise a traffic management system applicable to and used by virtually all vessels transiting within or through the Ocean SAMP area. Questions regarding this traffic management system may be referred to the U.S. Coast Guard Sector Southeastern New England.

720.2. Shipping Lanes, Traffic Separation Schemes and Precautionary Areas

1. There are two main shipping lanes traversing the Ocean SAMP area: the approach to Narragansett Bay and the approach to Buzzards Bay. A precautionary area in the center of the Ocean SAMP area, centered on 41°06'06"N., 71°23'22"W (marked by a mid-channel buoy, RW "A"), marks the offshore limits of these shipping lanes; see Figure 7.1. These shipping lanes and the precautionary area were designed in accordance with standards and adopted under the auspices of the International Maritime Organization (NOAA National Ocean Service 2009). While designed as a measure of safety to aid commercial shipping entering and exiting Narragansett Bay and Buzzards Bay, use of these lanes and precautionary area are not mandatory. Most prudent mariners will, however, transit within the appropriate traffic lanes when entering or exiting port (LeBlanc, pers. comm.).

2. The approach to Narragansett Bay runs north/south and comprises inbound and outbound traffic lanes, which are separated by a traffic separation zone. The offshore limit of this approach is marked by a precautionary area as described above. The inshore limit of this approach is marked by a precautionary area, centered on 41°25'35" N., 71°23'22"W (marked by a mid-channel buoy, RW "NB"); see Figure 7.1.

3. The approach to Buzzards Bay is also characterized by inbound and outbound traffic lanes that are divided by a traffic separation zone. The offshore limit of this approach is marked by a precautionary area as described above. There is no inshore precautionary area; the next inshore navigational aid is the Buzzards Bay Entrance Light; see Figure 7.1.

4. Ship traffic passing through the approaches to Narragansett Bay and Buzzards Bay are directed by Traffic Separation Schemes. In both cases, the Traffic Separation

[1] For further information on NOAA nautical charts and the U.S. Coast Pilot, please contact the NOAA Office of Coast Survey, Silver Spring, MD. For further information on U.S. Coast Guard Notices to Mariners, please contact the U.S. Coast Guard District 1.

Schemes comprise the above-mentioned traffic lanes, separation zone, and precautionary area, and are a means of preventing collisions. Traffic Separation Schemes are recommended for large commercial ships entering or leaving the respective bays and are not intended for smaller vessels or those engaged in inshore transit; for further information see the *U.S. Coast Pilot* Volume 2 (NOAA National Ocean Service 2009). However it should be noted that under federal navigation rules, vessels engaged in fishing are prohibited from impeding the transit of a vessel following a traffic lane.[2].

720.3. Recommended Vessel Routes

1. In addition to the official shipping lanes described above, there are two formally designated Recommended Vessel Routes running through the Ocean SAMP area roughly parallel to the mainland. One route runs from The Race at the entrance to Long Island Sound along the Rhode Island coast to Point Judith, and a second route runs from the approach to Narragansett Bay in a northeasterly direction toward Buzzards Bay (see Figure 7.1). Recommended Vessel Routes are established for commercial deep-draft traffic transiting the inshore waters of Block Island and Rhode Island Sounds and are designed to reduce conflicts with recreational boaters and other users of these areas. However, vessels are not required to utilize these routes nor are fishermen required to keep fishing gear outside these routes. Recommended Vessel Routes in the Ocean SAMP area are established by the U.S. Coast Guard in cooperation with the Southeastern Massachusetts and Rhode Island Port Safety and Security Forums. For further information see the *U.S. Coast Pilot* Volume 2 (NOAA National Ocean Service 2009).

720.4. Ferry Routes

1. Ferries operating within the Ocean SAMP area travel relatively consistent routes that do not necessarily align with charted shipping lanes or recommended vessel routes. At the time of this writing, the only Ocean SAMP area ferry route that is noted on NOAA nautical charts is the Block Island Ferry route between Point Judith and Block Island's Old Harbor, though it should be noted that this ferry route may still vary from its charted route; see NOAA Chart 13218 (NOAA Office of Coast Survey 2009) for further information. . See Section 730 for further discussion of ferries and Figure 7.8 for a map of approximate routes for ferries currently operating within the Ocean SAMP area.

720.5. Pilot Boarding Areas

1. Marine pilots board commercial vessels bound for Narragansett Bay or other area ports to provide local knowledge and navigation assistance. Marine pilots board commercial vessels in charted pilot boarding areas in order to guide commercial ships through state waters. Pilotage in the Ocean SAMP area is primarily provided by the Northeast Marine Pilots Association, based in Newport.

[2] 33 USC 2010 *et. seq.*

2. Currently there are four pilot boarding areas within the Ocean SAMP area: the Point Judith Pilot Station, south of Point Judith, centered at 41°17'N, 071°30.5'W; the Montauk Pilot Boarding Station, southeast of Montauk, N.Y., centered at 41°02'N, 071°42'W; the Brenton Point Pilot Boarding Station, south of Brenton Point, at about 41°23.2' N, 071°21.3' W; and the Buzzards Bay Pilot Station, centered at 41°23'48"N., 71°02'01"W (see Figure 7.1).

3. The Brenton Point Pilot Station is used for entry into Narragansett Bay, , and the Point Judith Pilot Station is used for entry into Long Island Sound. Because of this, vessels requiring a marine pilot frequently travel through the Ocean SAMP area to the Point Judith Pilot Station to board a pilot, even if they are destined for a port within Long Island Sound. The Montauk Pilot Boarding Station is only used by special arrangement due to the less favorable sea conditions that persist at that location (Costabile, pers. comm.).

720.6. Anchorages

1. Vessels bound to or from Narragansett Bay or other area ports may temporarily anchor within or outside of Narragansett Bay. Vessels do this for a variety of reasons including waiting for dock space, waiting for a favorable tide or better weather, waiting for shipping orders, or in order to lighter cargo (transfer cargo from a larger to a smaller vessel). In the vicinity of the Ocean SAMP area, all lightering activity takes place within the Bay where weather conditions are more favorable.

2. At present there are no anchorages charted within the Ocean SAMP area; all anchorages are within Narragansett Bay. However, a general anchorage is proposed for the waters south of Brenton Point in the Brenton Reef area in federal waters (see Figure 7.1). According to the U.S. Coast Guard Sector Southeastern New England, as of late 2010 this proposed anchorage is in the conceptual stage and undergoing development, and a formal proposal and public comment period is expected sometime in 2011. For further information on the status of this proposed general anchorage, please contact the U.S. Coast Guard Sector Southeastern New England (LeBlanc, pers. comm.).

720.7. Navy Restricted Areas

1. There are two Navy restricted areas within the Ocean SAMP area as indicated in the *U.S. Coast Pilot* that are used for military testing: a torpedo range and a practice minefield training area (see Figure 7.2) (NOAA National Ocean Service 2009).

2. The first Navy restricted area is a 2-nautical mile-wide strip that begins within the northern precautionary area of the approach to Narragansett Bay, and extends south for over 11.5 nautical miles, coinciding with the Traffic Separation Zone (see Figure 7.2). During appropriate weather conditions this area is used as a torpedo range under the direction of the Naval Undersea Warfare Center in Newport. Navigation in this

area is prohibited during times of torpedo range use. For further information see the *U.S. Coast Pilot* Volume 2 (NOAA National Ocean Service 2009).

3. The second Navy restricted area is located approximately 4 nautical miles south of Lands End in Newport, and is a 1-nautical mile by 1.5-nautical mile box. Under federal navigation rules, this area is restricted as a naval practice minefield (see Figure 7.2) (33 CFR 334.78). Navigation in this area is prohibited during times of minefield training under the direction of the U.S. Naval Base in Newport. For further information see the *U.S. Coast Pilot* Volume 2 (NOAA National Ocean Service 2009).

4. In addition to these charted areas, the Navy has designated Submarine Transit Lanes for submerged submarine transit. One of these lanes overlaps with the southern border of the Ocean SAMP area. For further discussion of submarine activity and other Naval activities within the Ocean SAMP area, please refer to Section 730.

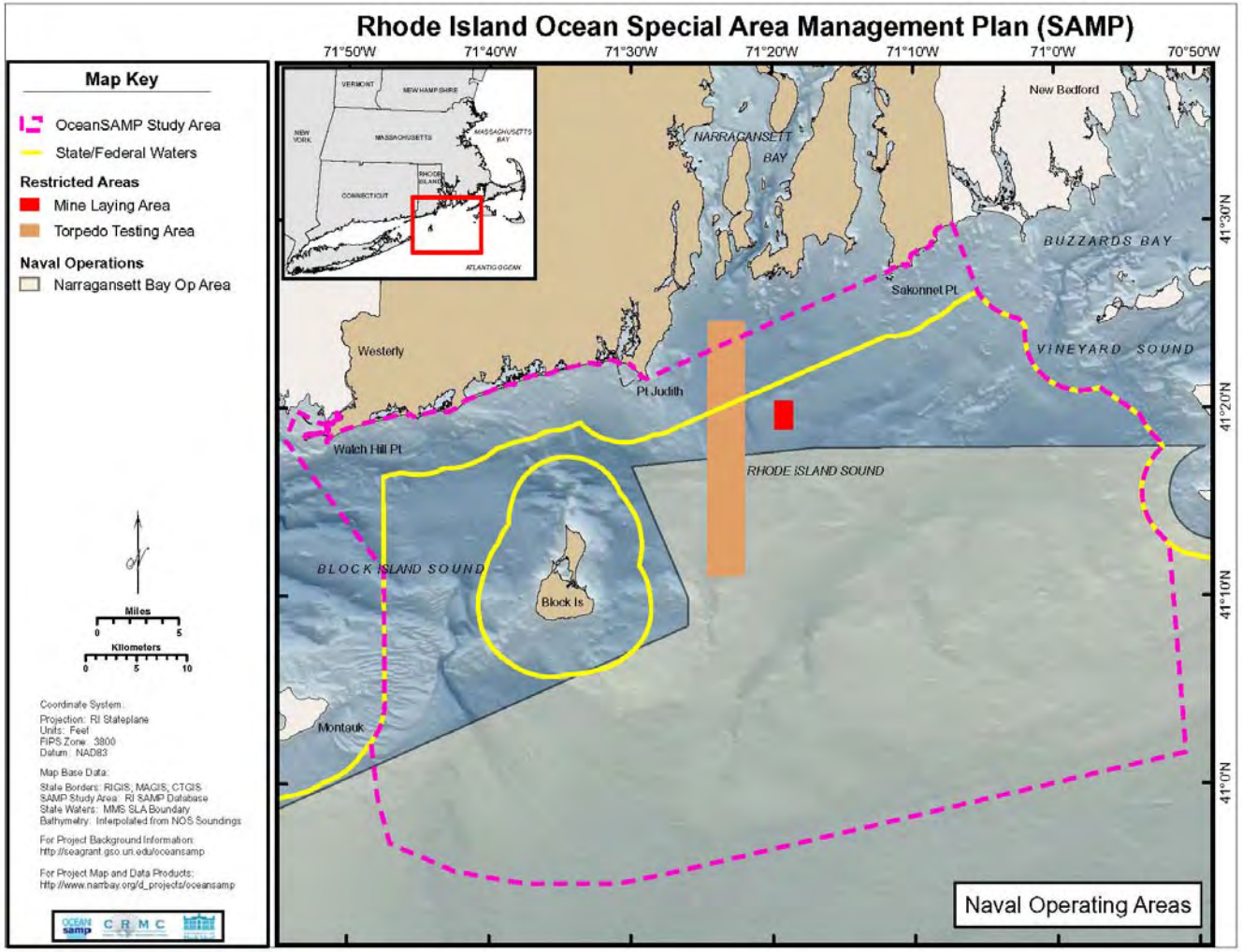


Figure 7.2 Naval operating areas.

720.8. Right Whale Seasonal Management Area

1. In 2008, NOAA National Marine Fisheries Service enacted a Right Whale Ship Strike Reduction Rule (50 CFR 224.105) with the goal of reducing right whale mortality due to ship traffic (National Oceanic and Atmospheric Administration 2008). This rule applies to discrete areas of Atlantic coastal waters during certain times of the year (see Chapter 2, Ecology). The Ocean SAMP area includes part of the Mid-Atlantic Seasonal Management Area (see Figure 7.3), which encompasses right whale migratory routes and calving grounds and is in effect from November 1 through April 30. During these months, all vessels 65 feet or longer and operating in the designated Seasonal Management Area must reduce speed to no more than 10 nautical miles per hour (NOAA National Marine Fisheries Service n.d.).

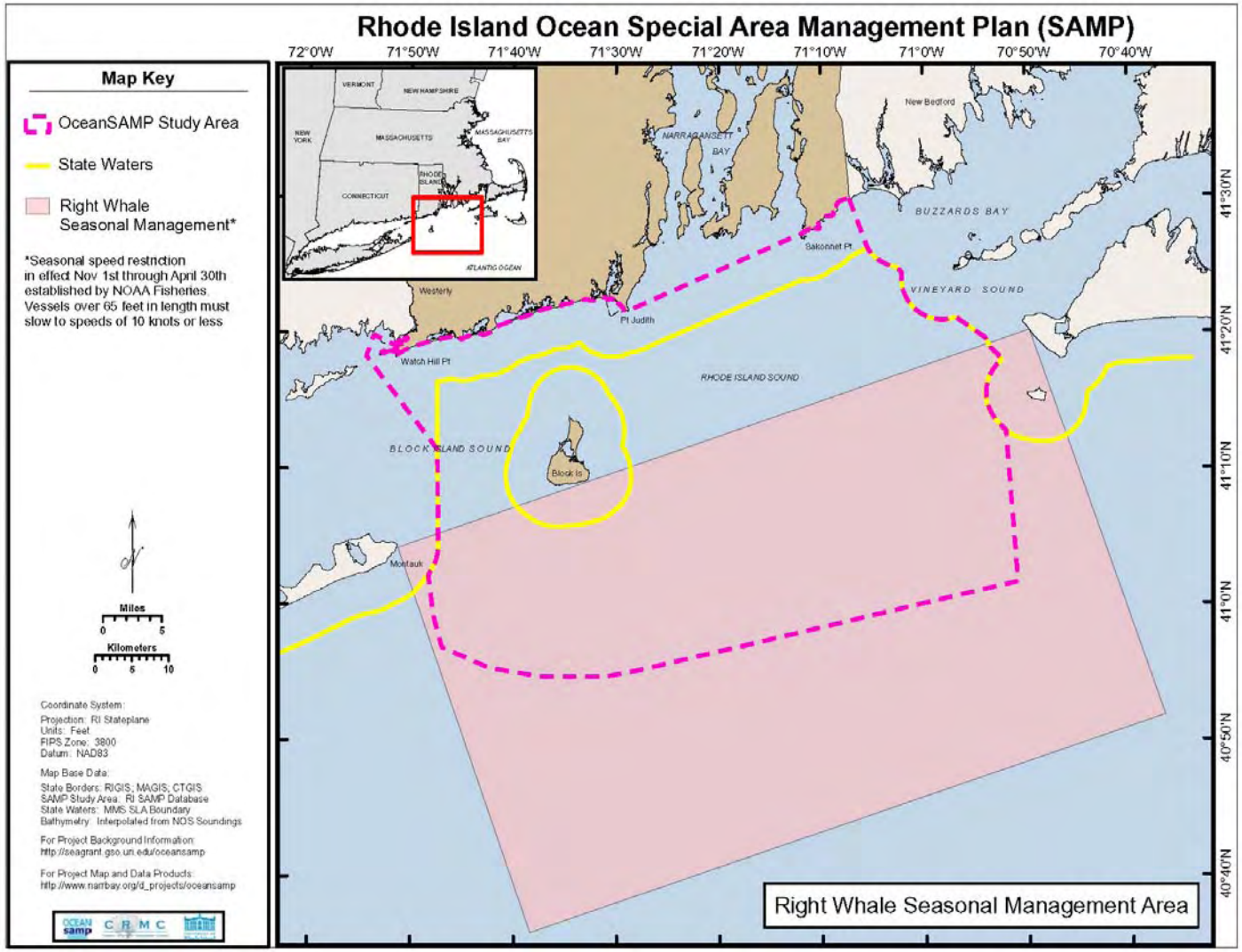


Figure 7.3 Right whale seasonal management area.

Section 730. Marine Transportation in the Ocean SAMP Area

1. Marine transportation in the Ocean SAMP area is characterized by a range of vessel types and activities. Commercial shipping involves the transport of goods such as petroleum products, coal, and cars through this area, while passenger ferries and cruise ships transport people between nearby coastal communities. Pilot boats and government enforcement and search and rescue vessels provide critical support to commercial vessel operations and facilitate safe navigation. Naval vessels engage in training activities in Ocean SAMP area waters, or pass through the area when traveling between ports.

2. Recreational and fishing vessels also operate in this area and utilize the same navigational features. For an extensive discussion of fishing vessels and activity areas, see Chapter 5, Commercial and Recreational Fisheries . For an extensive discussion of recreational vessels and activity areas, see Chapter 6, Recreation and Tourism.

730.1. Shipping Activity

1. Commercial shipping within the Ocean SAMP area includes cargo vessels transiting to or from the Narragansett Bay ports of Providence, Quonset/Davisville, and Fall River.. It also includes ships transiting the Ocean SAMP area between a variety of other ports including the Port of New York and New Jersey, the Port of Boston, and other ports located on the east coast or abroad. While data is available on the number of ships calling at Narragansett Bay ports, it is difficult to quantify the remaining shipping traffic traveling through the Ocean SAMP area because these data are typically collected only for specific ports or harbors.

2. The U.S. Army Corps of Engineers (USACE) collects annual data on freight traffic (tonnage per year), the number of vessel transits, and drafts of vessels utilizing federally-maintained navigation channels.[3] Given that the Ocean SAMP area's northern boundary coincides with the three entrances to Narragansett Bay, USACE data collected for Narragansett Bay provide one measure of commercial traffic through this area. The 2007 data for Narragansett Bay (see Table 7.1) illustrate that the majority of traffic entering the Bay is destined for the ports of Providence or Fall River (U.S. Army Corps of Engineers 2007). Of a total of 2,412 vessel transits to and from Narragansett Bay in 2007, 1,762 were headed to and from Providence; of these transits, 23 percent were foreign-flagged vessels. An additional 650 transits were to and from Fall River, 16 percent of which were foreign-flagged vessels. This vessel transit total is conservative in that it does not include transits by car carriers to and

[3] The U.S. Army Corps of Engineers Waterborne Commerce statistics only records trips in waterways and channels maintained by the U.S. Army Corps of Engineers. Therefore, the data do not capture Narragansett Bay traffic proceeding to Davisville because this traffic does not pass any channels that are maintained by the U.S. Army Corps of Engineers.

from the Port of Davisville at Quonset/Davisville.[4] Between 80 and 100 ships call at Davisville each year, resulting in 160 to 200 additional transits in and out of Narragansett Bay (Quonset Development Corporation 2009; see Section 740.2). See Section 740 for further discussion of the ports of Providence, Quonset/Davisville, and Fall River.

Table 7.1. Vessel transits in and out of Narragansett Bay using federally maintained navigation channels in 2007 (U.S. Army Corps of Engineers 2007)[5].

Type of Vessel	Port of Call	
	Providence	**Fall River**
Dry Cargo	178	145
Tanker	233	6
Tow or Tug	403	388
Barges	948	111
Total	**1,762**	**650**

3. The majority of shipping traffic into Narragansett Bay via the Ocean SAMP area consists of vessels delivering coal and petroleum products. These products are critical in meeting the energy needs of Rhode Island, northeastern Connecticut and southeastern Massachusetts (Energy Information Administration 2009; U.S. Army Corps of Engineers 2001). In 2007, the Army Corps of Engineers Waterborne Commerce Statistics recorded that approximately 4.3 million short tons of coal and 6.2 million short tons of petroleum products entered the Bay headed for Fall River and Providence (see Table 7.2).[6] Other products including sodium hydroxide, rubber, and gum forest products are imported into Fall River in smaller amounts, and a number of chemical products, stone, aluminum ore, other non-metal minerals, manufactured goods, and equipment are imported into Providence (See Table 7.2). Steel scrap is the primary cargo exported out of Rhode Island through the Port of Providence (U.S. Army Corps of Engineers 2007). In addition, as of 2007, ProvPort, which operates the Port of Providence, has begun exporting used automobiles to the Middle East and West Africa (Curtis, pers. comm., December 21, 2009).

4. Petroleum and other energy products imported into the Port of Providence via the Ocean SAMP area are of great regional value. The market served by the Port of Providence covers approximately 2,000 square miles and provides services for a population conservatively estimated at roughly 1.25 million people (U.S. Army Corps of Engineers 2001). See Section 740.1 for an extensive discussion of the Port of Providence and the regional benefits it provides.

[4] USACE data do not include traffic to and from Davisville because the navigation channel approaching Davisville is not a USACE-maintained federal channel.
[5] For more detailed information on vessel transits to Providence and Fall River, including vessel drafts, see the U.S. Army Corps of Engineers, *Waterborne Commerce of the United States*, Part 1 (Atlantic Coast).
[6] A short ton is equal to 2,000 lbs.

Table 7.2. Volume of cargo transported in 2007 (thousands of short tons) (U.S. Army Corps of Engineers 2007).

Cargo Type	Port of Call		
	Fall River	**Providence**	**Total**
Coal	3,521	796	**4,317**
Petroleum Products	82	6,142	**6,224**
Chemical and Fertilizers	12	328	**340**
Gravel, Sand, and Stone	0	18	**18**
Iron Ore and Steel Scrap	0	632	**632**
Aluminum Ore	0	67	**67**
Other Non-metal Minerals	0	234	**234**
Forest Products	33	0	**33**
Manufactured Goods	0	890	**890**
Manufactured Equipment	0	117	**117**
Unknown	0	1	**1**
Total	**3,648**	**9,225**	**12,873**

4. In general, the volume of imports into Narragansett Bay remains constant throughout the year. Tankers and barges carrying home heating oil, gasoline, and other petroleum products, which make up the majority of cargo entering the Bay, are evenly spread out throughout the year (Federal Energy Regulatory Committee 2005). An important exception to this pattern is vehicle imports into Davisville, which peak in the late fall, generally October through December (Matthews, pers. comm.).

5. Time series shipping data for Narragansett Bay show that over the past two decades the total cargo tonnage processed by Narragansett Bay ports has remained relatively constant, between 11 and 13 million short tons per year (see Figure 7.4 and Table 7.3). However, the number of cargo vessels used to transport this amount of cargo has declined because vessel capacity is growing. For example, in 1980 there were 5,614 transits to and from Providence (Rhode Island Senate Policy Office 2002). Transits fell to 2,893 in 1997 and 1,762 in 2007 (see Figure 7.5) (U.S. Army Corps of Engineers 1997; U.S. Army Corps of Engineers 2007). Meanwhile, the amount of cargo imported into Providence during this time period increased from 7.5 million short tons in 1980 (Rhode Island Senate Policy Office 2002) to 8.8 million short tons in 1997 and 9.2 million short tons in 2007 (see Figure 7.5) (U.S. Army Corps of Engineers 2007).

6. The 2005 dredging of the Providence River to a controlling (minimum) depth of 40 feet allows for the accommodation of deeper-draft vessels. This channel deepening project is consistent with the abovementioned trend toward larger, deeper-draft cargo vessels.

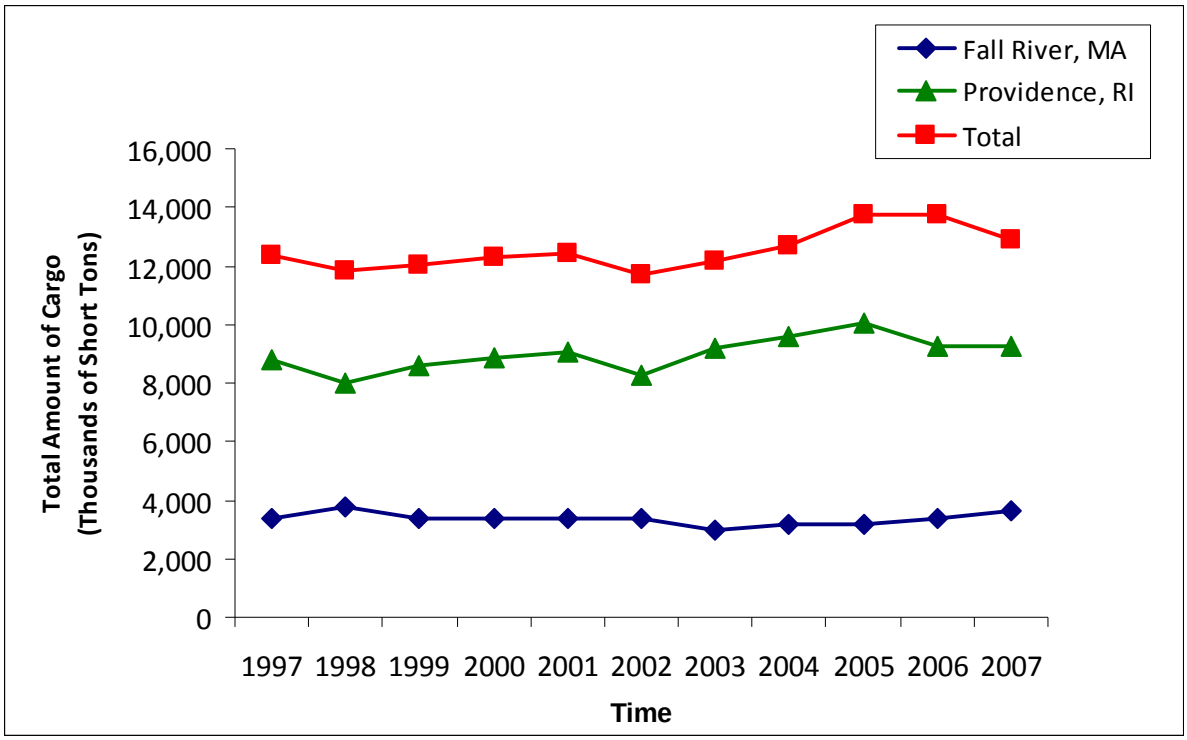


Figure 7.4. Annual cargo volume processed by Narragansett Bay ports, 1997-2007 (U.S. Army Corps of Engineers 2007).

Table 7.3. Annual cargo volume processed by Narragansett Bay ports between 1997 and 2007 (thousands of short tons; U.S. Army Corps Engineers 2007).

Year	Port of Call		
	Fall River	Providence	Total
1997	3,394	8,814	**12,362**
1998	3,776	8,028	**11,848**
1999	3,395	8,627	**12,063**
2000	3,402	8,870	**12,272**
2001	3,382	9,030	**12,414**
2002	3,392	8,244	**11,729**
2003	2,977	9,214	**12,192**
2004	3,161	9,559	**12,722**
2005	3,157	10,045	**13,742**
2006	3,364	9,267	**13,724**
2007	3,648	9,225	**12,873**

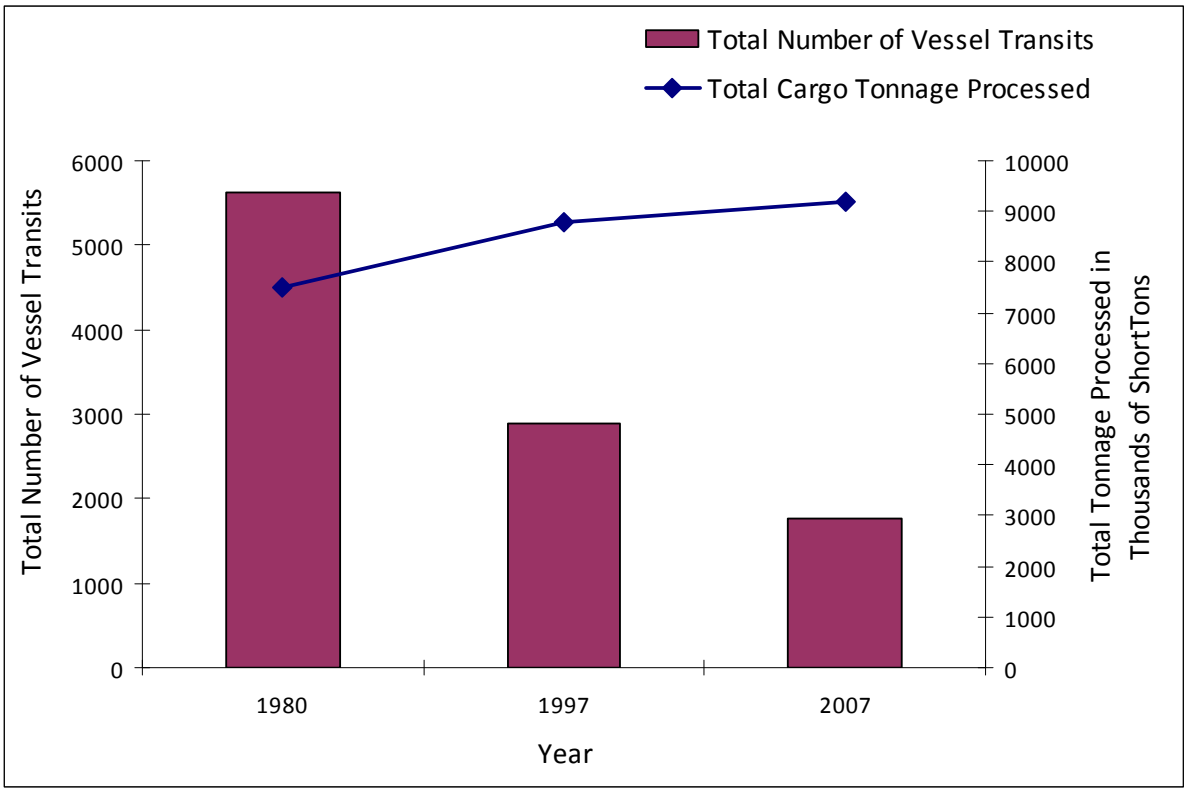


Figure 7.5. Total number of vessel transits and volume of cargo processed in Providence (U.S. Army Corps of Engineers 1980 as cited in R.I. Senate Policy Office 2002; U.S. Army Corps of Engineers 1997; U.S. Army Corps of Engineers 2007).

7. Traffic in and out of Narragansett Bay makes up only part of the commercial traffic moving through the Ocean SAMP area, much of which consists of vessels traveling coastwise. Many of these ships are tug and barge units carrying petroleum products; these vessels originate in the Port of New York and New Jersey or points south and travel to and from Buzzards Bay and the Cape Cod Canal. There are also ships transiting to and from Long Island Sound via Block Island Sound (McVay, pers. comm.). Exact numbers of coastwise transits through the Ocean SAMP area are not available; however, traffic data from Long Island Sound and the Cape Cod Canal provide an approximation of traffic traveling through this area associated with surrounding East Coast ports. In 2006, the U.S. Coast Guard estimated that there may be 2,0004,000 transits through Long Island Sound each year; those transits leaving the eastern end of Long Island Sound must pass through the Ocean SAMP area. Furthermore, in 2005, 443 foreign-flagged vessels were recorded traveling through the SAMP area, destined for ports within Long Island Sound (U.S. Coast Guard 2006). And in 2007, 649 foreign vessels were recorded passing through the Cape Cod Canal (U.S. Army Corps of Engineers 2007), thus passing through Buzzards Bay into the Ocean SAMP area.

8. Commercial traffic in the Ocean SAMP area may increase in the future if a short sea shipping industry develops in Rhode Island. Short sea shipping is the movement of

goods (usually containerized) domestically aboard barges, with the goal of reducing truck traffic on congested highways. The corridor between Boston, New York, and Washington, D.C., has been proposed as an attractive region in which to develop short sea shipping routes due to the amount of traffic congestion, the region's population density, and the availability of port facilities (R.I. Economic Monitoring Collaborative 2007). No short sea shipping routes are currently in use in the area, but some sources indicate that if this use were to develop, Rhode Island ports, particularly Providence, could serve as a central hub (R.I. Economic Monitoring Collaborative 2007; National Ports and Waterways Institute, University of New Orleans 2004). If short sea shipping were to develop in Rhode Island, it would greatly increase the number and frequency of vessel transits through the Ocean SAMP area. See Chapter 9, Other Future Uses, for further discussion of this and other future uses of this area.

9. Automatic Identification System (AIS) data, when aggregated and analyzed using Geographic Information System (GIS) tools, provide a fairly reliable means of analyzing commercial ship traffic activity and density within the Ocean SAMP area (see Figure 7.6). AIS is a transponder-based ship identification system that broadcasts vessel data (such as vessel name, type, position, course, speed, navigation status, dimensions, and type of cargo) among ships and with shore-side facilities. Generally, vessels currently required by federal regulation to carry an operational AIS include commercial ships of 65 feet or more in length, all tankers, most commercial towing vessels, and large passenger vessels.[7] In addition to the vessels listed above, a vessel navigating in an area in which there is a Vessel Traffic Service (VTS), such as the Port of New York and New Jersey, is also required to carry AIS. It is important to note that at the time of this writing, AIS is not required aboard commercial fishing vessels or many ferry boats.[8] However, required use of AIS may be expanded in the future.[9] It should also be noted that many vessels—especially large yachts or recreational vessels—carry AIS even though they are not required to do so (McVay, pers. comm.).

[7] According to 33 CFR §164.46, vessels that must carry AIS include self-propelled vessels of 65 feet or more in length that are used for domestic or international commercial shipping or that are certified to carry fewer than 151 passengers-for-hire; passenger vessels of 150 gross tons or more; all tankers, regardless of tonnage; vessels, other than passenger vessels or tankers, of 300 gross tonnages or more; commercial towing vessels of 26 feet or more in length and more than 600 horsepower, in commercial service; and passenger vessels certified to carry more than 150 passengers-for-hire.

[8] Although fishing vessels are not required to carry AIS, Vessel Monitoring Systems (VMS) are required on some commercial fishing vessels with federal permits as an enforcement mechanism. For further information, see Chapter 5, Commercial and Recreational Fisheries Resources and Uses.

[9] In December 2008, the Coast Guard published a Notice of Proposed Rulemaking in which it was proposed that federal regulations requiring the use of AIS be expanded to include some ferries and other vessels. Specifically, under the proposed rule, the use of AIS would be required by self-propelled vessels of 65 feet or more in length, engaged in commercial service; towing vessels of 26 feet or more in length and more than 600 horsepower, engaged in commercial towing; self-propelled vessels carrying 50 or more passengers, engaged in commercial service; vessels carrying more than 12 passengers for hire and capable of speeds in excess of 30 knots; dredges and floating plants operating near channels likely to restrict or affect navigation of other vessels; self-propelled vessels carrying or engaged in the movement of certain dangerous cargos (U.S. Coast Guard 2008). As of the time of this writing, final Coast Guard action on these proposed regulations is still pending.

10. To help visualize commercial ship usage of the Ocean SAMP area, a density plot was developed using AIS point data (from September 2007 to July 2008) and a 1 kilometer (km) by 1 km grid overlay to determine the relative density of commercial ship traffic.[10] See Figure 7.6 for a map of this ship traffic, and see Figure 7.7 for a map showing ship traffic as well as designated navigation areas. On these maps, vessel traffic density per 1 km square is shown. Traffic in squares with fewer than 50 vessel counts is not shown. The darkest squares represent the areas within the Ocean SAMP area that have the most traffic—in this case over 1,000 vessel transits recorded.

11. Figures 7.6 and 7.7 show that there are several heavily trafficked areas within the Ocean SAMP area. One is at the entrance to Narragansett Bay, which corresponds roughly with the northern precautionary area of the approach to Narragansett Bay (see Figure 7.7). A great deal of traffic is also concentrated within the vicinity of the coastwise Recommended Vessel Route, though it should be noted that this traffic pattern is not confined to the narrow Recommended Vessel Route that is delineated on nautical charts (see Figure 7.7). There is also a clear traffic pattern running north/south through the middle of the Ocean SAMP area that corresponds clearly with the charted shipping lanes and Traffic Separation Scheme (see Figure 7.7). Finally, it is important to note the concentration of traffic in the southwest corner of the Ocean SAMP area that represents ships rounding Montauk Point and passing into Long Island Sound; this heavily used area does not correspond to a shipping lane or any other codified transportation area. Conversely, relatively little traffic is shown passing through the charted approach to Buzzards Bay, which runs diagonally through the Ocean SAMP area (see Figure 7.7). See Section 720 for further information on the abovementioned navigation areas.

12. Previous AIS analysis conducted by the U.S. Coast Guard of commercial vessel traffic through Block Island Sound suggests that the majority of commercial vessel traffic within the Ocean SAMP area does not experience significant month to month variation (U.S. Coast Guard, 2006). Monthly AIS data for commercial vessel traffic in Block Island Sound, Montauk Channel, the Race, and Long Island Sound from 2005 were compared and determined by the U.S. Coast Guard to have no "significant month by month variation" (U.S. Coast Guard, 2006).

[10] AIS data used in this analysis were purchased by URI researchers from a private consulting company.

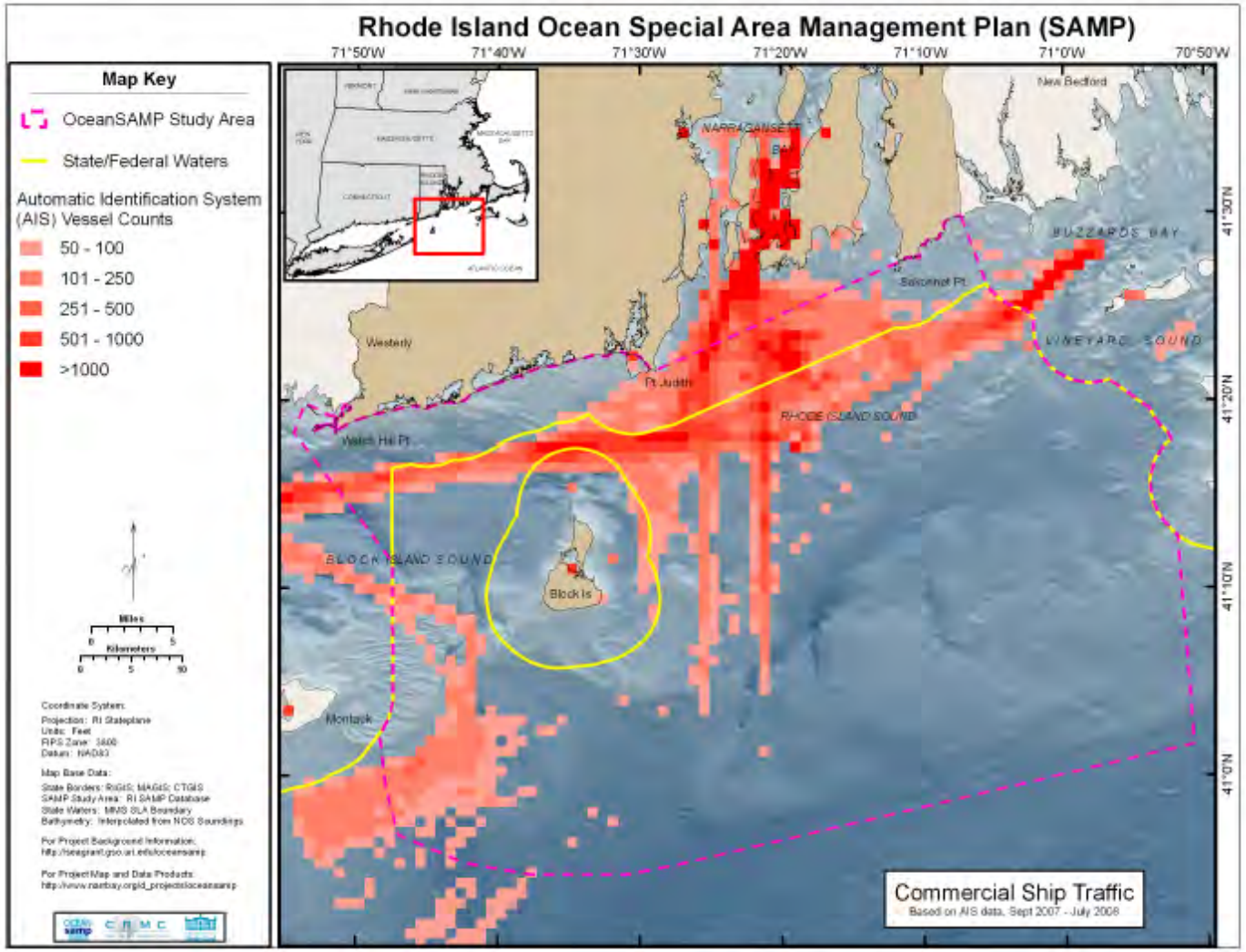


Figure 7.6. Commercial ship traffic based on AIS data.

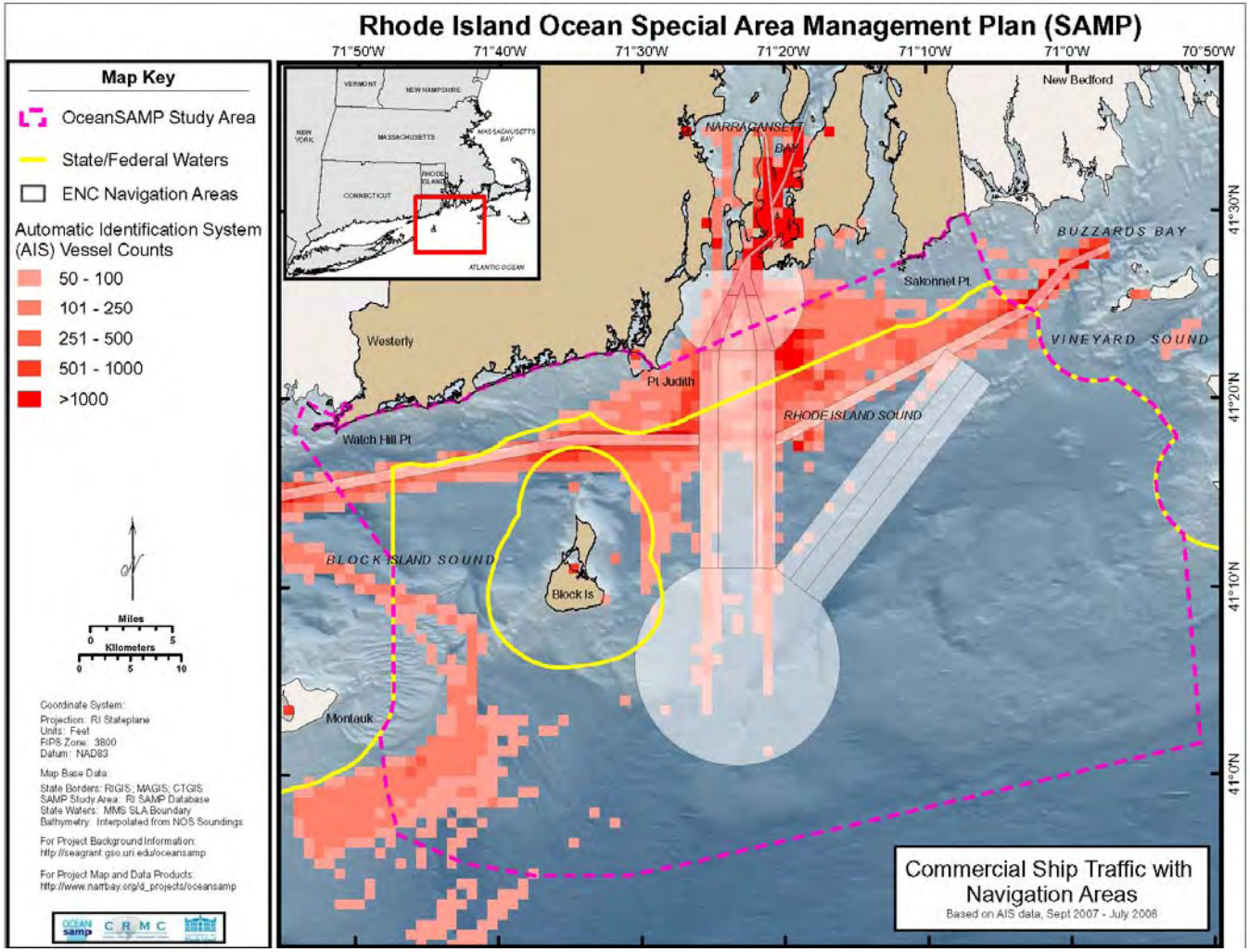


Figure 7.7. Commercial ship traffic and navigation areas.

730.2. Cargo Vessels

1. There are multiple types of commercial vessels transporting cargo through the Ocean SAMP area. These include bulk vessels (merchant ships designed to carry unpackaged, dry, bulk cargo), break bulk carriers (ships designed to carry packaged goods), coal carriers, tankers delivering liquid bulk cargo such as petroleum products, tug and barge units, and car carriers. Pilot boats also operate in the Ocean SAMP area, transporting marine pilots to arriving commercial vessels and taking them off departing vessels.

2. Bulk cargo vessels entering the Bay via the Ocean SAMP area carry coal, chemicals, cement, aggregates, ore, oxide, metals, salt, cobblestone, and limestone (Waterson Terminal Services 2008). Break bulk cargo vessels operating in the area transport forest products, steel, copper, and calcium into Providence (Waterson Terminal Services 2008). A typical bulk carrier transiting through the Ocean SAMP area is over 700 feet long, 106 feet abeam, and roughly 36,000 gross tons (Costabile, pers. comm.).

3. Coal is one of the most common bulk cargos transported by ship into the Bay. Coal carriers entering the Bay are destined for either Providence or Somerset, Mass., across from Fall River. Ships destined for Providence travel directly up the East Passage of the Bay. Larger coal ships destined for Somerset power plants along the Taunton River sometimes need to transfer cargo, through a process known as lightering, onto barges that can navigate the channel's 35-foot controlling depth (Weaver's Cove Energy LLC 2009). These barges usually each carry an average of 20,000 tons of coal to Somerset (Costabile, pers. comm.). Typical coal carriers that head straight for Somerset without lightering onto barges are roughly 750 feet long, 105 feet abeam, and between 38,000 and 43,000 gross tons (Costabile, pers. comm.). Because the two coal-powered facilities located in Somerset can require approximately 10,000 tons of coal per day to operate, a steady inflow of coal is required.[11] Therefore, bulk vessels carrying coal enter the Bay at least once a week, sometimes every two to three days (McVay, pers. comm.). In 2008, Northeast Marine Pilots handled 60 coal carriers making round trips to Brayton Point alone, whereas many other coal ships went to Providence or lightered in the Bay (Costabile, pers. comm.). See Chapter 8, Renewable Energy and Other Offshore Development, for further discussion of power sources.

4. Southern New England's demand for petroleum products is met largely by oil tankers and barges that transit through the Ocean SAMP area and into Narragansett Bay via the East Passage. As has been noted by the Energy Information Administration (2009), petroleum products imported into Providence provide nearly all of the

[11] In December 2009, the NRG Energy coal-powered facility in Somerset, Mass., closed and ceased operations indefinitely (Dion 2009). As of the time of this writing a determination as to when, if ever, the facility may resume operations has not been made. If this facility is ultimately permanently closed, a significant reduction in coal barge and coal ship deliveries through the SAMP area to Mount Hope Bay can be expected (LeBlanc, pers. comm.).

transportation and home heating fuel used in Rhode Island, northeastern Connecticut, and southeastern Massachusetts. The majority of the petroleum-carrying ships entering Narragansett Bay are domestic tankers, both self- and non-self propelled, carrying petroleum products to Providence and East Providence. Petroleum imports are evenly distributed throughout the year, with vessels transiting day and night. Only a few deeper-draft vessels require tidal lift, requiring the ships' arrival to be coordinated with the occurrence of high tide (Federal Energy Regulatory Committee 2005).

5. In total, 239 tanker transits were recorded within Narragansett Bay during 2007 (six headed to and from Fall River and 233 to and from Providence) (U.S. Army Corps of Engineers 2007). Tanker drafts ranged from 20 to 40 feet, with the deepest draft vessels destined for Providence. A typical tanker transiting the Ocean SAMP area to or from Narragansett Bay is roughly 600 feet long, 90 feet abeam, and over 23,000 gross tons (Costabile, pers. comm.). In addition to traditional petroleum products, liquefied petroleum gas (LPG) ships also transit this area en route to Providence. Typically, 10 to 12 ships per year enter the Bay, primarily in fall and winter, unloading approximately 20,000 to 30,000 metric tons of LPG per visit (Federal Energy Regulatory Committee 2005). These vessels are subject to special U.S. Coast Guard safety and security requirements upon entering the Bay (Federal Energy Regulatory Committee 2005).

6. The majority of traffic entering the Bay via the Ocean SAMP area is non-self propelled barges, carrying petroleum and petroleum products, which are towed by tugboats or moved as part of integrated tug and barge units. In 2007, 592 barges, making over 1,000 transits, entered the Bay, primarily headed for Providence (see Table 7.4) (U.S. Army Corps of Engineers, 2007). While the majority of barges entering Rhode Island are petroleum barges, dry cargo products including asphalt, coal, cement, and road salt destined for Providence are also carried by barges (U.S. Army Corps of Engineers 2006). Fall River receives smaller amounts of dry cargo via barges; products imported to Fall River are mainly coal, chemicals, and other crude materials such as rubber and gum (U.S. Army Corps of Engineers 2006). Barge traffic originates mainly from the Port of New York and New Jersey or points south, and travels northward for ports throughout New England. Tug and barges are more commonly used in coastal shipping because they are less expensive to operate (McVay, pers. comm.).

Table 7.4. Number and type of barges entering Narragansett Bay in 2007 (U.S. Army Corps of Engineers 2007).

Type of Non-Self Propelled Barge	**Port of Call**	
	Providence	**Fall River**
Dry Cargo	57	49
Tanker	474	12
Total	**531**	**61**

7. Approximately 100 car carrier ships enter the Bay each year, destined for the Port of Davisville (FXM Associates 2008b). Typical car carriers transiting the area are up to 650 feet long and 106 feet abeam, and between 46,000 and 54,000 gross tons (Costabile, pers. comm.). Per trip, these ships import approximately 800 to 1,000 units of VW, Audi, Subaru, and Bentley vehicles that are subsequently distributed throughout the Northeast. Typically, car carriers anchor overnight outside the mouth of Narragansett Bay and transit up the East Passage toward Davisville in the early morning. Car carriers are usually unloaded in a single day, though some stay for two days (Matthews, pers. comm.). Average car carriers headed to Davisville are approximately 590 feet in length and 106 feet abeam (Costabile, pers. comm.). See Section 740.2 for additional information on car carrier traffic into the Port of Davisville.

8. All foreign-flagged vessels, regardless of tonnage, and many U.S.-flagged commercial vessels entering Narragansett Bay must be escorted by a licensed marine pilot.[12] A pilot provides a ship's master with local knowledge on navigation and the safest route to the final destination. In the Ocean SAMP area, marine pilots board Narragansett Bay–bound commercial vessels in designated pilot boarding areas; see Figure 7.1 and Section 720 for further discussion.

9. For ships bound for Narragansett Bay, a marine pilot from the Northeast Marine Pilots Association travels via pilot boat out to meet the inbound ship in order to guide it through state waters. The pilot then boards the vessel, and under the authority of the ship's master, safely navigates the ship through the confined waters of a port, river, or bay to its destination. Two pilot boats operate within the Ocean SAMP area, serving vessels bound for Narragansett Bay, Eastern Long Island Sound, and Buzzards Bay (Northeast Marine Pilots Association 2009). Both vessels are docked in Newport Harbor.

730.3. Passenger Ferries

1. Multiple passenger ferries operate within the Ocean SAMP area, connecting a variety of mainland and island destinations within and adjacent to this area. Some ferries connect Rhode Island destinations such as Block Island, Newport, and Point Judith; others link Connecticut and New York ports with Rhode Island and Massachusetts destinations. Within the Ocean SAMP area, ferries serving Block Island and Martha's Vineyard are the most prominent routes and are of particular importance insofar as they create access to the mainland for island communities. See Table 7.5 for a detailed description of each of the passenger ferry services operating in the Ocean SAMP area.

2. Figure 7.8 illustrates the typical routes of all ferries operating in the Ocean SAMP area. As noted above, many ferries do not carry AIS transponders and so the map of commercial ship traffic (Figure 7.6) does not reflect ferry traffic. Ferries operating in this area typically follow standard routes that do not correspond to shipping lanes or

[12] 46 R.I.G.L. § 46-9 *et. seq.*

other codified transportation areas, though these routes vary occasionally due to weather, traffic, or other conditions.

3. Interstate Navigation, whose ferries connect both Point Judith and Newport with Block Island, provides a critical lifeline to Block Island through its ferry service. It is the only ferry-operating company within the Ocean SAMP area that is regulated under the R.I. Public Utilities Commission. The Division of Public Utilities and Carriers and the Public Utilities Commission hold jurisdiction over intrastate water carriers of passengers and vehicles operating between ports in Rhode Island (R.I. Public Utilities Commission 2009). As a result of this authority, the Public Utilities Commission must approve Interstate Navigation ferry schedules, fares, and routes (Myers, pers. comm.).

4. Passenger counts for all ferries operating within the Ocean SAMP area between 2003 and 2005 indicate that the greatest number of passengers travel from Point Judith to Block Island on Interstate Navigation's Block Island ferry (see Table 7.6). In 2005 alone, Interstate Navigation's traditional ferries carried 244,000 passengers (hi-speed was not yet in operation), 67,700 vehicles, 18,000 bicycles, 1,000 motorcycles and 10,000 tons of freight (Interstate Navigation 2006).

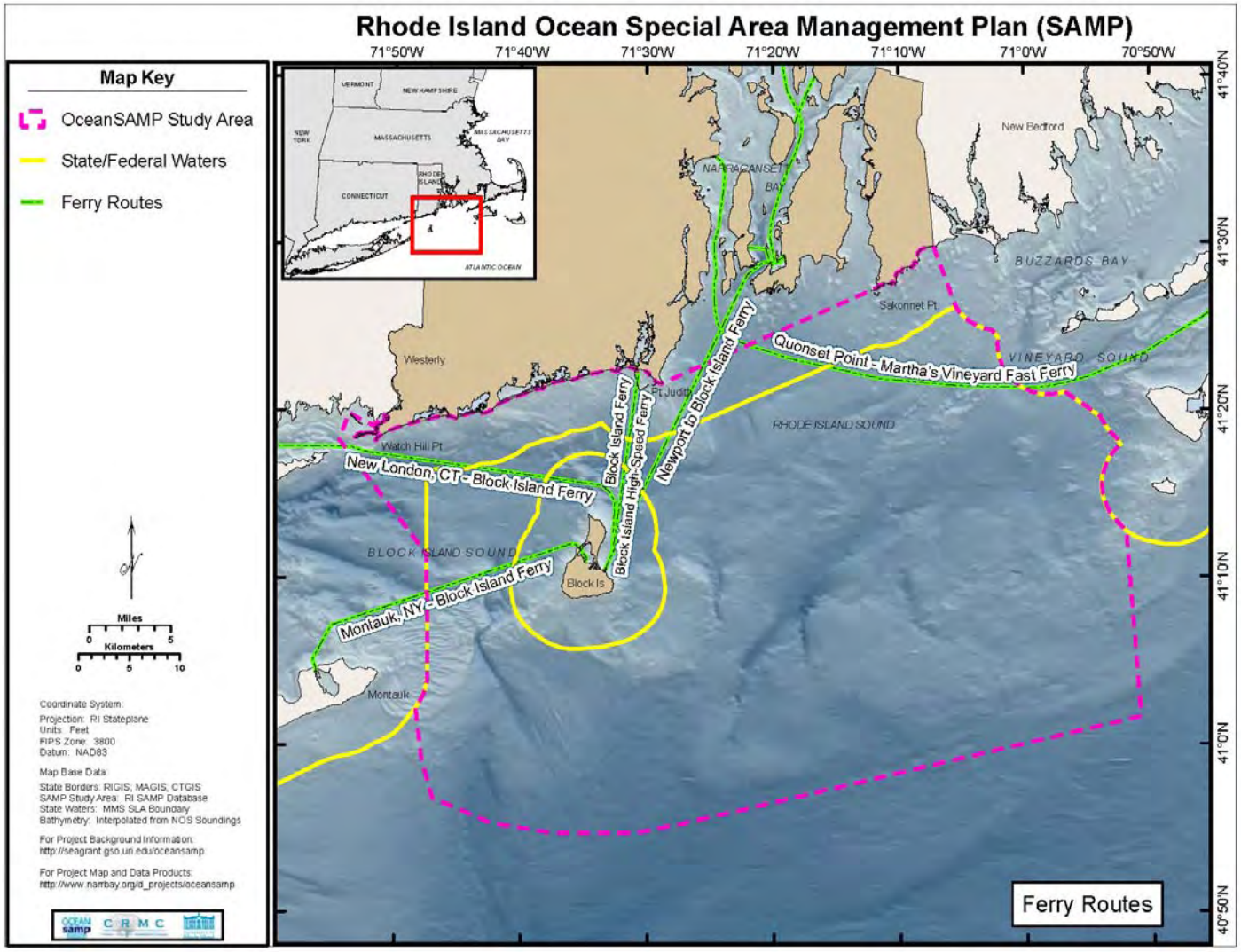


Figure 7.8 Ferry routes.

Table 7.5. Ferries operating within the Ocean SAMP area.

Ferry	Origin/ Destination	Description
Block Island Ferry	Point Judith, R.I. to Old Harbor, Block Island.	Interstate Navigation operates both traditional and high-speed ferries out of Point Judith Harbor in Galilee. The traditional ferry can accommodate 1,200 passengers per trip, along with approximately 30 vehicles. During the peak season, between June and September, the traditional ferry makes 6-10 round trips per day, compared to only 1-3 trips per day during the off-season (Interstate Navigation 2009). Trips out to the island take approximately 55 minutes, with the ferry traveling on average 16 knots). The high-speed ferry only operates May through October, offering 4-6 round trips per day. This ferry operates at 30 knots, with trips out to the island taking 30 minutes (Myers, pers. comm.). Both of these ferries dock at the Old Harbor terminal.[13]
Newport to Block Island Ferry	Fort Adams, Newport to Old Harbor, Block Island.	Interstate Navigation also operates a traditional ferry out of Newport. This ferry makes one trip per day from Fort Adams State Park to Old Harbor, Block Island, July 1st through Labor Day. Trips on this route take approximately an hour and 45 minutes and can accommodate 800 passengers. The route traveled by the Newport to Block Island ferry is a direct course from the mouth of the East Passage to the Old Harbor ferry terminal (see Figure 7.8). This ferry operates at approximately 12.5 knots through the Ocean SAMP area. At the end of each day, rather than staying in Newport, this ferry transits back to the Point Judith ferry terminal to overnight (Myers, pers. comm.).[14]
Viking Fast Ferry	Montauk Harbor, Montauk, N.Y. to New Harbor, Block Island.	Viking Fleet operates both traditional and high-speed ferry service between Montauk Harbor and New Harbor between late May and mid-October. During the season, this ferry provides one or two daily round trips. Most trips occur on the M/V Viking Superstar, which is 120 feet long and can accommodate 225 passengers (Viking Fleet 2009). Viking Fleet ferries are the only ferries operating within the Ocean SAMP area that dock at New Harbor (see Figure 7.8).[15]

[13] The high-speed ferry route varies each June when Interstate Navigation offers service from Point Judith to New Harbor during Block Island Race Week.

[14] Service between Point Judith and Newport is offered aboard the ferry during July and August when transiting back and forth at the beginning and end of each day; however, very few passengers utilize this service.

[15] Once a season, usually in August, the Viking Fleet ferry takes a trip from Montauk to Oak Bluffs on Martha's Vineyard.

Block Island Express	New London, Conn., to Old Harbor, Block Island.	High-speed ferry service between New London, and Old Harbor is available aboard the Block Island Express. During July and August, this ferry runs 3-4 round-trips per day, with each leg taking approximately 1 hour and 15 minutes. In May, June, and September, the ferry runs only on weekends. This ferry travels at a speed of 35 knots (Block Island Express 2009).
Vineyard Fast Ferry	Quonset Point to Oak Bluffs, Martha's Vineyard.	Vineyard Fast Ferry operates a high-speed ferry between Quonset Point and Martha's Vineyard from May through October. The 100-foot-long, jet-propelled catamaran can accommodate 400 passengers and reach speeds of 33 knots. Round-trip service is offered 2-4 times per day, with the greatest number of trips occurring on holidays and weekends. The ferry departs the Bay via the East Passage and takes a direct course to Oak Bluffs (Vineyard Fast Ferry 2009) (see Figure 7.8).

Table 7.6. Passengers carried between 2003 and 2005 aboard ferries operating within the Ocean SAMP area (United States Coast Guard 2006).

Ferry	Passengers	Daily Transits	
		Maximum	Minimum
New London to Block Island (High-Speed)	132,500	10	8
Montauk to Block Island	8,700	10	4
Point Judith to Block Island (High-Speed)	66,605	12	6
Point Judith to Block Island (Traditional)	520,000 (plus 64,000 vehicles)	18	2
Newport to Block Island	6,500	2	2

730.4. Cruise Ships

1. Cruise ships frequently travel through the Ocean SAMP area destined for Rhode Island ports of call, which include Newport, Block Island, Bristol, and Providence. Tens of thousands of visitors are transported aboard Rhode Island-bound cruise ships each year. In 2008, over 68,000 cruise ship passengers disembarked in Newport, contributing millions of dollars to the local economy. Cruise ship activity in and adjacent to the Ocean SAMP area is detailed below; see Section 740.4 for a discussion of cruise ship port infrastructure and Chapter 6, Recreation and Tourism, for a description of the tourism activity and economic impact associated with cruise ships.

2. According to the Newport Convention and Visitors Bureau (2009), 58 cruise ships from 11 cruise lines were scheduled to stop in Newport in 2009 between April and November, with the most visits occurring in September and October (see Chapter 6, Recreation and Tourism). Normally, only one cruise ship is in port at any time and

remains at anchor in Newport Harbor for 8 to 10 hours, though occasionally there are two ships scheduled for the same day (Newport Convention and Visitors Bureau 2009). During a cruise ship's port call, a 200-yard U.S. Coast Guard-mandated security zone is maintained around the ship (City of Newport 2009). The security zone is activated at the Brenton Point pilot boarding station as a cruise ship begins its transit to Newport. The security zone remains in effect while the ship is in Newport and during the ship's transit back out of the Bay until the ship reaches the pilot boarding station again (LeBlanc pers. comm.). No vessels are allowed within this security zone without permission of the U.S. Coast Guard Captain of the Port. The majority of cruise ships that visit Newport anchor off Newport Harbor in a general anchorage west of Goat Island and shuttle passengers to Newport's Perrotti Park via ship tenders or local tenders (City of Newport, Department of Economic Development 2009). American Cruise Line ships, which are generally smaller, dock at Newport's Fort Adams rather than anchoring out in the harbor.

3. Most cruise ships transiting the Ocean SAMP area utilize the Recommended Vessel Route through this area (see Section 720) and enter the Bay via the East Passage. However, ships operated by American Cruise Lines, which are more common within the SAMP area, may utilize the Sakonnet River entrance to Narragansett Bay (American Cruise Lines 2009). The larger cruise ships that call in Newport can carry up to 3,000 passengers and are as big as 1,132 feet long,134 feet abeam, and 528 gross tons (Costabile, pers. comm.). Smaller American Cruise Line ships carry up 100 passengers and average around 170 feet in length and 40 feet abeam (Costabile, pers. comm.).

730.5. Naval Vessels

1. While naval activity in Rhode Island and adjacent waters has been reduced since the active fleet left in 1972, the Navy still maintains a variety of strategic facilities at Naval Station Newport, including the Newport division of the Naval Undersea Warfare Center, and still conducts various land- and water-based training and testing operations in Newport and in Narragansett Bay, Block Island Sound, and Rhode Island Sounds. In addition, U.S. and foreign naval vessels visit the Newport Naval facilities on a regular basis.

2. Naval ships heading to Naval Station Newport enter Narragansett Bay using the Traffic Separation Scheme (see Section 720) and enter the Bay's East Passage to reach the Naval Station Newport facilities.

3. Northeast Marine Pilots will in most cases provide a pilot for naval ships entering Narragansett Bay. While a commissioned government ship with an officer aboard is not required to use the services of a pilot, most ships choose to do so (Costabile, pers. comm.). See Section 720.5 for further information on pilot boarding areas.

4. Northeast Marine Pilots provided pilots for Navy vessels seven times in 2006, six times in 2007, 10 times in 2008, and five as of November 1 in 2009 (Costabile, pers.

comm.). This results in an annual average of about seven port visits or 14 total transits.

5. The Navy retains two restricted areas for torpedo testing and mine laying exercises—see Figure 7.2 and Section 720.7 for information on Navy restricted areas. The Navy also maintains a large portion of Rhode Island Sound and the Ocean SAMP area as the Narragansett Bay Operations Area (see Figure 7.2).

6. Naval fleet training exercises are generally carried out in deeper waters, as the Ocean SAMP area is regarded as too shallow (Tompsett, pers. comm.). Surface vessels may take part at times and upon request in submarine training exercises in the Operations Area.

7. Whereas there is little Naval fleet training activity within the Ocean SAMP area, the Naval Undersea Warfare Center, Division Newport (NUWC), routinely performs testing in this area. NUWC is based in Newport in part because it provides access to the Ocean SAMP area, where conditions are appropriate for testing and evaluation. Within the Ocean SAMP area six different test operation types occur: launcher testing, torpedo testing, semi-stationary equipment testing, towed equipment testing, unmanned surface vehicle (USV) testing; and unmanned undersea vehicle (UUV) testing. High speed launcher and torpedo testing are confined to the designated Navy restricted areas (see Section 720.7), while all other activities are allowed to be conducted in waters both inside and outside the restricted areas. These activities have been determined to be consistent with the CRMC's coastal policies; see the 2007 "Coastal Consistency Determination for Test Operations in Rhode Island Waters" for further information (Naval Undersea Warfare Center Division Newport 2007).

8. The number of annual tests performed by NUWC varies each year. Estimates provided by NUWC indicate that there are five days of torpedo testing each year, five days of launcher testing, five days of towed equipment testing, 20 days of USV testing, 10 days of UUV testing, and 20 operations with semi-stationary equipment (these tests may occur over a number of days; e.g., a test item is deployed then recovered a week later). Navy vessels are generally associated with all test operations and can range in size from the smaller USVs to the TWR-841, a 120-foot torpedo weapons retriever (Tompsett, pers. comm.).

9. Submarine traffic originates primarily from New London, Conn. Submarines travel on the surface from New London through the southwest corner of the Ocean SAMP area to reach deepwater Naval Fleet Operations Submarine Lanes. The only part of the SAMP area where submarines might be submerged is in a submarine lane which intersects the southern boundary of the Ocean SAMP area, as submarines generally wait until they reach the 100-fathom depth far offshore (Vincent, pers. comm.).

10. The submarine fleet also uses the Narragansett Bay Operations Area for training exercises and to prepare submarines and their crews for their formal voyages. This training can include the use of surface vessels and/or planes and helicopters. Detailed

information on submarine transits through the SAMP area is unavailable as this information is classified (DeBow, pers. comm., Tompsett, pers. comm.).

730.6. Other Government/Enforcement Vessels

1. There are two main types of enforcement vessels that operate within the Ocean SAMP area, R.I. Department of Environmental Management (DEM) vessels and U.S. Coast Guard vessels.

2. DEM's Division of Law Enforcement operates enforcement vessels around Block Island and along Rhode Island's southern coast within 3 nautical miles of shore, enforcing regulations regarding recreational and commercial fishing, boating safety, and water quality. In addition, DEM also investigates recreational boating accidents, conducts water-based search and rescues as well as state beach and coastal park patrols, and responds to marine animal complaints (R.I. Department of Environmental Management 2009).

3. The U.S. Coast Guard operates a variety of enforcement, search and rescue, and government vessels within the Ocean SAMP area. Coast Guard vessels maintain maritime homeland security and enforce federal maritime law; conduct search and rescue missions, address marine environmental protection goals, and maintain all aids to navigation (United States Coast Guard 2009). The Ocean SAMP area lies within the First District of the U.S. Coast Guard, a district that extends from Maine to New Jersey.

4. Other government vessels operating in the Ocean SAMP area may include survey or research vessels such as those operated by CRMC, NOAA, the Environmental Protection Agency, the U.S. Geological Survey, and other entities. Such vessels collect data on the physical characteristics or biological resources of the area.

730.7. Other Vessels

1. Commercial and recreational fishing vessels use the navigational channels and infrastructure within the Ocean SAMP area when transiting out to fishing grounds or engaging in fishing activities. Fishing vessels use the same navigational infrastructure and some of the same port facilities as the vessel types discussed in this chapter. Fishing vessels and activity areas are discussed at length in Chapter 5, Commercial and Recreational Fisheries.

2. Recreational powerboats and sailboats frequently pass through or engage in recreational activities within the Ocean SAMP area. These vessels use the same navigational infrastructure and some of the same port facilities as the vessel types discussed in this chapter. Recreational boating and cruising routes/activity areas are discussed at length in Chapter 6, Recreation and Tourism.

3. Other vessels that may pass through the Ocean SAMP area include commercial yacht carriers, tall ships, and university or private research vessels.

Section 740. Ports and Harbors Adjacent to the Ocean SAMP Area

1. The transport of goods and passengers by ship through the Ocean SAMP area and into Rhode Island is supported by port infrastructure in Rhode Island and neighboring ports. As described above in section 730, commercial shipping in Narragansett Bay is primarily facilitated by the ports of Providence and Quonset/Davisville as well as Fall River. Passenger ferry vessels utilize port infrastructure on Block Island and in Newport, Point Judith, and Quonset Point, whereas cruise ships rely on port facilities in Newport, Block Island, and Providence.

2. Industrial waterfronts throughout Rhode Island and adjacent states provide critical infrastructure in support of ports and marine transportation activities. Per the R.I. Coastal Resources Management Program (CRMP), coastal waters adjacent to industrial waterfronts are zoned as Type 6 waters ("Industrial Waterfronts and Commercial Navigation Channels"). See Section 200.6 of the CRMP for further information (R.I. Coastal Resources Management Council 2008). According to the draft report of the Rhode Island Ports and Commercial Harbors Inventory (Becker et al. in review), marine commercial waterfront property adjacent to Type 6 waters is quite limited yet valuable insofar as it supports a variety of marine commercial activities. See *Rhode Island's Ports and Commercial Harbors: A GIS-based Inventory of Current Uses and Infrastructure* (Becker et al., in review) for further information.

3. Fishing vessels rely on fishing-related infrastructure in Point Judith, Newport, Block Island, and other Rhode Island ports. For detailed descriptions of Rhode Island's fishing ports, see Chapter 5, Commercial and Recreational Fisheries. Recreational vessels take advantage of recreational marinas, boat ramps, and other infrastructure designed specifically for recreational users. For further information on these facilities see Chapter 6, Recreation and Tourism.

740.1. Providence

1. The Port of Providence is Rhode Island's principal commercial port, handling over 70 percent of the cargo entering Narragansett Bay via federally maintained navigation channels (see Table 3, U.S. Army Corps of Engineers 2007). Services provided by the Port of Providence provide significant benefits to Rhode Island and the entire region. The market served by the Port of Providence covers approximately 2,000 square miles in Rhode Island, northeastern Connecticut, and southeastern Massachusetts (U.S. Army Corps of Engineers 2001). The Port of Providence is an intermodal port that offers interstate highway access as well as rail service that reaches inland to major connections throughout the U.S. Coal imported into Providence is transported as far afield as Merrimack, N.H. (Waterson Terminal Services 2008, as reported in R.I. Coastal Resources Management Council in review), and road salt is distributed from the port over a 100-mile radius throughout all of New England (Sprague Energy 2008,, as reported in R.I. Coastal Resources Management Council in review).

2. The Port of Providence is of particular importance, both locally and regionally, for its role in supplying energy products to southern New England. Providence has been referred to as the "energy lifeline of the state" (U.S. Army Corps of Engineers 1998) due to its critical role in importing home heating oil and other petroleum products. One estimate suggested it would take approximately 140,000 truckloads to transport the equivalent amount of cargo carried by tanker and barges into the state annually (U.S. Army Corps of Engineers 1998). Furthermore, the U.S. Energy Information Administration (2009) recognizes the importance of the Port of Providence as "a key petroleum products hub for the New England area. Almost all of the transportation and heating fuel products consumed in Rhode Island, eastern Connecticut, and parts of Massachusetts are supplied via marine shipments through this port." The U.S. Department of Homeland Security also recognizes the Port of Providence as a critical port in supplying energy to New England. Homeland Security has allocated in the past, and continues to allocate, port security grant funding to ensure the security of this important energy supply line (U.S. Department of Homeland Security 2008).

3. Shipping operations into the Port of Providence are reliant on port facilities located in both Providence and East Providence. Most of the port's maritime activity is concentrated in ProvPort (a private port facility located in Providence), though these industries depend on support services provided by tugboat, shipyard, and other services located throughout Providence Harbor. Petroleum import facilities and tank farms are located on both sides of the Harbor in Providence and East Providence. For further information on port facilities in Providence, see the R.I. Metro Bay Special Area Management Plan (R.I. Coastal Resources Management Council in review) and the Rhode Island Ports and Commercial Harbors Inventory (Becker et al. in review).

4. Marine transportation into the Port of Providence is facilitated by a federally maintained navigational channel, which was recently dredged in 2005 to a 40-foot depth, allowing Providence to accommodate larger-draft vessels. The deep draft channel—as well as its intermodal capabilities, connecting water, rail, and land transportation—together make the Port of Providence attractive to both domestic and international vessels (ProvPort 2009). Providence is one of the few New England ports that can accommodate large ocean-going vessels and can offer direct access to interstate highways (I-95 and I-195), making it an attractive port for cargo destined for inland Northeastern cities (FXM Associates 2008a).

740.2. Quonset/Davisville

1. The Quonset Business Park includes the Port of Davisville, which is the second intermodal shipping terminal in Rhode Island; a ferry terminal utilized by Vineyard Fast Ferry; and several other maritime businesses. For further information on maritime facilities in Quonset/Davisville, see the Rhode Island Ports and Commercial Harbors Inventory (Becker et al., in review).

2. The Port of Davisville offers direct access to rail service and major highways from the port facilities. Vehicle imports comprise the majority of the cargo handled by the

port. The Port of Davisville is home to the 12th largest automobile importing, processing, and distribution center in the U.S., with approximately 100 car-carrier ships handled by the port per year (FXM Associates, 2008b). Each vessel imports approximately 800 to 1,000 vehicles per trip, to be later distributed throughout New England and the Northeast. Table 7.7 shows the number of ships and vehicles processed at Davisville for the past two years. In peak months Davisville handles up to 13 vessels and in slower months as few as four vessels (see Table 7.7).

Table 7.7. Port of Davisville monthly car carrier visits and vehicle units imported, July 2007 through June 2009 (Quonset Development Corporation, 2009).

Month	Units	Ship Calls
July 2007	9,535	10
August 2007	7,852	8
September 2007	7,133	7
October 2007	7,831	8
November 2007	5,018	4
December 2007	6,276	6
January 2008	5,030	4
February 2008	7,689	6
March 2008	4,070	6
April 2008	11,611	9
May 2008	6,253	8
June 2008	4,690	5
July 2008	8,828	7
August 2008	7,341	9
September 2008	11,089	9
October 2008	15,314	11
November 2008	10,314	8
December 2008	15,838	13
January 2009	5,088	4
February 2009	8,824	8
March 2009	8,417	9
April 2009	5,858	6
May 2009	4,447	7
June 2009	9,143	10
Total	**193,489**	**182**

3. Sea-frozen fish are also imported and exported at the Port of Davisville. Davisville is home to the largest producer of sea-frozen fish on the U.S. East Coast, supplying sea-frozen and land-frozen fish to a worldwide range of markets, including bait products to domestic and international longline fleets (Seafreeze Ltd. 2009).

4. Ships access the Port of Davisville through a shipping channel with a 29-foot controlling depth that is not maintained by the U.S. Army Corps of Engineers. For this reason, the port is exempt from the federal harbor maintenance tax. This means that federal funds are not available for maintaining this channel, but also that it is cheaper for ships to call at Davisville because they are not required to pay the harbor maintenance tax on their cargo (Matthews, pers. comm.). Davisville's tax-exempt status means a savings of $12.50 per $10,000 in cargo value (North Atlantic Distribution 2009).

5. The Port of Davisville has several advantages in attracting commercial vessel traffic. These include the lack of a harbor maintenance tax charged on cargo (discussed above) and its designation as a Foreign Trade Zone with U.S. Customs operations (FXM Associates 2008b; Quonset Development Corporation 2009). Together these features help attract foreign vessel traffic to the state.[16]

6. Vineyard Fast Ferry, which runs a seasonal fast ferry between Quonset Point and Martha's Vineyard, operates a small ferry terminal in the Quonset Business Park. See Section 730.3 for further information on this and other passenger ferries operating in the Ocean SAMP area.

7. Other current marine transportation-related uses at the Quonset Business Park include businesses such as Senesco Marine, a barge-building company, and General Dynamics Electric Boat, which builds parts of U.S. Navy submarines. In addition, the park is scheduled to become the home port of the new NOAA research ship, R/V *Okeanos Explorer* (Kuffner 2009).

740.3. Fall River

1. The Port of Fall River is the third major commercial port in Narragansett Bay, and is the second most active port in Massachusetts (Donovan 2003). In the Port of Fall River, which for the purposes of this chapter includes both Fall River and Somerset, commercial cargo and fishing vessels are accommodated at the Fall River State Pier. Coal carriers also make berth at power plants in Somerset, across from Fall River. Most commercial traffic transiting through the Ocean SAMP area to Fall River and Somerset consists of coal carriers and barges, as well as chemical cargo, to support nearby power stations and chemical facilities. Coal brought to Somerset via the Ocean SAMP area directly supports the operations of the Brayton Point Power Station (Dominion Power 2009).

[16] U.S. Customs and Border Protection charges a fee of 0.125% of the cargo value on all imported goods admitted into a foreign trade zone via navigable waterways, maintained by the U.S. Army Corps of Engineers. Harbor Maintenance Fees are subsequently deposited into the Harbor Maintenance Trust Fund, which is then made available, to the Army Corps of Engineers for the improvement, dredging and maintenance of U.S. navigational channels, ports, and harbors (Water Resources Development Act of 1986, 33 U.S.C. 2238 §210, Internal Revenue Code of 1986, §9505c).

2. Due to the shallow depth of Mount Hope Bay outside the federally maintained channel approaching the Port of Fall River, many larger commercial vessels lighter within Narragansett Bay in an anchorage near Gould Island before proceeding to port (Weavers Cove Energy LLC 2009).

740.4. Newport

1. Newport Harbor is a major hub of activity for vessels traveling through the Ocean SAMP area. Within Newport Harbor and Brenton Cove, terminals at Fort Adams and Perotti Park are frequently used by visiting cruise ships as well as passenger ferries destined for Block Island (see Section 730.4 and Chapter 6, Recreation and Tourism, for further discussion).

2. Naval vessels associated with the Naval Station Newport and NUWC travel through the Ocean SAMP area and are supported by infrastructure located at these facilities. See Section 730.5 for further discussion of naval operations.

3. Newport is a popular staging area or destination for recreational vessels; a number of privately owned docks, moorings, marinas, yacht clubs, public piers, and other infrastructure support recreational vessels. See Chapter 6, Recreation and Tourism, for further discussion. Newport also has some fisheries-related port infrastructure used by commercial and recreational fishermen. See Chapter 5, Commercial and Recreational Fisheries, for further discussion.

740.5. Point Judith

1. Point Judith Harbor supports both commercial and privately owned vessels that utilize the Ocean SAMP area through privately owned marinas and moorings and the public boat state pier facilities located here. The outer harbor is also designated on NOAA charts as a Harbor of Refuge, offering a protected and sheltered anchorage for vessels transiting this area.

2. Point Judith Harbor is the main port of embarkation for Interstate Navigation's Block Island Ferry (see Section 730.3), which utilizes the state pier facilities.

3. Point Judith is the center of the Rhode Island commercial fishing industry and is the home port for many commercial as well as party/charter boat fishing vessels; see Chapter 5, Commercial and Recreational Fisheries, for further discussion.

740.6. Block Island

1. Block Island's shore-side infrastructure includes two ferry terminals, one each in Old Harbor and New Harbor, as well as a number of public boat ramps and privately owned marinas. Apart from the ferry service and the occasional cruise ship described in Section 730, vessel traffic to and from Block Island is comprised mainly of

pleasure craft. For more information on recreational boating associated with Block Island and the marinas and boat ramps that support these activities see Chapter 6, Recreation and Tourism.

Section 750. Other Infrastructure in the Ocean SAMP Area

750.1. Disposal Site

1. There is one active dredged material disposal site within the Ocean SAMP area, named the Rhode Island Sound Disposal Site. This site was designated in December 2004; before its formal site designation it was used as a disposal site for sediment from the Providence River dredging project (USACE n.d.) This site is managed by the Environmental Protection Agency. It is centered at 41° 13.8' N, 71° 22.8'W, approximately 9.1 nautical miles south-southeast of Point Judith within the traffic separation zone (See Figure 7.9). A second inactive disposal site, labeled on NOAA charts as "Dumping Ground," is located about 4.5 nautical miles south of Brenton Point (see Figure 7.9).

750.2. Unexploded Ordnance

1. There are seven identified locations of unexploded ordnance within the Ocean SAMP area, all to the east of Block Island (see Figure 7.9). These include unexploded depth charges, unexploded bombs and unexploded general ordnance. There is no evidence that these will be removed, as some date back to the 1940s and '50s. (Battelle 2003). Moving from east to west on Figure 7.9, these include a depth charge (1995); depth charges (1952); bombs (1958); depth charge (1947); general ordnance (1971); depth charge (1957); and general ordnance (1992) See NOAA Chart 13218 (NOAA Office of Coast Survey 2009) for further information.

750.3. Underwater Cables

1. Underwater cables running through the Ocean SAMP area are owned by three companies: AT&T, Verizon, and Reliance Globalcom. They include both in-service and out-of-service telecommunications cables (See Figure 7.9).

2. There are six communications cables running through the Ocean SAMP area. Three are owned by AT&T and one is managed by the company, and they all originate at Green Hill in South Kingstown, R.I. Two of these cables are in active use. One AT&T cable, TAT 12/13 Interlink (in service), runs to the west of Block Island. The other three communications cables (TAT 6 [out of service], TAT 10 [out of service] and TAT 12 [in service]) run to the east of Block Island (Wargo pers. comm.). Another cable, CB-1 (formerly Gemini North), is owned by Verizon, and also originates in Green Hill, and runs to Bermuda (Salley pers. comm.). The last cable, FA-1 North (formerly FLAG Atlantic North) is an international telecommunications cable owned by Reliance Globalcom and is in service, and originates from the north shore of Long Island at Crab Meadow (Tegg pers. comm.). All of these cables exit the southern boundary of the Ocean SAMP area.

3. NOAA nautical charts may list "Cable Areas" but that does not necessarily mean that actual cables reside there. Cables are shown on NOAA charts at the request of a data

provider, such as the U.S. Army Corps of Engineers or other permitting entity, so that mariners do not anchor or drag gear over these areas and damage cables (NOAA 1992).

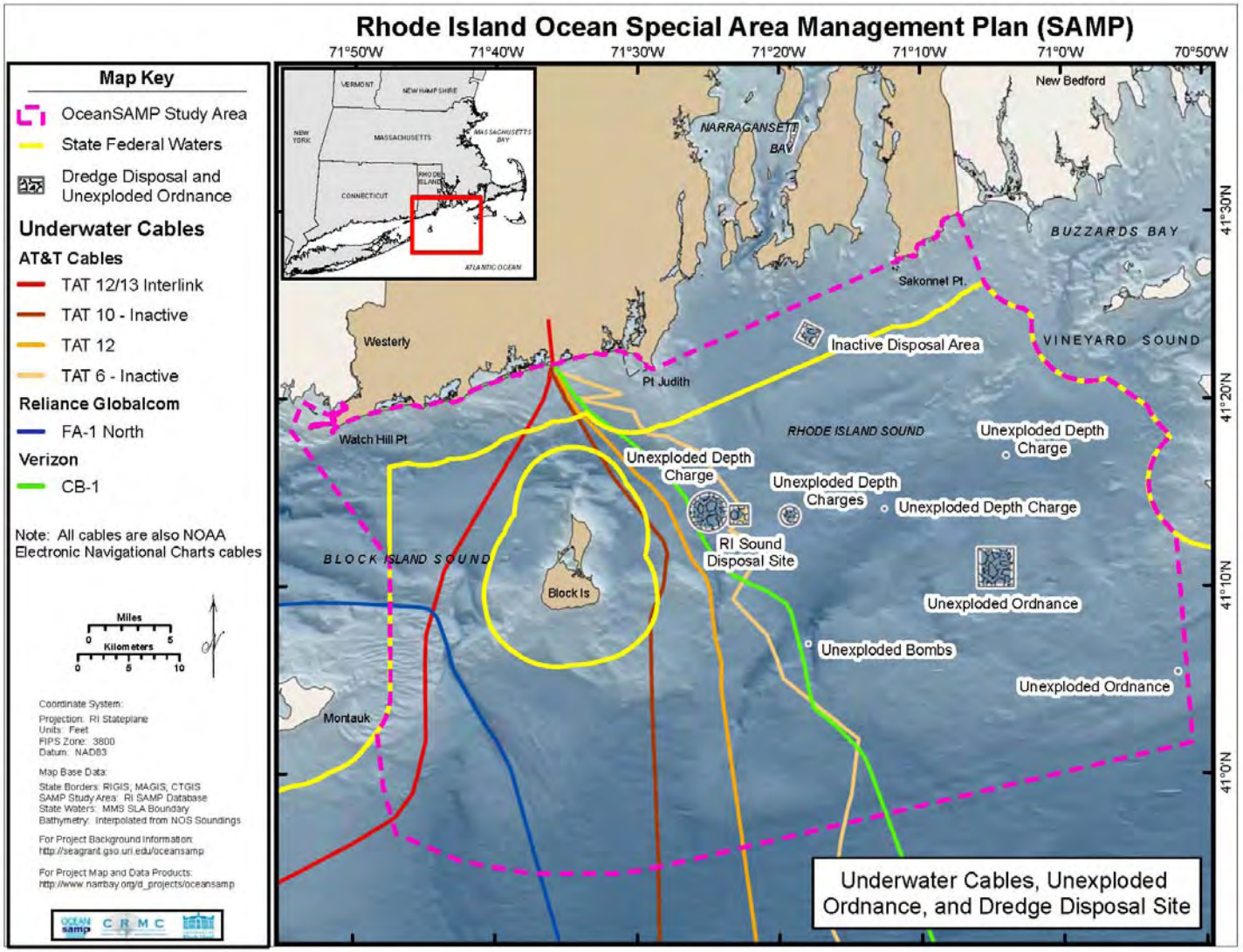


Figure 7.9. Underwater cables, unexploded ordnance, and dredge disposal site.

Section 760. Economic Impact of Marine Transportation and Navigational Uses within the Ocean SAMP Area.

1. Marine transportation and navigational uses of the Ocean SAMP area are economically valuable to Rhode Island and to the entire southern New England region. Imports into the Port of Providence, which pass through this area, provide an "energy lifeline" not only to Rhode Island residents, but also to households and businesses in Massachusetts and Connecticut (U.S. Army Corps of Engineers 1998; U.S. Energy Information Administration 2009). In addition, these uses facilitate commerce through the import of consumer and manufacturing goods, and support marine-related industries throughout the state. These industries in turn create jobs, both on ships and ashore, for Rhode Island residents. Detailed statistics on Rhode Island marine transportation-related jobs and wages are included below.

2. A 2004 economic impact study of Rhode Island's navigation-dependent industries conducted in connection with the 2002 Rhode Island Region Long-Term Dredged Material Disposal Site Evaluation Project found that "navigation-dependent activity in Rhode Island has a significant impact on the state's economy as a whole that goes beyond the navigation-dependent sectors" (The Greeley-Polhemus Group, Inc. 2004). This study found that navigation-dependent marine transportation industries as well as recreational and fishing-related industries had an economic impact of $586 million on the gross state product .If indirect and induced GSP were considered, the economic impact of navigation-dependent activities in Rhode Island totaled $1.1 billion. This assessment also found that navigation-dependent industries supported 12,265 direct jobs and $425 million in wages (The Greeley-Polhemus Group, Inc. 2004).

3. The National Ocean Economics Program (2009) found that in 2004, marine transportation-related industries in Rhode Island alone accounted for 1,968 jobs, $134 million in wages, and $97 million in gross domestic product. These statistics are based on analysis of Bureau of Labor Statistics data and reflect jobs in freight and passenger transportation, marine transportation-related equipment, and other marine transportation-related businesses.[17]

4. Rhode Island's ports, which rely on ships passing through the Ocean SAMP area, generate a significant amount of economic activity. A 2009 study of the Port of Providence found that in fiscal year 2008, 953 direct jobs were supported by port operations, generating $42.1 million in personal income, $21.8 million in local purchases, and $16.9 million in state and local tax revenue (see Table 7.8; Martin Associates 2009). This does not include the economic impact associated with other Providence businesses that support the port. A 2008 study of the port-related

[17] Marine transportation-related businesses are defined by the National Ocean Economics Program as businesses falling under the following Standard Industrial Classification and North American Industrial Classification System categories: Water Transportation of Freight, Water Transportation of Passengers, Deep Sea Freight Transportation, Marine Passenger Transportation, Marine Transportation Services, Search and Navigation Equipment and Warehousing (Colgan 2007).

businesses on Allens Avenue in Providence, which include a shipyard and a tugboat company, found that these businesses support 372 employees and generate about $294 million in sales and $20 million in payroll (FXM Associates, 2008a).

5. In 2007, the economic impact of the Port of Davisville was found to include 1,100 direct jobs, $42 million in wages, and $9 million in tax revenue (see Table 7.9; FXM Associates 2008a). The total output of the Port of Davisville was estimated at $119 million, which included expenditures on materials, labor, interest, rent, as well as income, profit, dividends and depreciation (FXM Associates 2008b).

Table 7.8. Economic impact of the Port of Providence in Fiscal Year 2008 (2008 Dollars; Martin Associates 2009).

Number of Direct Jobs	953
Personal Income	$42.1 million
Local Purchases	$21.8 million
Local and State Tax Revenue Generated	$16.9 million

Table 7.9. Economic impact of the Port of Davisville in 2007 (2007 Dollars; FXM Associates 2008b).

Number of Direct Jobs	1,100
Wages Paid	$42 million
Total Business Output*	$119 million
Local and State Tax Revenue Generated	$9 million

**Total business output is roughly equivalent to GDP and includes expenditures on materials, labor, interest, and rent, as well as income, profit, dividends and depreciation.*

6. Most commercial ships (excluding tug and barge units) passing through the Ocean SAMP area en route to Rhode Island ports are required to carry a licensed marine pilot when navigating state waters. These ships generate state revenue through pilotage fees, which are based on a ship's tonnage (McVay pers. comm.) and are deposited into the State's general revenue account (Rhode Island State Pilotage Commission 2007). In 2007, pilotage fees generated over $175,000 (Rhode Island State Pilotage Commission 2007).

7. Cruise ship traffic through the Ocean SAMP area contributes revenue to local economies, such as Newport, through the influx of cruise ship passengers during the summer season. For every passenger that disembarks from a cruise ship in Newport, the city collects a $4 port tax (Smith, pers. comm.). In 2008, this amounted to approximately $272,000 in city revenue. Cruise ship passengers also have an economic impact through their personal spending; see Chapter 6, Recreation and Tourism, for further discussion.

8. Navy operations in the Ocean SAMP area contribute not only to national security, but also to the local economies in which military facilities are based through expenditures, development, and the creation of jobs. The economic value of naval

uses of this area is difficult to quantify, as much of the military activity occurring in this area is based out of facilities in neighboring states, such as Groton, Conn. However, in 2008 NUWC Division Newpor reported over $531 million in total institutional spending, and over $240 million in wages for 2,600 employees (see Table 7.9). Moreover, local businesses also benefitted from $189 million awarded in Navy contracts to Rhode Island-based companies (see Table 7.10).

Table 7.10. Economic impact of the NUWC Division Newport, 2007-2008 (NUWC Division Newport 2008 and 2009).

	2007	**2008**
Total Number of Employees	2,578	2,602
Total NUWC Spending	$466 mil	$531 mil
Wages Paid	$235 mil	$246 mil
Contracts Awarded to Rhode Island-Based Companies	$123 mil	$189 mil

9. Recreational boaters and commercial and recreational fishing vessels also utilize the Ocean SAMP area for fishing or other recreational uses. These uses support Rhode Island's marine-related industry, as well as coastal economies, through the sale of fuel, supplies, and marina services and are discussed in detail in Chapter 5, Commercial and Recreational Fisheries, and Chapter 6, Recreation and Tourism.

10. The data presented here reflects the economic importance of marine transportation and navigational uses of the Ocean SAMP area to the state as a whole, as well as the coastal communities of the state. Port operations within Rhode Island rely on the waters of this area to transport valuable cargo and facilitate commerce within the region. In addition, the economic activity of cruise ship tourism, recreational boating, and military uses that navigate and operate within the Ocean SAMP area contribute to both state and local economies.

Section 770. Policies and Standards

770.1. General Policies

1. The Council recognizes the importance of designated navigation areas, which include shipping lanes, precautionary areas, recommended vessel routes, pilot boarding areas, anchorages, military testing areas, and submarine transit lanes to marine transportation and navigation activities in the Ocean SAMP area. The Council also recognizes that these and other waters within the Ocean SAMP area are heavily used by numerous existing users who have adapted to each other with regard to their uses of ocean space. Any changes in the spatial use patterns of any one of these users will result in potential impacts to the other users. The Council will carefully consider the potential impacts of such changes on the marine transportation network. Changes to existing designated navigational areas proposed by the Coast Guard, NOAA, the R.I. Port Safety and Security Forums, or other entities could similarly impact existing uses. The Council requests that they be notified by any of these parties if any such changes are to be made to the transportation network so that they may work with those entities to achieve a proper balance among existing uses.

2. The Council recognizes the economic, historic, and cultural value of marine transportation and navigation uses of the Ocean SAMP area to the state of Rhode Island. The Council's goal is to promote uses of the Ocean SAMP area that do not significantly interfere with marine transportation and safe navigation within designated navigation areas, which include shipping lanes, precautionary areas, recommended vessel routes, pilot boarding areas, anchorages, military testing areas, and submarine transit lanes. See section 770.2 for discussion of navigation areas which have been designated as Areas of Particular Concern.

3. The Council will encourage and support uses of the Ocean SAMP area that enhance marine transportation and safe navigation within designated navigation areas, which include shipping lanes, precautionary areas, recommended vessel routes, pilot boarding areas, anchorages, Navy restricted areas, and submarine transit lanes.

4. The Council shall work together with the U.S. Coast Guard, the U.S. Navy, the U.S. Army Corps of Engineers, NOAA, fishermen's organizations, marine pilots, recreational boating organizations, and other marine safety organizations to promote safe navigation around and through offshore structures and developments, and along cable routes, during the construction, operation, and decommissioning phases of such projects. The Council will promote and support the education of all mariners regarding safe navigation around offshore structures and developments and along cable routes.

5. Discussions with the U.S. Coast Guard, the U.S. Department of Interior Bureau of Ocean Energy Management, Regulation, and Enforcement, and the U.S. Army Corps of Engineers have indicated that no vessel access restrictions are planned for the waters around and through offshore structures and developments, or along cable

routes, except for those necessary for navigational safety. Commercial and recreational fishing and boating access around and through offshore structures and developments and along cable routes is a critical means of mitigating the potential adverse impacts of offshore structures on commercial and recreational fisheries and recreational boating. The Council endorses this approach and shall work to ensure that the waters surrounding offshore structures, developments, and cable routes remain open to commercial and recreational fishing, marine transportation, and recreational boating, except for navigational safety restrictions. The Council requests that federal agencies notify the Council as soon as is practicable of any federal action that may affect vessel access around and through offshore structures and developments and along cable routes. The Council will continue to monitor changes to navigational activities around and through offshore developments and along cable routes. Any changes affecting existing navigational activities may be subject to CZMA Federal Consistency review if the federal agency determines its activity will have reasonably foreseeable effects on the uses or resources of Rhode Island's coastal zone.

770.2. Regulatory Standards

1. Navigation, military, and infrastructure areas including: designated shipping lanes, precautionary areas, recommended vessel routes, ferry routes, dredge disposal sites, military testing areas, unexploded ordnance, pilot boarding areas, and anchorages, as shown in Figures 7.1, 7.2, 7.8, and 7.9, have been designated as Areas of Particular Concern. The Council recognizes the importance of these areas to marine transportation, navigation and other activities in the Ocean SAMP area. See Chapter 11, The Policies of the Ocean SAMP, for requirements associated with Areas of Particular Concern.

2. The Council shall consult with the U.S. Coast Guard, the U.S. Navy, marine pilots, the Fishermen's Advisory Board as defined in section 1160.1.6, fishermen's organizations, and recreational boating organizations when scheduling offshore marine construction or dredging activities. Where it is determined that there is a significant conflict with season-limited commercial or recreational fisheries activities, recreational boating activities or scheduled events, or navigation uses, the Council shall modify or deny activities to minimize conflict with these uses.

3. The Council shall require the assent holder to provide for communication with commercial and recreational fishermen, mariners, and recreational boaters regarding offshore marine construction or dredging activities. Communication shall be facilitated through a project website and shall complement standard U.S. Coast Guard procedures such as Notices to Mariners for notifying mariners of obstructions to navigation.

4. Where possible, Offshore Developments should be designed in a configuration to minimize adverse impacts on other user groups, which include but are not limited to: recreational boaters and fishermen, commercial fishermen, commercial ship

operators, or other vessel operators in the project area. Configurations which may minimize adverse impacts on vessel traffic include, but are not limited to, the incorporation of a traffic lane through a development to facilitate safe and direct navigation through, rather than around, an Offshore Development

5. Any assent holder of an approved Offshore Development shall work with the Council when designing the proposed facility to incorporate where possible mooring mechanisms to allow safe public use of the areas surrounding the installed turbine or other structure.

6. The facility shall be designed in a manner that minimizes adverse impacts to navigation. As part of its application package, the project applicant shall submit a navigation risk assessment under the U.S. Coast Guard's Navigation and Vessel Inspection Circular 02-07, "Guidance on the Coast Guard's Roles and Responsibilities for Offshore Renewable Energy Installations."

7. Applications for projects proposed to be sited in state waters pursuant to the Ocean SAMP shall not have a significant impact on marine transportation, navigation, and existing infrastructure. Where the Council, in consultation with the U.S. Coast Guard, the U.S. Navy, NOAA, the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement, the U.S. Army Corps of Engineers, marine pilots, the R.I. Port Safety and Security Forums, or other entities, as applicable, determines that such an impact on marine transportation, navigation, and existing infrastructure is unacceptable, the Council shall require that the applicant modify the proposal or the Council shall deny the proposal. For the purposes of Chapter 7 and policies 770.1.1 to 770.2.7, impacts will be evaluated according to the same criteria used by the U.S. Coast Guard, as follows; these criteria shall not be construed to apply to any other Ocean SAMP chapters or policies:

    a. Negligible: No measurable impacts.
    b. Minor: Adverse impacts to the affected activity could be avoided with proper mitigation; or impacts would not disrupt the normal or routine functions of the affected activity or community; or once the impacting agent is eliminated, the affected activity would return to a condition with no measurable effects from the proposed action without any mitigation.
    c. Moderate: Impacts to the affected activity are unavoidable; and proper mitigation would reduce impacts substantially during the life of the proposed action; or the affected activity would have to adjust somewhat to account for disruptions due to impacts of the proposed action; or once the impacting agent is eliminated, the affected activity would return to a condition with no measurable effects from the proposed action if proper remedial action is taken.
    d. Major: Impacts to the affected activity are unavoidable; proper mitigation would reduce impacts somewhat during the life of the proposed action; the affected activity would experience unavoidable disruptions to a degree beyond what is normally acceptable; and once the impacting agent is eliminated, the

affected activity may retain measurable effects of the proposed action indefinitely, even if remedial action is taken.

Section 780. Literature Cited

Albion, R.G., Labaree, B.W., and Baker, W.A.. 1970. *New England and the Sea*. Mystic, CT: Mystic Seaport Press.

American Cruise Lines. 2009. New England Islands Eight-Day/Seven-Night Cruise. Online at: www.americancruiselines.com. Last accessed December 7, 2009.

Becker, A., A. Wilson, R. Bannon, J. McCann, C. Damon, D. Goulet, D. Robadue, and S. Kennedy (ed.). In review. *Rhode Island's Ports and Commercial Harbors: A GIS-based Inventory of Current Uses and Infrastructure*

Block Island Express. 2009. Jessica W. Online at: https://www.longislandferry.com/bif/home.htm. Last accessed December 7, 2009.

Blount, Kevin. U.S. Coast Guard Sector Southeastern New England. Personal communication, July 14, 2009.

City of Newport, Department of Economic Development. 2009. Cruise Ships. Online at: http://www.cityofnewport.com/departments/economic-development/harbor/cruise.cfm. Last accessed June 1, 2010.

Colgan, C.L. 2007. *A Guide to the Measurement of the Market Data for the Ocean and Coastal Economy in the National Ocean Economics Program.* National Ocean Economics Program, January 2007. Online at: www.oceaneconomics.org. Last accessed November 17, 2009.

Costabile, Cpt. Paul. 2009. Northeast Marine Pilots Association. Personal communication, August 31, 2009.

Costabile, Cpt. Paul. 2009. Northeast Marine Pilots Association. Personal communication, November 10, 2009.

Costabile, Cpt. Paul. 2009. Northeast Marine Pilots Association. Personal communication, November 13, 2009.

Costabile, Cpt. Paul. 2009. Northeast Marine Pilots Association. Personal communication, December 23, 2009.

Curtis, Steven. 2009. ProvPort. Personal communication, December 21, 2009.

DeBow, Sam. 2009. URI Graduate School of Oceanography. Personal communication, July 7, 2009.

Dion, M. 2009. Somerset's NRG power plant closing down. Fall River, MA:

Herald News. November 4, 2009. Online at http://www.heraldnews.com/business/x1312013989/Somersets-NRG-power-plant-closing-down.

Dominion Power. 2009. Brayton Point Power Station. Online at: http://www.dom.com/about/stations/fossil/brayton-point-power-station.jsp. Last accessed October 21, 2009.

Donovan, A. 2003. Beyond Boston Harbor – The Bay State's 'Four Ports'.*Coastlines*, 2003 edition. Massachusetts Office of Coastal Zone Management.

Energy Information Administration. 2009. State Energy Profiles: Rhode Island. Online at: http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=RI#map

Federal Energy Regulatory Committee. 2005. *Weaver's Cove LNG Project Final Environmental Impact Statement*. Available online at: http://www.ferc.gov/industries/lng/enviro/eis/2005/05-20-05-eis.asp. Last accessed October 16, 2009.

FXM Associates. 2008a. *Economic Effects of Allens Avenue Businesses*. Prepared for the Providence Working Waterfront Alliance.

FXM Associates. 2008b. *Economic Effects of the Port of Davisville, RI.* Prepared for the Quonset Development Corporation.

Global Security. 2009. Military-Newport. Online at: http://www.globalsecurity.org/military/facility/newport.htm Last accessed November 11, 2009.

Greeley-Polhemus Group, Inc. 2004. *Final Report, Task 15.1: The Economic Significance of the Navigation-Dependent Industries with the Zone of Siting Feasibility*. Rhode Island Region Long-Term Dredged Material Disposal Site Evaluation Project. Report to the U.S. Army Corps of Engineers, Contract Number DACW33-01-D-0004, Delivery Order No. 0002.

Hale, S.O.. 1998 (updated ed.). *Narragansett Bay: A Friend's Perspective*. University of Rhode Island Marine Advisory Service NOAA/Sea Grant Marine Bulletin 42.

Hall-Arber, M., Dyer, C., Poggie, J., McNally, J., Gagne, R. 2001. *New England's Fishing Communities.* Cambridge (MA): MIT Sea Grant 01-15. Available online at http://seagrant.mit.edu/cmss/.

Interstate Navigation. 2009. Schedule. Online at http://www.blockislandferry.com. Last accessed December 7, 2009.

Interstate Navigation. 2006. Sum of monthly reports, entitled "Vessel Operation Report

Statement of Freight and Passengers Carried (shallow draft traffic)," submitted to the U.S. Army Corps of Engineers in 2005.

Kellner, G. H. and J. S. Lemons. 2004. *Rhode Island, the Ocean State: An Illustrated History.* Sun Valley, CA: American Historical Press.

Kuffner, A. 2009. "Quonset lands NOAA research vessel Okeanos Explorer." Providence, RI: *Providence Journal*, April 22, 2009. Online at http://www.projo.com/business/content/BZ_QUONSET_OKEANOS_04-22-09_MDE3V96_v21.30b12ba.html.

Labaree, B. W., W. M. Fowler Jr., E. W. Sloan, J. B. Hattendorf, J. J. Safford, and A. W. German. 1998. *America and the Sea: A Maritime History.* Mystic, CT: Mystic Seaport Press.

LeBlanc, Edward. 2009. U.S. Coast Guard Sector Southeastern New England. Personal communication, November 11, 2009.

LeBlanc, Edward. 2009. U.S. Coast Guard Sector Southeastern New England. Personal communication, December 16, 2009.

LeBlanc, Edward. 2010. U.S. Coast Guard Sector Southeastern New England. Personal communication, September 15, 2010.

Marine Transportation System National Advisory Council. 2009. Marine Transportation System National Advisory Council. Online at www.mtsnac.org. Last accessed December 7, 2009.

Martin Associates. 2009. *The Local and Regional Economic Impacts of Maritime Activity at PROVPORT.* Prepared for ProvPort. June 5, 2009.

McVay, Cpt. Howard. 2009. Northeast Marine Pilots Association. Personal communication, August 31, 2009.

Matthews, Evan. 2009. Quonset Development Corporation. Personal communication, July 27, 2009.

Minerals Management Service. 2009. *Cape Wind Energy Project Final Environmental Impact Statement.* January 2009.

Myers, Cpt. Chris. 2009. Interstate Navigation Company. Personal communication, August 7, 2009.

National Oceans Economics Program. 2009. *Ocean Economy: Rhode Island*. Online at: http://www.oceaneconomics.org. Last accessed October 21, 2009.

National Ports and Waterways Institute, University of New Orleans. 2004. *The Public Benefits of the Short Sea Intermodal Shipping System*. Report prepared for the Short Sea Cooperative Program. Online at: http://advancedmaritimetechnology.aticorp.org/short-sea-shipping/Public%20Benefits%20of%20SSS%20-%20UNO.pdf. Last accessed December 7, 2009.

Naval Undersea Warfare Center (NUWC) Division Newport. 2009. NUWC Division Newport's economic impact topped half-billion mark in 2008. Press Release, January 29, 2009. Online at: http://www.navsea.navy.mil/nuwc/newport/pages/pr.aspx. Last accessed October 21, 2009.

Naval Undersea Warfare Center (NUWC) Division Newport. 2008. Naval Undersea Warfare Center Newport's economic impact topped $466 million in 2007. Press Release, January 18, 2008. Online at: http://www.navsea.navy.mil/nuwc/newport/pressroom/0208-EconomicImpact.pdf. Last accessed October 21, 2009.

Naval Undersea Warfare Center (NUWC), Division Newport. 2007. *Coastal Consistency Determination for Test Operations in Rhode Island Water*. October 2007.

Newport & Bristol Convention and Visitors Bureau. 2009. Cruise Ship Schedule. Online at http://www.gonewport.com/. Last accessed December 7, 2009.

National Oceanic and Atmospheric Administration (NOAA). 2008. Final Rule: Endangered Fish and Wildlife; Final Rule To Implement Speed Restrictions to Reduce the Threat of Ship Collisions With North Atlantic Right Whales. *Federal Register*, October 10, 2008, pg. 60173-60191.

NOAA. 1992. *Nautical Chart Manual, Volume 1, Part 1*. Seventh (1992) Edition, updated through March 2004.

NOAA National Marine Fisheries Service. n.d. Reducing Ship Strikes to North Atlantic Right Whales. Online at http://www.nmfs.noaa.gov/pr/shipstrike/. Last accessed October 30, 2009.

NOAA National Ocean Service. 2009. *United States Coast Pilot*. Volume 2, Atlantic Coast: Cape Cod, MA to Sandy Hook, NJ. 38th Edition.

NOAA Office of Coast Survey. 2009. Chart 13218: Martha's Vineyard to Block Island. Revised through October 2009.

NOAA Office of Coast Survey. 2007. Chart 13205: Block Island Sound and Approaches. Revised through February 2007.

North Atlantic Distribution (NORAD). 2009. *Highlights and Points.* Online at: http://www.noradinc.com. Last accessed December 7, 2009.

Northeast Marine Pilots Association. 2009. *The Pilot Boats*. Online at: http://www.nemarinepilots.com. Last accessed October 16, 2009.

ProvPort. 2009. *Facilities.* Online at: http://www.ProvPort.com/. Last accessed December 7, 2009.

Quonset Development Corporation. 2009. Ship Waybill Database. Accessed July 27th, 2009.

R.I. Coastal Resources Management Council (CRMC). In review. R.I. *Metro Bay Special Area Management Plan (SAMP).*

R.I. Coastal Resources Management Council. 2008. *Coastal Resources Management Program.* Amended through December 2008. Online at http://www.crmc.ri.gov/regulations/RICRMP.pdf.

R.I. Department of Environmental Management. 2009. Division of Law Enforceent Marine Unit. Online at http://www.dem.ri.gov/programs/bnatres/enforce/marine.htm. Last accessed June 1, 2010.

R.I. Economic Monitoring Collaborative. 2007. *FY07 Economic Monitoring Report.*

R.I. Public Utilities Commission. 2009. Ferry Services. Online at http://www.ripuc.org/utilityinfo/ferryservices.html. Last accessed December 7, 2009.

R.I. Senate Policy Office. 2002. *The Marine Cluster: An Investment Agenda for Rhode Island's Marine Related Economy*.

R.I. State Pilotage Commission. 2007. *Rhode Island State Pilotage Commission Annual Report Fiscal Year 2007.* R.I. Department of Environmental Management, Division of Coastal Resources Management.

Salley, Frank. 2009. Verizon. Personal communication, November 13, 2009.

Scanlon, Michael. 2009. R.I. Department of Environmental Management. Personal communication, June 17, 2009.

Seafreeze Ltd. 2009. Seafreeze, Ltd. Online at http://www.seafreezeltd.com/. Last accessed October 20, 2009.

Smith, Evan. 2009. Newport & Bristol County Convention and Visitors Bureau. Personal communication, July 16, 2009.

Tegg, Martin. 2009. Reliance Globalcom. Personal communication, November 16, 2009.

Tompsett, Chris. 2009. Naval Undersea Warfare Center Division Newport. Personal communication, November 10, 2009.

Tompsett, Chris. 2009. Naval Undersea Warfare Center Division Newport. Personal communication, November 25, 2009.

U.S. Army Corps of Engineers, 2007. *Waterborne Commerce of the United States: Calendar Year 2007, Part 1– Waterways and Harbors Atlantic Coast*. WR-WCUS-07-1. Online at: http://www.ndc.iwr.usace.army.mil. Last accessed October 16, 2009.

U.S. Army Corps of Engineers. 2006. *Waterborne Commerce of the United States: Calendar Year 2006, Part 1– Waterways and Harbors Atlantic Coast*. WR-WCUS-06-1. Online at: http://www.ndc.iwr.usace.army.mil. Last accessed October 16, 2009.

U.S. Army Corps of Engineers. 2001. *Providence River and Harbor Maintenance Dredging Project Final Environmental Impact Statement.* U.S. Army Corps of Engineers, New England District, August 2001.

U.S. Army Corps of Engineers. 1998. *Providence River and Harbor Maintenance Dredging Project Draft Environmental Impact Statement*. U.S. Army Corps of Engineers, New England District, October 1998.

U.S. Army Corps of Engineers. 1997. *Waterborne Commerce of the United States: Calendar Year 1997, Part 1- Waterways and Harbors Atlantic Coast*. Online at http://www.ndc.iwr.usace.army.mil. Last accessed October 16, 2009.

U.S. Army Corps of Engineers. n.d. Rhode Island Sound Disposal Site. Disposal Area Monitoring System (DAMOS)

U.S. Coast Guard. 2009. About Us. Online at http://www.uscg.mil/top/about. Last accessed December 7, 2009.

U.S. Coast Guard. 2008. *Vessel Requirements for Notices of Arrival and Departure, and Automatic Identification System.* Notice of proposed rulemaking published in the Federal Register, December 16, 2008.

U.S. Coast Guard. 2006. *U.S. Coast Guard Captain of the Port Long Island Sound Waterways Suitability Report for the Proposed Broadwater Liquefied Natural Gas Facility.*

U.S. Department of Homeland Security. 2008. FY 2008 Infrastructure Protection Activities. Online at

http://www.dhs.gov/xlibrary/assets/fy2008_infrastructure_protection_activities.pdf. Last accessed December 23, 2009.

U.S. Navy. 2009. Naval Station Newport: History. Online at https://www.cnic.navy.mil/Newport/AboutCNIC/GeneralInformation/index.htm. Last accessed December 2, 2009.

Viking Fleet, 2009. Ferries. Online at www.vikingfleet.com. Last accessed December 7, 2009.

Vincent, Bud. 2009. University of Rhode Island Graduate School of Oceanography. Personal communication, November 12, 2009.

Vineyard Fast Ferry. 2009. About the Martha's Vineyard Fast Ferry. Online at: http://www.vineyardfastferry.com. Last accessed December 7, 2009.

Wargo, Robert. 2009. AT&T. Personal communication, November 13, 2009.

Wargo, Robert. 2009. AT&T. Personal communication, November 19, 2009.

Waterson Terminal Services. 2008. Presentation to Providence Waterfront Charrette, June 9, 2008, Providence, Rhode Island. Available online at: www.watersonllc.com. Last accessed October 22, 2009.

Weaver's Cove Energy LLC. 2009. *United States Coast Guard Waterway Suitability Assessment for Weaver's Cove.* Redacted Version.

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Section 800. Introduction

1. One of the objectives of the Ocean SAMP is to encourage marine-based economic development that considers the aspirations of local communities, and is consistent with and complementary to the state's overall economic development, social, and environmental needs and goals.

2. Obtaining a portion of Rhode Island's energy from renewable sources has been a central theme in the recent energy policies of the state.[1] The justification behind renewable energy development in Rhode Island includes: diversifying the energy sources supplying electricity consumed in the state; stabilizing long-term energy prices; enhancing environmental quality, including the reduction of air pollutants and greenhouse gas emissions; reducing the state's reliance on fossil fuels; and creating jobs in Rhode Island in the renewable energy sector. Renewable energy resources offshore have the greatest potential for utility-scale development to meet Rhode Island's renewable energy goals. The Ocean SAMP area has the potential to provide sites for those resources, which is addressed in this chapter, along with a discussion of the potential effects renewable energy development may have on the economics of Rhode Island, natural resources, and existing uses of the Ocean SAMP area.

3. The objectives of this chapter are to: (1) provide an overview of renewable energy resources, and existing statutes, standards and initiatives in Rhode Island; (2) identify what offshore renewable resources in the Ocean SAMP area have the potential for utility-scale energy generation; (3) describe utility-scale offshore wind energy technology and stages of development; (4) identify areas within the Ocean SAMP area with the greatest potential to support utility-scale development; (5) delineate a Renewable Energy Zone within state waters of the Ocean SAMP area; (6) summarize the current understanding of the potential economic and environmental effects of offshore renewable energy and; (7) outline CRMC policies and regulatory standards for offshore renewable energy and other offshore development in the Ocean SAMP area.

4. CRMC's authority to plan for the future of energy facilities in the coastal zone is defined in the CRMC's 1978 Energy Amendments, which apply federal regulations governing approved coastal management programs (15 CFR 923 *et. seq.*). As stated in the 1978 Energy Amendments, the CRMC is required to identify and develop a planning process for energy facilities that are likely to be located in, or which may significantly affect, the coastal zone. This planning process must include procedures for assessing the suitability of sites for energy development, as well as policies and techniques to manage energy facilities and their anticipated impacts. The Ocean SAMP has been developed consistent with this authority.

5. This chapter is not meant to be a state energy plan, as such plans are developed by the Rhode Island Statewide Planning Program and the Office of Energy Resources. Furthermore, this chapter does not focus on any one particular proposed project; rather it examines the potential for offshore renewable energy as one future use of the Ocean SAMP area. Any specific offshore renewable energy project will be examined

[1] R.I. Gen. Law § 39-26-1 et seq.; R.I. Gen. Law § 42-141-3; Rhode Island State Guide Plan Section 781.

specifically during the application process, outlined in Section 860. Moreover, the environmental impacts of any proposed offshore renewable energy project will be reviewed and evaluated under the National Environmental Policy Act (NEPA).

Section 810. Renewable Energy Overview

810.1. Increasing Energy Demands and Global Climate Change

1. Demand for electricity in the region and the nation as a whole is projected to increase in the coming decades. For example, the most recent forecast by the U.S. Energy Information Administration estimates that annual electricity consumption in the United States will increase from 3,873 terawatt-hours (TWh) in 2008 to 5,021 TWh in 2035. This increase represents a 29% increase in demand, requiring an additional 1,148 TWh of production by 2035 (U.S. Energy Information Administration 2010).[2] To help put this increased energy demand in perspective, 1,148 TWh is enough energy to power over 100 million residential homes for a year.[3] Likewise, the Independent System Operator New England (ISO-NE) forecasts that the overall annual electricity usage of New England will increase by 10,810 GWh between 2009 and 2018, from current levels of 131,315 GWh to 142,125 GWh (see Table 8.1). Rhode Island accounts for a portion of this increase in energy within the region, as ISO-NE predicts that total electricity use will increase from 8,460 GWh in 2009 to 9,025 GWh in 2018, requiring an additional 565 GWh of energy production to meet anticipated annual electricity needs (see Table 8.1). The largest increase in peak loads is projected during the summer months, when an additional 235 MW of production capacity is expected to be required to meet the 2018 summer demand (ISO New England Inc. 2009a). Increases in energy efficiency, or efforts to decrease energy consumption may lower the amount of energy required in the future (see Section 810.2 for a discussion of Rhode Island legislation dealing with energy efficiency). However, if these projections are accurate and demand continues to rise into the future, New England will require greater generation capacity to meet the region's need for electricity.

[2] The capacity of an electric generating unit and the load for electricity use is measured in watts; 1,000 watts is equal to a *kilowatt* (kW), a *megawatt* is 1,000 kWs (MW, 1 million watts), a *gigawatt* is 1,000 MW (GW, 1 billion watts), and a *terawatt* is 1,000 GW (TW, 1 trillion watts). These terms are most commonly used to describe the capacity of an electric generator (e.g. a wind turbine or a power plant). Electricity production and consumption are most commonly measured in *kilowatt-hours (kWh).* A kilowatt-hour refers to one kilowatt (1,000 watts) of electricity produced or consumed for one hour of time; similarly 1,000 kilowatt-hours is a *megawatt-hour (MWh)*,1,000 megawatt-hours is a *gigawatt-hour* (GWh), and 1,000 gigawatt-hours is a *terawatt-hour* (TWh).

[3] This estimate is based on the Energy Information Administration statistic that in 2007, the average monthly residential electricity consumption equaled 936 kWh, which equals 11.2 MWh per year.

Table 8.1. Summary of forecasted annual and peak energy loads for New England states (ISO New England Inc. 2009a).

	Net Energy for Load* (GWh)			Summer Peak Loads (MW)			Winter Peak Loads (MW)		
	2009	2018	Difference	2009	2018	Difference	2009	2018	Difference
CT	32,710	33,850	1,140	7,500	8,105	605	5,715	5,765	50
ME	11,755	12,610	855	2,075	2,325	250	1,915	1,930	15
MA	60,420	67,095	6,675	12,925	14,455	1,530	10,030	10,505	475
NH	11,660	12,925	1,265	2,450	2,815	365	2,020	2,160	140
RI	**8,460**	**9,025**	**565**	**1,850**	**2,085**	**235**	**1,395**	**1,440**	**45**
VT	6,310	6,625	315	1,075	1,180	105	1,035	1,060	25
Total New England	131,315	142,125	10,810	27,875	30,960	3,085	22,100	22,860	760
* The Net Energy for Load shown in the table is the net generation output within an area, accounting for electric energy imports from other areas and electric energy exports to other areas.									
Note: for Summer and Winter Peak Loads, the "reference" or 50/50 forecasted value was used.									

2. Currently, fossil fuels supply over 70% of the generating capacity for electricity in New England (see Figure 8.1). Natural gas and oil are the primary fuels, accounting for more than 60% of the existing capacity. Nearly all (99.5%) generating capacity in Rhode Island is fueled by burning natural gas (ISO New England Inc. 2009b). Gas-fired electrical generating facilities in Rhode Island are located in Burrillville, Providence, Tiverton and Johnston (Rhode Island Office of Energy Resources 2010).

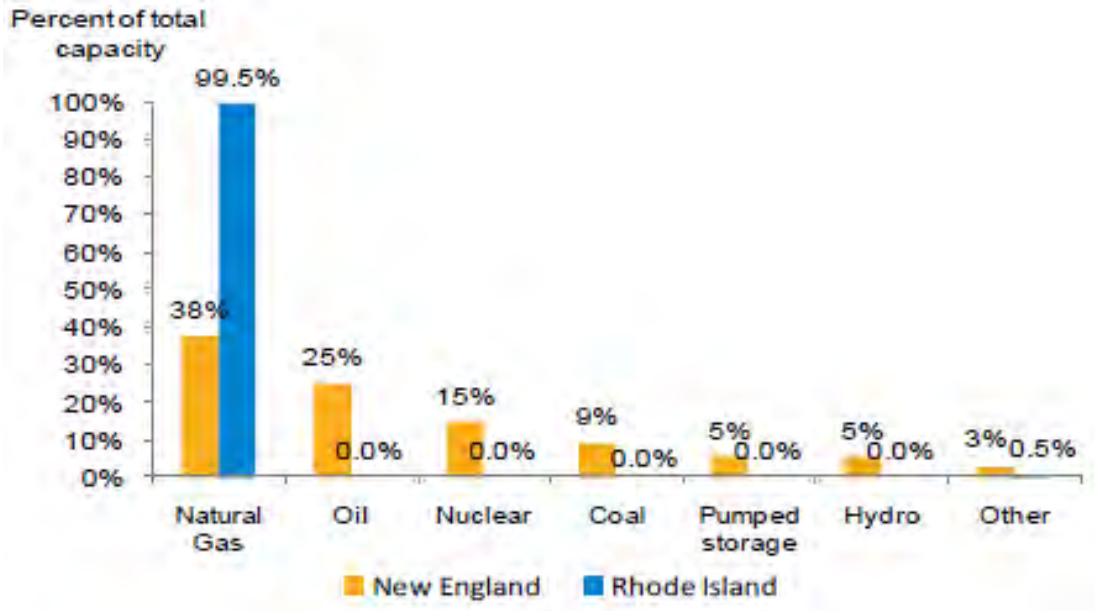


Figure 8.1. Fuel sources used for electricity generation in New England and Rhode Island (ISO New England Inc. 2009b).

3. It is important to note that the energy generated in Rhode Island does not directly supply the energy needs of the state, rather it is fed into the regional electric grid operated by ISO-NE and then distributed to consumers by a distributer. In Rhode Island, National Grid provides electrical transmission and distribution services to approximately 99% of residents, the main exception being the residents of Block Island who are not currently integrated into the regional utility grid (see below for further discussion). National Grid procures the electricity it supplies to Rhode Island from multiple sources; for the period July 1, 2007 to June 30, 2008 the mix was as follows: natural gas (31.4%), nuclear (27.5%), imported electricity (12.4%), coal (11.2%), hydro power (4.7%), oil (3.8%); a diversity of other sources provided the remaining nine percent (9%), see Figure 8.2 (Rhode Island Office of Energy Resources 2010).[4]

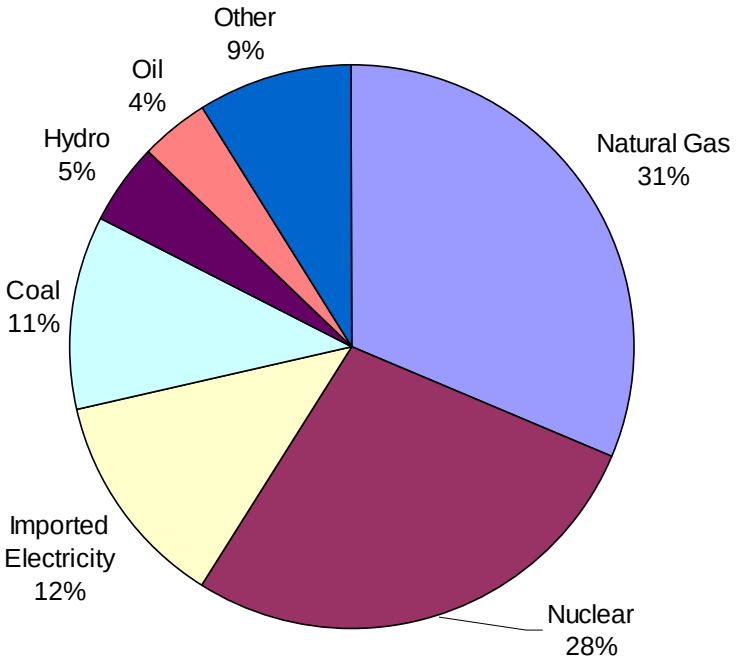


Figure 8.2. Energy sources supplying Rhode Island electricity demand from July 1, 2007, to June 30, 2008 (National Grid data cited in Rhode Island Office of Energy Resources 2010).

4. Natural gas is not an energy resource indigenous to New England, and therefore must be brought into the region by interstate natural gas pipelines from other states in the Northeast, Texas and Louisiana, the Trans-Canada pipeline from Canada into New York and Vermont, and by the offshore buoy-based offshore LNG receiving facilities Northeast Gateway Deepwater Port located off the coast of Massachusetts (U.S. Energy Information Administration 2009; U.S. Department of Energy 2004; Rhode Island Office of Statewide Planning 2002; Excelerate 2010).[5] Petroleum products, home heating oil and transportation fuels, as well as some liquefied petroleum gas are supplied to Rhode Island

[4] Electricity providers do programs for consumers to voluntarily pay a premium to obtain electricity from renewable sources. For example, National Grid in Rhode Island offers the GreenUp program, allowing consumers to request that all or part of their electricity come from renewable sources.

[5] A second offshore LNG facility, Neptune LNG LLC is currently under construction and is expected to be online during 2010. This facility will also provide natural gas to the regional pipeline (GDF Suez Energy North America 2010).

through the Port of Providence, which is a sub-regional center for the distribution of these fuels (see Chapter 7, Marine Transportation, Navigation and Infrastructure for further information). See Chapter 9, Other Future Uses, for further discussion of the potential future transport of natural gas through the Ocean SAMP area.

5. The ISO-NE has stated that over-reliance on natural gas subjects the New England region to substantial price fluctuations that are influenced by a variety of market-based factors (i.e. exercising of natural gas contractual rights, tight gas spot-market trading), and technical factors (i.e. pipeline maintenance requirements and limited pipeline capacity) (ISO New England Inc. 2005). The U.S. Department of Energy (2004) also recognized the region's need for increased energy diversity and suggesting renewable energy development as a possible solution: "To alleviate New England's volatile energy market and reduce its over-reliance on natural gas, the region needs to pursue an energy policy that is focused on fuel diversity. Increased use of renewable energy will enable New England to diversify the region's energy portfolio, thereby increasing electric reliability and lowering energy costs by utilizing local resources in the generation of electricity" (U.S. Department of Energy 2004, 1). Moreover, in the Cape Wind Energy Project Final Environmental Impact Statement (Cape Wind FEIS), the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE, formerly the Minerals Management Service) stated that: "Over-reliance on natural gas and other fossil fuel sources (e.g. coal) for the generation of electricity also subjects the region to adverse air quality impacts associated with ground level ozone. There is, therefore, a need for projects in New England that aid in diversifying the region's energy mix in a manner that does not significantly contribute to the region's existing air quality concerns" (MMS 2009a, 1-2). In addition to ozone concerns, increasing energy production through the burning of fossil fuels adds to greenhouse gas emissions. Today, CO_2 emissions in the United States approach 6 billion metric tons annually, 39% of which are produced when electricity is generated from fossil fuels (U.S. Department of Energy 2008; U.S. Energy Information Administration 2008a). Refer to Chapter 3, Global Climate Change for further discussion on CO_2 emissions and the impacts of increased greenhouse gas emissions. See also Section 850.1 for further discussion of renewable energy development and avoided air emissions.

6. Block Island is not currently connected to the mainland utility grid that supplies electricity to the rest of Rhode Island. Instead, the island generates its energy using diesel-powered generators operated by the Block Island Power Company. The fuel is transported by truck aboard the Block Island Ferry (see Chapter 7, Marine Transportation, Navigation and Infrastructure), and stored in four 20,000 gallon (75,708 liter) storage tanks located on the island. In 2006, the Block Island Power Company used almost 950,000 gallons (3.6 million liters) of #2 fuel oil to meet the energy demands of Block Island (HDR Engineering Inc. 2007). Currently, there are five generating units, with a total generating capacity of approximately 7.3 MW (HDR Engineering Inc. 2007). As of 2007, Block Island Power Company served a total of 1,742 customers, who use a total of approximately 10.7 GWh of electricity. Based upon the seasonal nature of tourism and island living, the loads on the island vary greatly between winter and summer months. In the summer, peak demand may reach 4MW as a result of all the businesses operating and the large number of visitors. In comparison, the winter peak demand is much lower, measuring approximately 1.5 MW. Rates on Block Island are the highest in Rhode Island

and the region as a whole. Rates generally hover between 30 cents and 40 cents a kilowatt-hour, but in the summer of 2008 it went as high as 62 cents (Rhode Island Public Utilities Commission 2010b), compared to an average electricity rate in Rhode Island of 17.4 cents per kWh (U.S. Energy Information Administration 2010). Given the use of diesel and its fluctuating market costs, Block Island Power Company includes a fuel adjustment charge within its rates to cover the carrying costs of fuel (HDR Engineering Inc. 2007). See Section 840.2 for more information.

810.2. Renewable Energy Statutes, Initiatives and Standards in Rhode Island

1. Developing renewable energy in Rhode Island is one option to help meet the increasing demand for energy, to add to the energy mix of the state and to also help mitigate the effects of global climate change by reducing the amount of greenhouse gases emitted into the atmosphere from energy production. Legislation and initiatives adopted in Rhode Island, including the Renewable Energy Standard[6], the Systems Reliability and Least-Cost Procurement Act[7], the Regional Greenhouse Gas Initiative (RGGI), and the Long-Term Contracting Standard for Renewable Energy[8] recognize the need for greater diversification of the state's energy resources and a commitment to renewable energy development in the state.

2. Enacted in 2004, the Renewable Energy Standard (RES) mandates a minimum share of electricity generation within the state come from renewable sources. As stated within the RES: "It is in the interest of the people, in order to protect public health and the environment and to promote the general welfare, to establish a renewable energy standard program to increase levels of electric energy supplied in the state from renewable resources" (R.I.G.L. 39-26). Specifically, Rhode Island's RES has the goals of (i) diversifying the energy sources supplying electricity consumed in the state, (ii) stabilizing long-term energy prices, (iii) enhancing environmental quality, including the reduction of air pollutants, carbon dioxide emissions, that adversely affect public health and contribute to global warming, and (iv) creating jobs in Rhode Island in the renewable energy sector.

3. Twenty-nine other states, plus the District of Columbia, have enacted similar standards (see Figure 8.3 and Table 8.2). Under these standards, electricity retailers must meet a certain percentage of total energy production from renewable sources through the use of Renewable Energy Credits (RECs). Energy retailers can obtain RECs by: (i) generating renewable energy themselves, (ii) purchasing energy from a renewable energy producer, or (iii) buying credits from a renewable energy producer without purchasing the electricity from them directly (Redlinger et al. 2002).

[6] R.I. Gen. Law § 39-26-1 et seq.
[7] R.I. Gen. Law § 39-1-27.7
[8] R.I. Gen. Law § 39-26.1-1.

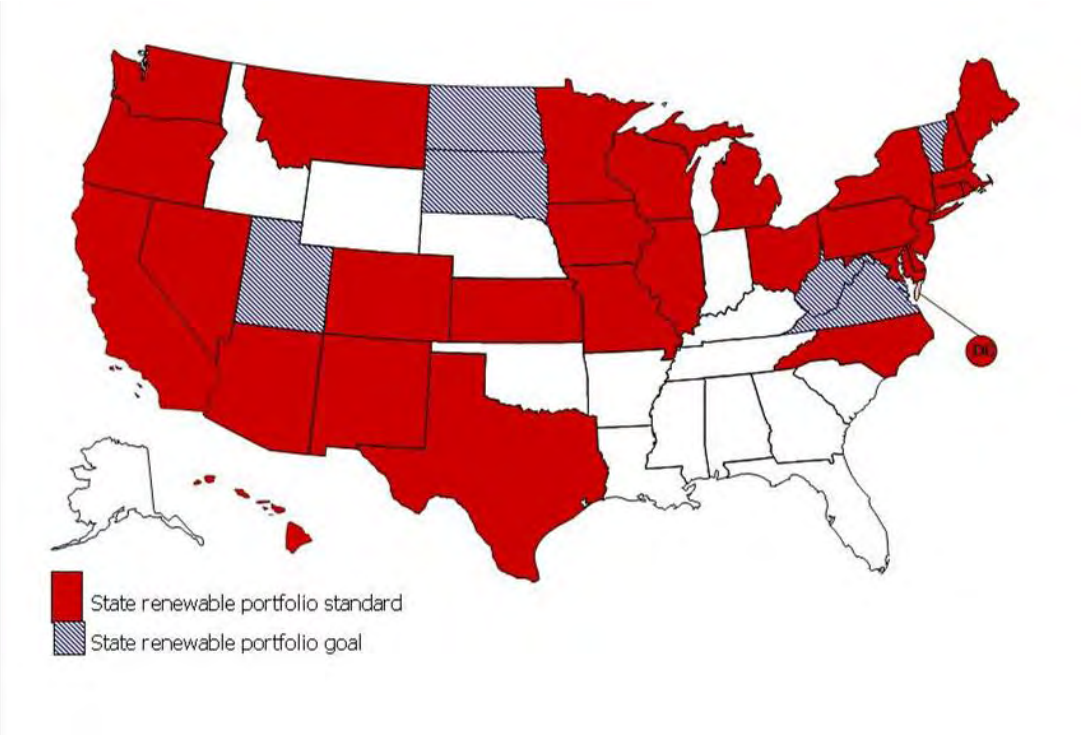


Figure 8.3. U.S. states with renewable energy standards (DSIRE 2010).

Table 8.2. Summary of all state renewable energy standards (DSIRE 2010).

State	Amount	Year
Arizona	15%	2025
California	33%	2030
Colorado	20%	2020
Connecticut	23%	2020
District of Columbia	20%	2020
Delaware	20%	2019
Hawaii	20%	2020
Iowa	105 MW	
Illinois	25%	2025
Massachusetts	15%	2020
Maryland	20%	2022
Maine	40%	2017
Michigan	10%	2015
Minnesota	25%	2025
Missouri	15%	2021
Montana	15%	2015
New Hampshire	23.8%	2025
New Jersey	22.5%	2021
New Mexico	20%	2020
Nevada	20%	2015
New York	24%	2013
North Carolina	12.5%	2021
North Dakota*	10%	2015
Oregon	25%	2025
Pennsylvania	8%	2020
Rhode Island	16%	2019
South Dakota*	10%	2015
Texas	5,880 MW	2015
Utah*	20%	2025
Vermont*	10%	2013
Virginia*	12%	2022
Washington	15%	2020
Wisconsin	10%	2015

4. Rhode Island's Renewable Energy Standard, enacted in June 2004, requires electric utility providers within the state to supply 16% of their retail sales from renewable resources by the end of 2019. The target began at 3% by the end of 2007, increasing by an additional 0.5% per year through 2010, an additional 1% per year from 2011 through 2014, and an additional 1.5% per year from 2015 through 2019 (see Figure 8.4 and Table 8.3). In 2020, and in each year thereafter, the minimum renewable energy target established in 2019 must be maintained unless the Rhode Island Public Utilities Commission determines that the standard is no longer necessary. Electric distributors may meet these targets by purchasing certificates from approved renewable energy generators, paying Alternative Compliance Credits to the Rhode Island Renewable Energy Development Fund (equal to $60.92/MWh in 2009), or a combination of both (Rhode Island Public Utilities Commission 2009; DSIRE 2010). If renewable energy credits are purchased, the Renewable Energy Standard requires that a certain percentage come from new sources

(see Table 8.3). In addition, the legislation that created Rhode Island's Renewable Energy Standard also directed the Rhode Island State Energy Office to authorize the Rhode Island Economic Development Corporation to integrate and coordinate all renewable energy policies within the state to maximize their impact.

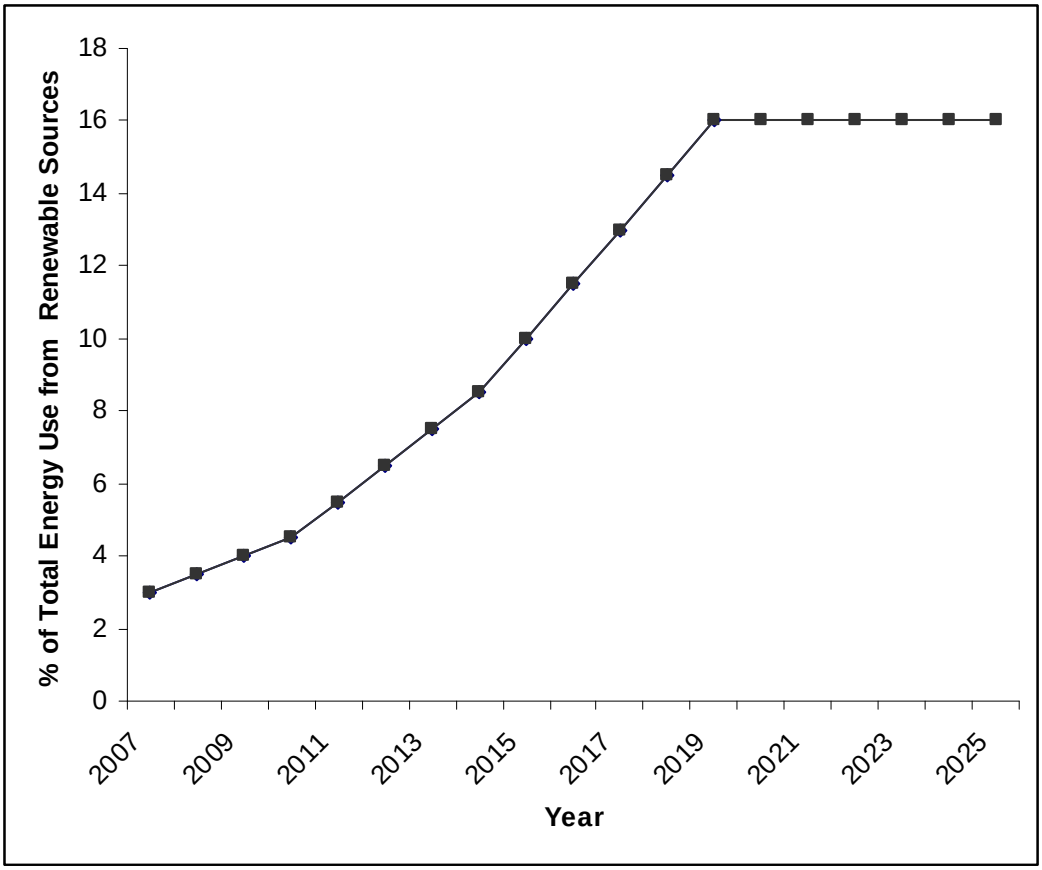


Figure 8.4. Renewable energy targets under the Rhode Island Renewable Energy Standard, 2007-2020.

Table 8.3. Renewable energy targets under the Rhode Island Renewable Energy Standard 2007-2020 (Rhode Island Public Utilities Commission 2010b).

Year	Total Target Percentage	Minimum Percentage of Target that must be obtained from New Renewable Energy Sources	Actual* or Forecasted Amount of New Renewable Energy Needed to Satisfy RES Requirements (MWh)
2007	3.0	1.0	83,357*
2008	3.5	1.5	124,190*
2009	4.0	2.0	168,389
2010	4.5	2.5	212,064
2011	5.5	3.5	299,097
2012	6.5	4.5	387,174
2013	7.5	5.5	476,416
2014	8.5	6.5	566,822
2015	10.0	8	701,509
2016	11.5	9.5	838,113
2017	13.0	11	976,318
2018	14.5	12.5	1,116,434
2019	16.0	14	1,258,274
2020 and thereafter	16.0	14	1,266,191

5. In 2008, only 8% of the new renewable energy credits used to meet the Renewable Energy Standard originated from sources within Rhode Island (Rhode Island Public Utilities Commission 2010b). The majority of the new renewable energy generation being used to meet the 2007 and 2008 target is located in New Hampshire and New York (see Figure 8.5).

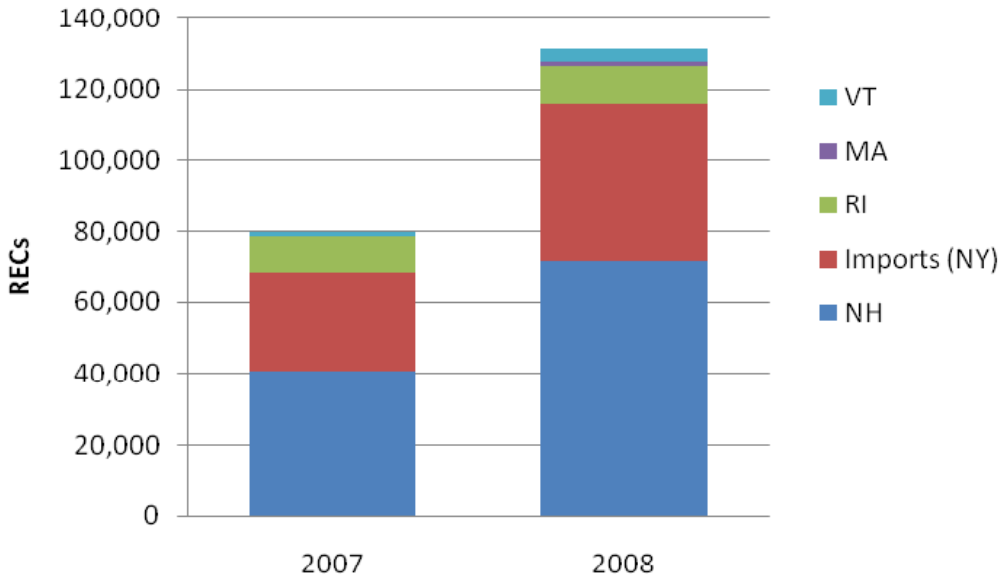


Figure 8.5. Contribution of new renewable energy generation used to meet the Rhode Island Renewable Energy Standard in 2007 and 2008 (Rhode Island Public Utilities Commission 2010b).

6. Over the next decade, the requirements for new renewable energy sources to meet Rhode Island's Renewable Energy Standard will increase (see Table 8.3). Similarly, the demand for renewable energy generation in the region will increase as a result of the targets set by other states in New England (see Figure 8.6). As a result of this increasing demand for renewable energy credits, development of renewable energy facilities will be necessary. Alternatively, if there is not a sufficient amount of renewable energy generation to fulfill the targets, energy distributors will be required to make payment into the appropriate state renewable energy fund.

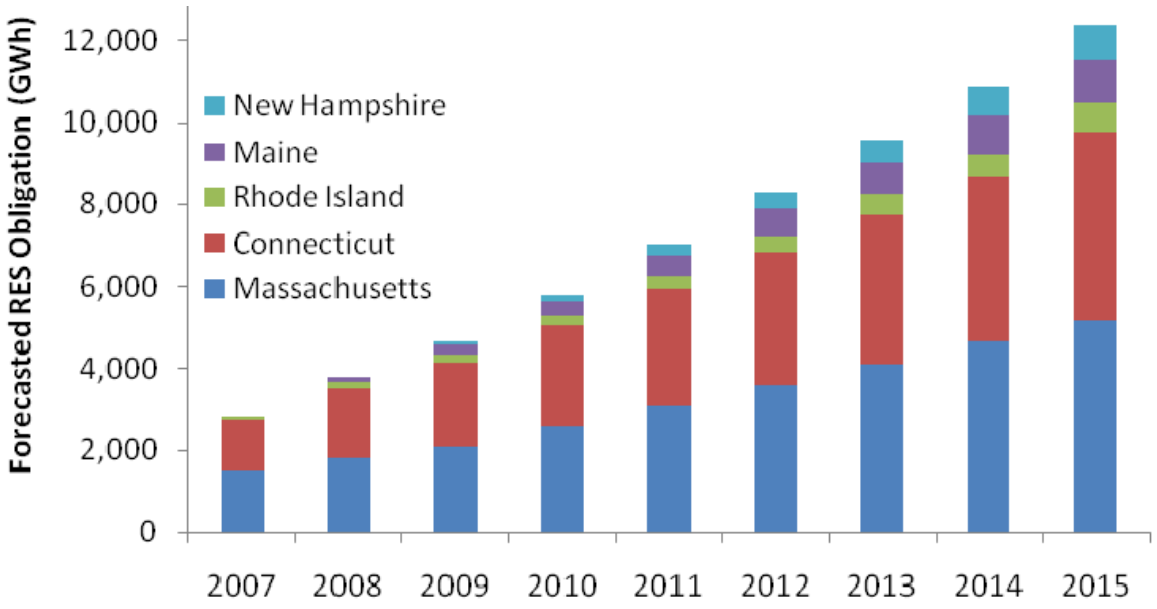


Figure 8.6. Projection of the demand for new renewable energy needed to meet the renewable energy targets set by all New England states (Rhode Island Public Utilities Commission 2010b).

7. In 2006, Rhode Island then adopted the System Reliability and Least-Cost Procurement Act requiring the Rhode Island Public Utilities Commission to establish standards and guidelines related to energy diversification (system reliability procurement) and energy efficiency and conservation (least-cost procurement). System reliability procurement refers to increasing the diversity in Rhode Island's energy portfolio, by diversifying the energy supply to include sources such as renewable energy. Least-cost procurement refers to using energy efficiency and energy conservation measures that are prudent and reliable when such measures are lower cost than the acquisition of additional supply. Moreover, under this legislation, each electrical distribution company must submit plans for how the company plans to reach the standards and guidelines outlined by the Rhode Island Public Utilities Commission. This plan (which must be updated every three years) must include measurable goals and targets for multiple criteria including efficiency and renewable energy.

8. Following the enactment of the RES and the System Reliability and Least-Cost Procurement Act, in 2007 Rhode Island entered into the Regional Greenhouse Gas Initiative (RGGI). RGGI is an agreement among ten Northeastern and Mid-Atlantic States (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Jersey, New Hampshire, New York, Rhode Island and Vermont) to reduce greenhouse gas emissions from power plants. Participating States have committed to cap and then reduce the amount of carbon dioxide that certain power plants are allowed to emit, limiting the region's total contribution to atmospheric greenhouse gas levels. This initiative is implementing the first mandatory cap-and-trade program in the United States to reduce greenhouse gas emissions (RGGI 2010). Beginning in 2011, RGGI will limit the total amount of CO_2 emissions from conventional fossil-fuel power plants in all ten states to an amount called the "cap," currently set at 188 million tons of CO_2 per year (RGGI 2010). While there is no limit on the amount of CO_2 that any particular power plant can emit, the combined CO_2 emissions

from all covered power plants within the region cannot exceed this cap. Under this system, every regulated power plant is required to own one permit (called an "allowance") for each ton of CO_2 that it emits. Allowances can be traded within a market, at any time before a compliance deadline, though the individual states control the total number of allowances available within their state to guarantee that the cap is not exceeded (RGGI 2010).

9. The most recent piece of legislation enacted within Rhode Island regarding renewable energy is the Long-Term Contracting Standard for Renewable Energy that was signed into law in 2009. Under this act energy distributors in Rhode Island (i.e. National Grid) are required to sign 10- to 15-year contracts to buy a minimum of 90 MW of its electricity load from renewable developers and up to 150 megawatts from utility-scale offshore wind energy facilities developed off the coast of Rhode Island.[9] These long-term contracts, referred to as Power Purchase Agreements, outline how much, and at what price, energy from a renewable energy producer will be purchased by a utility company. Power purchase agreements provide assurances to developers that the power produced by a project will be purchased at a stated price, which may in turn aid a developer in obtaining financing for a project. In addition, power purchase agreements define the purchase price of the renewable energy over many years, allowing utility companies to identify energy costs from the renewable source well in advance.

10. This body of existing laws and initiatives recognizes the importance of renewable energy development and energy diversification in Rhode Island, as well as the importance of reducing greenhouse gas emissions that contribute to global climate change. Given the commitment Rhode Island has exhibited to renewable energy through the passage of these laws and initiatives, the following section examines what sources of renewable energy hold the greatest potential for future development.

810.3. Renewable Energy Sources in Rhode Island

1. The U.S. Department of Energy has defined renewable energy as 'energy derived from natural sources that replenish themselves over short periods of time' (U.S. Department of Energy et al. 2004, 4). These resources include the sun, wind, moving water, organic plant and waste material (biomass), and the earth's heat (geothermal). Landfill gas (LFG) (i.e., the gas that results from decomposition in landfills and is collected, cleaned, and used for generation or is vented or flared) is also often regarded as a renewable resource (U.S. Department of Energy et al. 2004). In Rhode Island not all of these sources of renewable energy are capable of supporting utility-scale energy projects. Therefore, in order to determine which type of renewable energy technology can best meet the renewable energy goals of the state, the resource potential must be examined.

2. Energy from the sun may be converted to other more usable energy forms through a variety of demonstrated solar technologies including thermal and photonic systems. Solar thermal technologies first convert solar energy to heat (such as heating water for residential or commercial use), whereas solar photonic technologies directly absorb solar photons (i.e. particles of light that act as individual units of energy) converting photon

[9] R.I. Gen. Law §39-26.1

energy to electricity through the use of a photovoltaic [PV] cell. Resource assessments performed by the U.S. National Renewable Energy Laboratory (see Figure 8.7) suggest that the highest concentrations of solar energy in the U.S., with the potential to power large-scale electric generation facilities, are located in the southwest sections of the country. Average annual photovoltaic solar radiation for Rhode Island and the New England region range between 4 to 5 kWh per square meter per day; 6 kWh per square meter per day has been used as the screening criteria to eliminate marginal and less desirable solar energy sites (U.S. Department of the Interior Bureau of Land Management and U.S. Department of Energy, Energy Efficiency and Renewable Energy 2003). As stated by the Rhode Island State Energy Plan: "Rhode Island is in a more northerly latitude, is low in elevation, and is frequently overcast or cloudy; these circumstances militate against solar power, in the form of photo-voltaics, as means of meeting electric demand at a utility scale in a manner that is cost-effective. Solar thermal energy, for example to heat hot water, is justifiable for residential and commercial applications, dependent on site conditions" (Rhode Island Office of Energy Resources 2010, 5). Therefore, while solar energy in Rhode Island may not currently be a cost-effective means of generating utility scale renewable energy, residential and small scale commercial use of solar thermal and photo-voltaic energy may be feasible, depending on site-specific conditions.

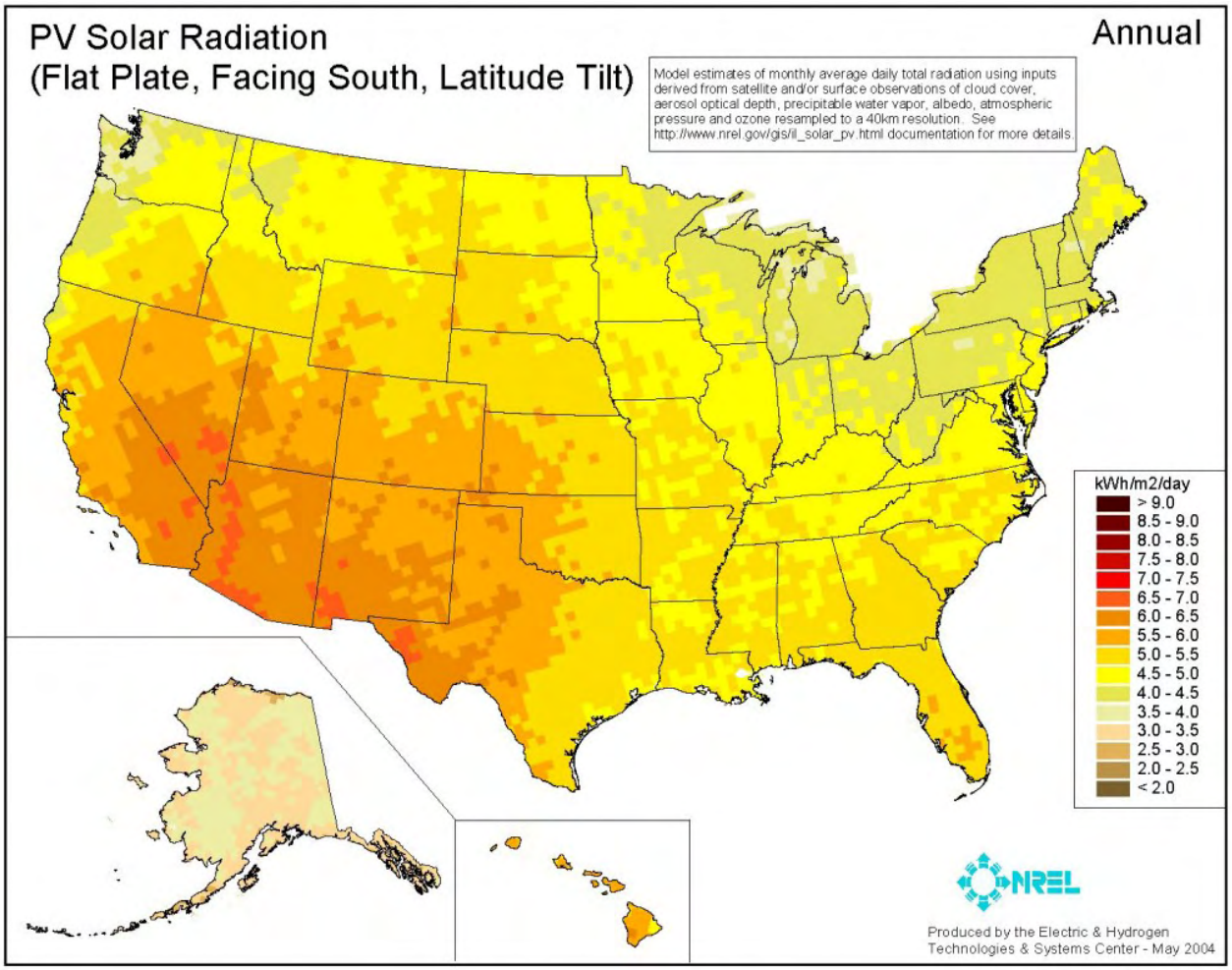


Figure 8.7. Average annual photovoltaic solar radiation in the United States (National Renewable Energy Laboratory 2004).[10]

3. Geothermal energy is energy derived from the natural heat within the earth. For commercial use, a high temperature geothermal reservoir (greater than 150°C [302°F]) capable of providing hydrothermal (hot water and steam) resources is necessary. These geothermal reservoirs are located in areas of the country where the earth's naturally occurring heat flow is near enough to the earth's surface to bring steam or hot water to the surface (U.S. Department of Energy 2010a). A map of the geothermal resources in the United States below shows the estimated subterranean temperatures at a depth of 6 kilometers (3.73 miles) (see Figure 8.8). Areas that have the greatest resource potential for utility-scale energy production include the Geysers Region in Northern California, the Imperial Valley in Southern California, and the Yellowstone Region in Idaho, Montana, and Wyoming (Idaho National Laboratory 2010). In Rhode Island, temperatures 6 km (3.73 miles) below the surface range between 100°C and 150°C (212°F and 302°F). Therefore, geothermal energy has the potential for small-scale commercial and residential

[10] These maps provide monthly average daily total solar resource information on grid cells of approximately 40 km by 40 km in size. The insolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal to equal to the latitude of the collector location.

applications, but not as a utility-scale source for electrical generation (Rhode Island Office of Energy Resources 2010).

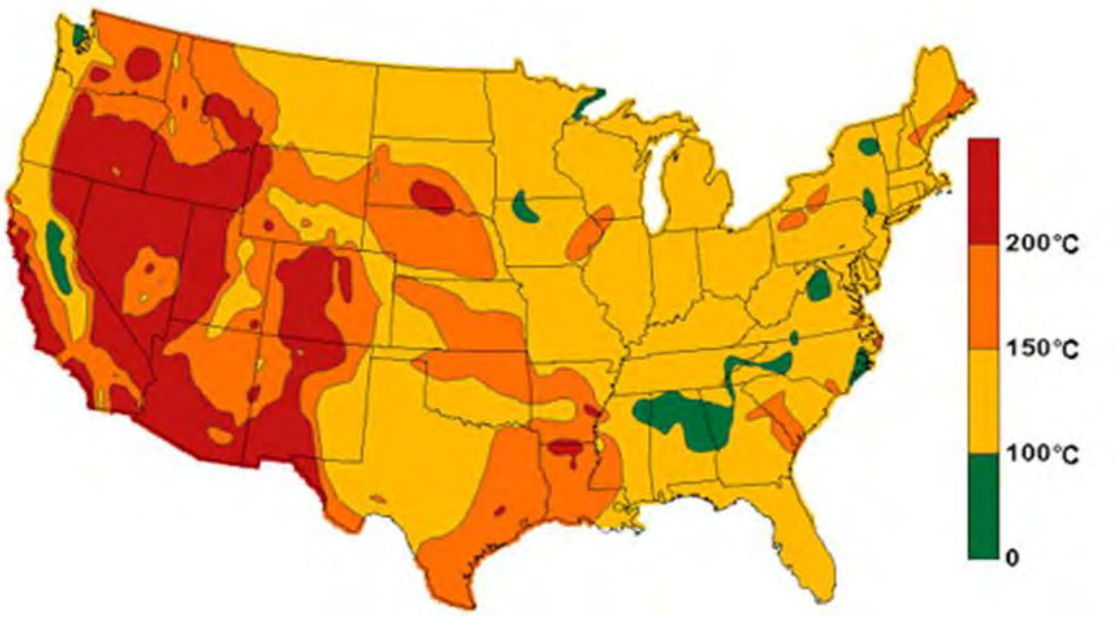


Figure 8.8. U.S. geothermal resource map at a depth of 6 km (U.S. Department of Energy 2010a).[11]

4. A related process called Ocean Thermal Energy Conversion (OTEC) uses the heat energy stored in the earth's oceans to generate electricity. OTEC is a viable renewable energy source in areas where the thermal gradient between the surface and a depth of 1,000 meters (0.62 miles) is at least 22°C (71.6° F) (Pelc and Fujita 2002). This technology has the greatest potential for energy production in tropical coastal areas, roughly between the Tropic of Capricorn and the Tropic of Cancer (U.S. Department of Energy 2010b). The difference in temperature between the surface and bottom waters in the Ocean SAMP area range between approximately 0-2°C (32-36°F) in the winter months and 10°C (50°F) in the summer months (Codiga and Ullman 2010a; 2010b; 2010c). As a result, OTEC technology is not a viable alternative energy source for Rhode Island. For more information on the water temperature in the Ocean SAMP area see Chapter 2, Ecology of the SAMP Region.

5. Wave energy uses energy of moving waves to generate electricity. The greatest potential for wave energy exists where the strongest winds and larger fetch are found, which in general corresponds to temperate latitudes between 40° and 60° north and south (Pelc and Fujita 2002). Furthermore, because global winds tend to move west to east across ocean basins, wave resources on the eastern boundaries of oceans also tend to be greater than those on the western edges since the fetch, or the distance a wave travels, is longer (Pelc and Fujita 2002; Musial 2008a) (see Figure 8.9). Therefore, in the U.S. the greatest

[11] To determine the Earth's internal temperature at any depth below the capabilities of normal well drilling, multiple data sets are synthesized. The data used for this figure are: thermal conductivity, thickness of sedimentary rock, geothermal gradient, heat flow, and surface temperature.

potential for wave energy development occurs on the west coast as a result of the wind resources that move west to east across the Pacific Ocean (Musial 2008a; Hagerman 2001). Musial (2008a) estimates that the entire New England and Mid-Atlantic coasts have approximately only one-tenth the wave resources estimated for the southern coast of Alaska (see Table 8.4). Further studies examining the wave energy potential off Southern New England have determined that the greatest resource potential for the area exists far offshore (beyond the Ocean SAMP area boundary) because in nearshore areas there is not adequate fetch for winds out of the west to build up large waves. Exposed waters north of Cape Cod and within the Gulf of Maine were shown to have the greatest annual average significant wave height (approximately 2.0 meters [6.6 feet])(Hagerman 2001). Asher et al. (2008) found that the significant wave height for a site in Rhode Island Sound south of Block Island measured approximately 1.2 m (3.9 feet) over 20 years, and 8.4 m (27.6 feet) in extreme wave events. Closer to shore within Rhode Island Sound, Grilli et al. 2004 determined that the significant wave height at two locations equaled 1.04 m and 1.11 m (3.4 and 3.6 feet) (see Chapter 2, Ecology of the SAMP Region for further discussion on waves in the Ocean SAMP area). A rough estimate of the average power potential from wave energy off of Block Island has been cited as 5.7 kW/m (Spaulding 2008). Researchers have suggested that because of the current state of technology, it may not be economically viable or cost-effective to try to generate energy from the present resource capacity (e.g. Hagerman 2001; Spaulding 2008; Rhode Island Office of Energy Resources 2010). However, this may change in the future with technological advancements.

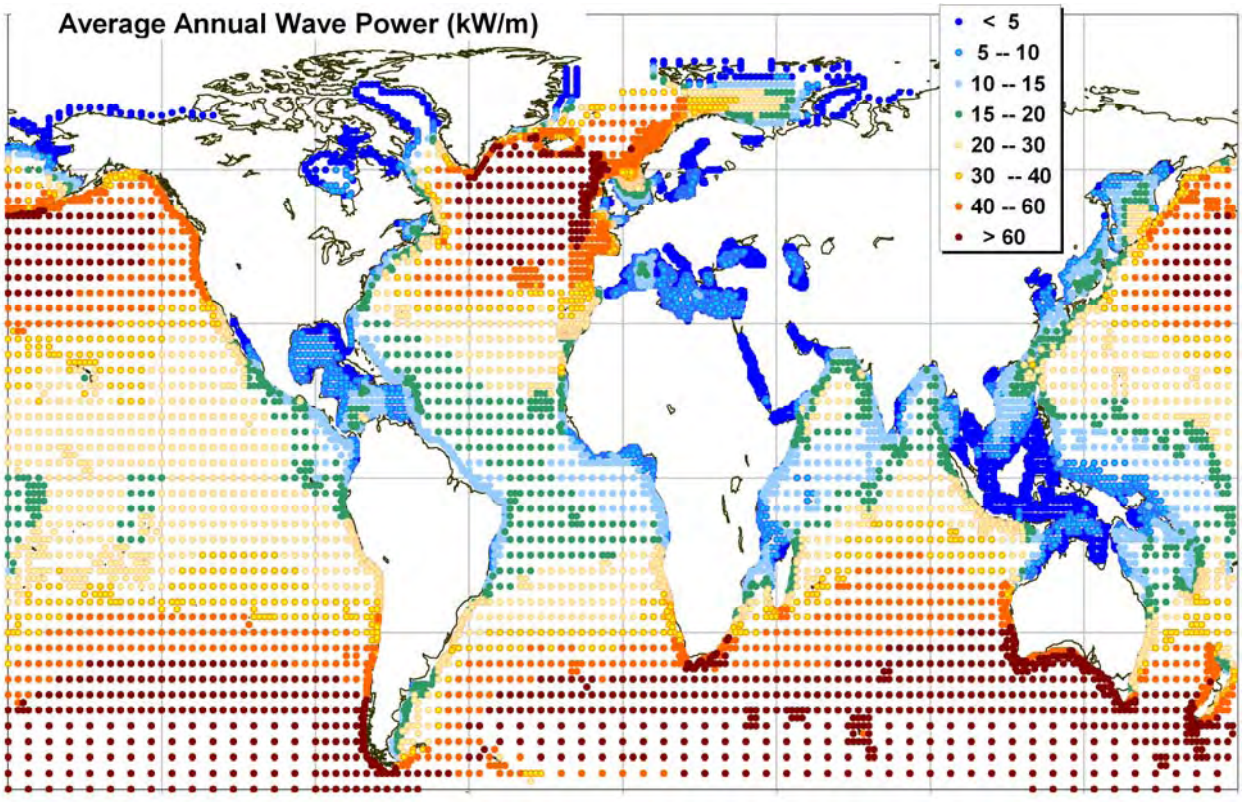


Figure 8.9. Global average annual wave power potential (kW/m) (Fugro OCEANOR AS 2008).

Table 8.4. Wave resources in the United States (Musial 2008a).

US Wave Resource Regions (>10kW/m)	TWh/yr
New England and Mid-Atlantic States	100
Northern California, Oregon and Washington	440
Alaska (exclusive of waves from the Bering Sea)	1,250
Hawaii and Midway Islands	330

6. Tidal energy produces kinetic energy from the rise and fall of the tides. The availability of tidal energy is very site specific, as tidal range and current velocity is amplified by factors such as shelving of the sea bottom, funneling in estuaries, reflections by large peninsulas, and resonance effects when tidal wave length is about 4 times the estuary length (Pelc and Fujita 2002). Utility-scale tidal energy requires large tidal ranges and strong tidal currents to produce sufficient energy to be feasible. In stream tidal energy typically requires velocities greater than 1.5- 2 m/sec [3-4 knots] (Spaulding 2008; Pelc and Fujita 2002). In the Ocean SAMP area, the mean tidal range equals 1.0 meters [3.28 feet] and tidal currents below 1 m/s (2.2 mph); see Figure 8.10 below (see also Chapter 2, Ecology of the SAMP Region for further discussion). Potential sites for tidal energy may exist within Narragansett Bay, or surrounding the Ocean SAMP area boundary (e.g. in and around Nantucket Sound or Long Island Sound); however, utility-scale tidal energy is not currently feasible for development in the Ocean SAMP area (Spaulding 2008).

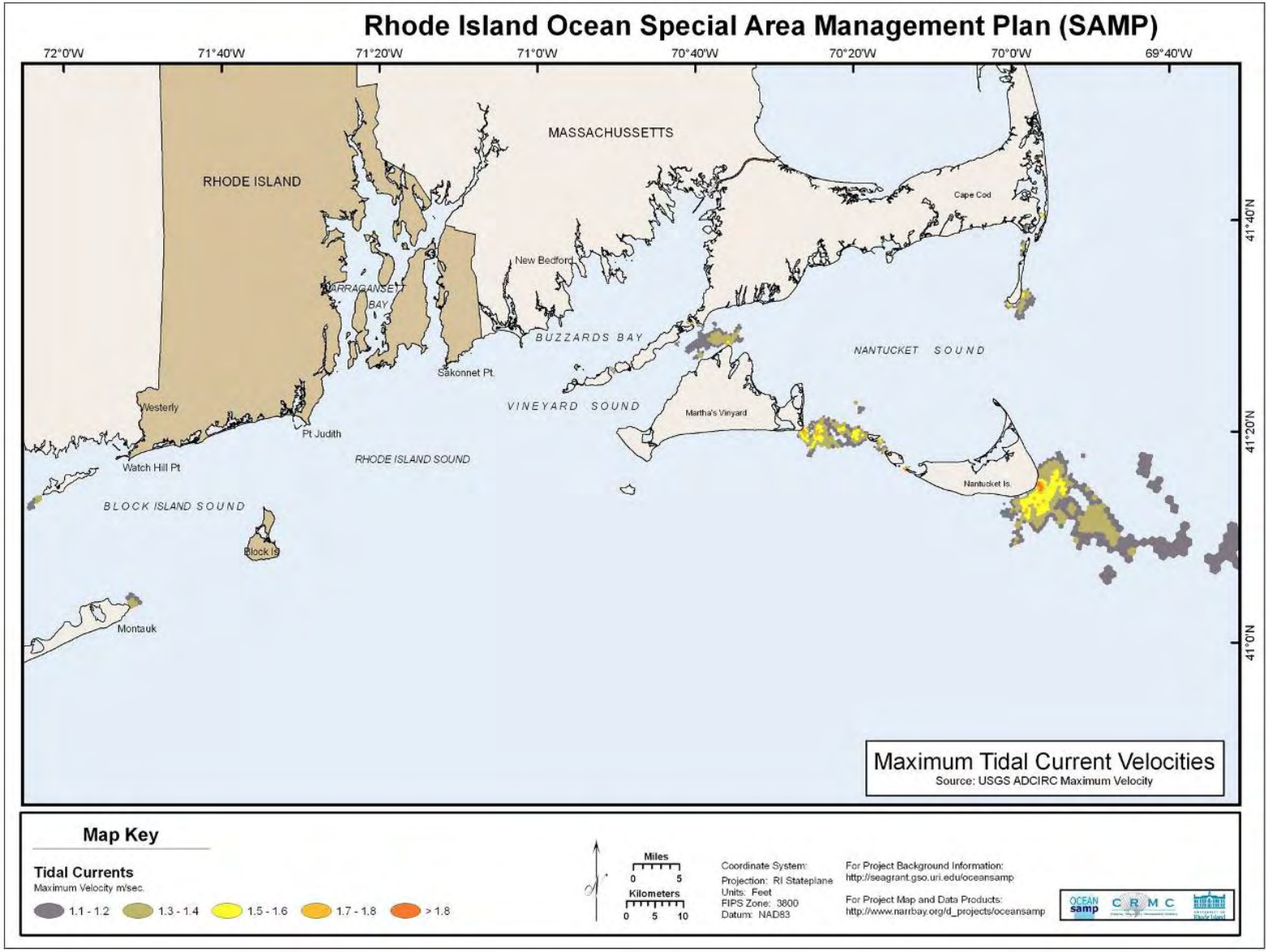


Figure 8.10. Map of maximum tidal current velocities of the Ocean SAMP area and surrounding waters.

7. Rhode Island also lacks the freshwater resources for large-scale hydropower. A 1995 study by the Idaho National Laboratory estimated that Rhode Island has only 11.5 to 13.5 MW of energy potential and that essentially all that potential occurred at sites already developed for other purposes (Francfort 1995). Only three sites, representing 1.3-1.6 MW of energy potential were undeveloped and therefore had the potential for any future hydropower production (Francfort 1995).

8. Biomass resources from wood, crops, manure, and some garbage may be used to generate renewable energy either through burning directly or by converting the biomass into other useable forms of energy such as methane gas. Currently, Rhode Island does produce some energy from methane captured from the state's landfill. As of 2005, over 90% of the methane gas produced from the Rhode Island Central Landfill has been captured and used to produce over 20 MW of power each year (Rhode Island Resource Recovery Program 2007). Additional sources of biomass in Rhode Island are not sufficient enough to support utility-scale energy production. For example, even though the western part of the state is more sparsely populated, there are neither large tracts of land for timber management, nor industries that use wood for paper production or lumber to generate wood waste as a by-product (Rhode Island Office of Energy Resources 2010) (See Figure 8.11). However, while wood is not used in energy production, it is used for home heating in Rhode Island (Rhode Island Office of Energy Resources 2010). Furthermore, an assessment of Rhode Island's biomass resources performed by the National Renewable Energy Laboratory, illustrates that crops and agricultural byproducts are not abundant enough in the state to support utility-scale biomass energy production; see Figure 8.11.

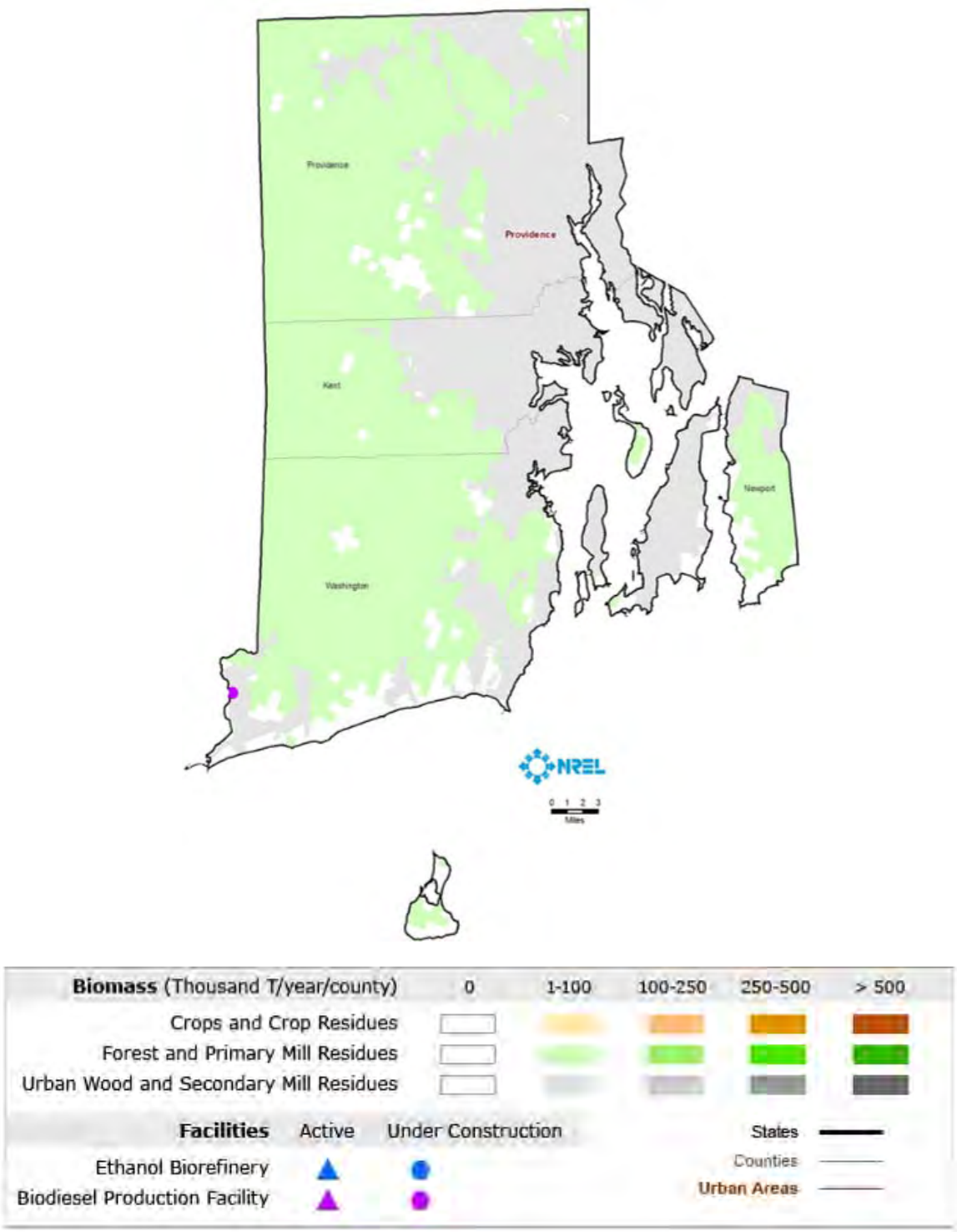


Figure 8.11. National Renewable Energy Laboratory assessment of Rhode Island biomass resources (U.S. Department of Energy 2010c).

9. The remaining source of potential renewable energy to be evaluated in Rhode Island is wind power. Wind turbines convert energy from wind into electricity and may be developed both onshore and offshore. As a renewable resource, wind is classified

according to wind power classes, which are based on typical wind speeds (see Table 8.5). These classes range from Class 1 to Class 7, with Class 1 having the slowest rated wind speeds and the least power-generating capability. In general, at 50 meters (164 feet) altitude, wind power Class 4 or higher is considered suitable for generating wind power with large turbines (Brower 2007; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy 2010). With current advances in technology, locations in Class 3 areas may also be suitable for utility-scale wind development. Also, depending on location and possible wind shear, particular locations in the Class 3 areas could have higher wind power class values at heights over 50 meters (164 feet) (U.S. Department of Energy Office of Energy Efficiency and Renewable Energy 2010b).

Table 8.5. Defined wind power classes (U.S. Department of Energy Office of Energy Efficiency and Renewable Energy 2010).

Wind Power Class	**Wind Power Density (Watts/m^2) at 50 m***	**Wind Speed at 50 m***	
		m/s	**mph**
1	0-200	0 - 5.6	0 – 12.5
2	200-300	5.6 - 6.4	12.5 – 14.3
3	300-400	6.4 - 7.0	14.3 – 15.7
4	400-500	7.0 - 7.5	15.7 – 16.8
5	500-600	7.5 - 8.0	16.8 – 17.9
6	600-800	8.0 - 8.8	17.9 – 19.7
7	>800	>8.8	>19.7
* Note 50 meter hub height is used here to define classes, however, heights above 50 m will give higher wind speeds and hence higher power output.			

10. The U.S. Department of Energy's National Renewable Energy Laboratory mapped the wind resources of Rhode Island at a height of 50 meters (164 feet), both onshore and offshore, using data provided by AWS TrueWind (see Figure 8.12). Onshore the wind power classes range from 1 to 3, with inland Rhode Island characterized as having primarily class 1 wind resources. Coastal areas and Block Island have the greatest onshore wind resources, characterized by class 3 to class 5. As a result, some coastal locations may have wind regimes feasible for community or small-scale wind power projects (Rhode Island Office of Energy Resources 2010). Offshore wind resources have been classified as class 3 or 4 in nearshore areas, increasing to class 5 or 6 further offshore. The difference is largely explained by the effect of surface roughness (Brower 2007). Land surfaces, especially forested areas exert friction on the wind, greatly reducing wind speeds near the surface. As one moves further offshore to measure wind speed, the frictional effect of land is removed, resulting in greater wind speeds near the surface (Brower 2007).[12] If Rhode Island had similar topography to the Great Plains, mostly open farmland, mean wind speeds would be at least 1 m/s higher (Brower 2007).[13] As a general rule, the power output of a wind turbine increases by the cube of wind speed, therefore even small increases in wind speed over the Ocean SAMP area may result in an

[12] The roughness of the sea surface is on the order of 10^{-4} versus 1 to 6 over trees.

[13] Brower provides this caveat regarding large scale wind resource mapping: "It should be emphasized that the mean wind speed or power at a site may differ substantially from the predicted values if there are differences in the elevation, exposure, or surface roughness compared to that assumed by the wind mapping system. The map estimates were developed using 1:100,000 scale topographical and land cover data from the US Geological Survey."

exponentially greater amount of energy production (Wizelius 2007). This resource assessment suggests that the greatest utility-scale wind power potential exists offshore, where the wind speeds reach speeds of 7.5 to 8.8 m/sec (16.8 to 19.7 mph), capable of generating 500-800 W/m^2. Further analysis of this data was performed to map wind speeds in the SAMP area and is discussed in greater detail in Section 830.1. See also Chapter 2, Ecology of the SAMP Region for more information on wind.

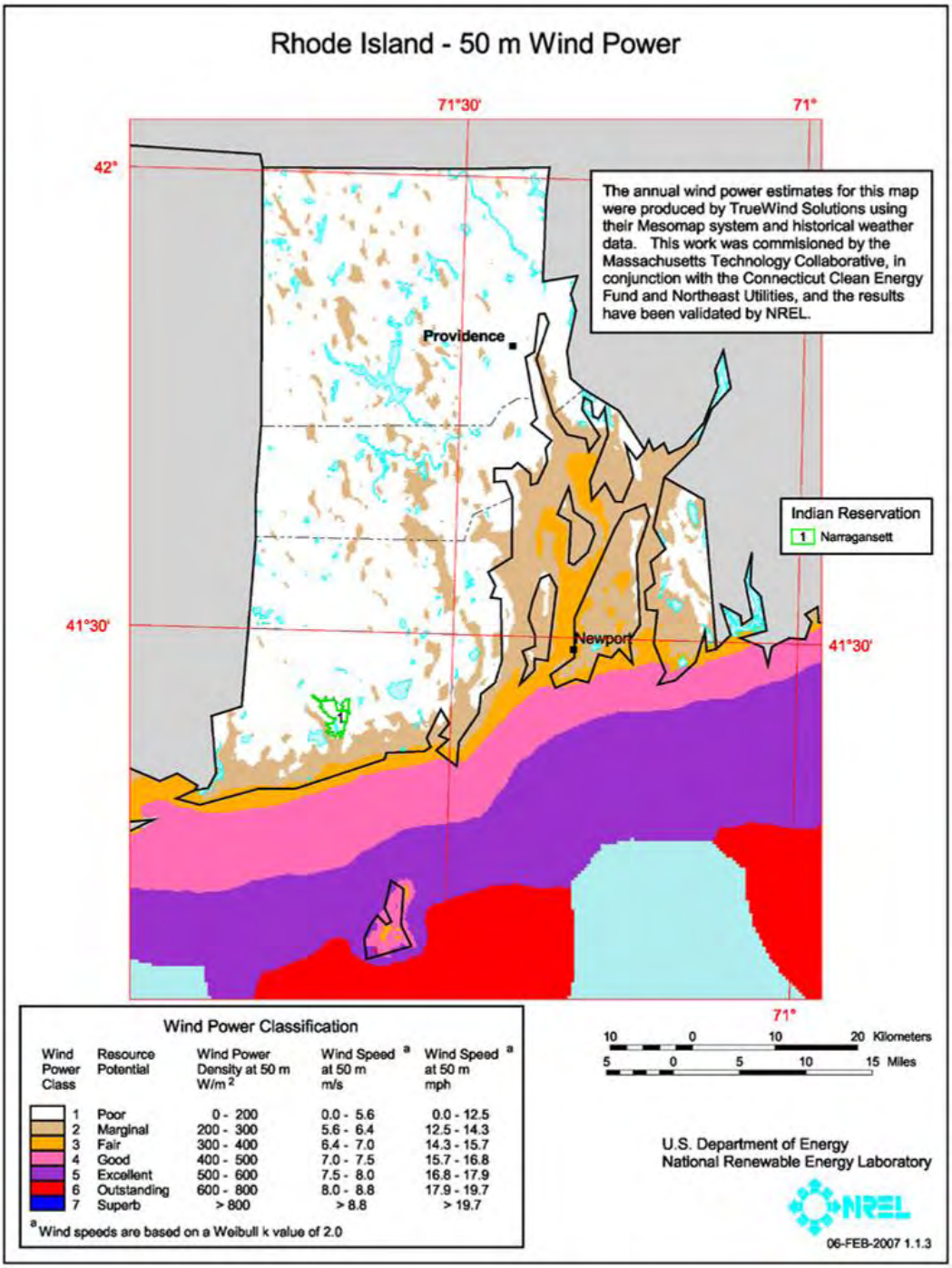


Figure 8.12. Map of wind power potential in Rhode Island (U.S. Department of Energy Office of Energy Efficiency and Renewable Energy 2010).[14]

[14] This map only illustrates the wind resources of Rhode Island out to the territorial sea border. The lack of data displayed in each of the lower corners of the map is a result of these areas lying outside the territorial sea border, and not because no wind resources exist in those areas.

11. The resource assessment presented in Figure 8.12 supports the findings of the *RIWINDS Phase I Wind Energy Siting Study* commissioned by the Rhode Island Office of Energy Resources. The study, completed by Applied Technology and Management Inc., concluded in April 2007 that the goal of meeting 15 percent of Rhode Island's energy needs (equivalent to 400-450 MW) with wind energy was achievable, and that 98 percent of the wind opportunity is offshore (ATM 2007).

12. In conclusion, of all renewable energy sources available in Rhode Island, wind power has the greatest potential to support utility-scale energy production with existing technology. While other renewable resources may be used in residential or small-scale commercial installations, to meet the targets set forth by the Rhode Island Renewable Energy Standard, the most feasible option for utility-scale development is offshore wind energy.

810.4. No Action Alternative

1. Alternatively, if offshore wind energy development did not occur in the Ocean SAMP area, the increased demand for electricity in Rhode Island and the New England region as a whole would need to be met with the development of one or more generating facilities, and/or adopting energy conservation measures to lower future demand. Alternative methods of energy generation may include: conventional energy generation facilities (e.g. gas-fired; coal; or oil-fired), renewable energy facilities located outside of Rhode Island, or a combination of both.

2. Generation facilities fueled by fossil fuels such as natural gas, coal or oil produce pollutants including: NO_x which may contribute to ground level ozone and acid rain; volatile organic compounds and carbon monoxide, as a result of incomplete fuel combustion; SO_2 which may contribute to acid rain; particulate matter which has been attributed to a variety of human health effects such as respiratory ailments, and; the emission of CO_2 a green house gas (MMS 2009a, U.S. Department of Energy 2008). A single 1 MW turbine operating for one year displaces approximately 1,800 tons of carbon dioxide, the primary global warming pollutant based on the current average U.S. utility fuel mix. Alternatively, to generate the same amount of electricity as a single 1-MW turbine operating for one year, using the average U.S. utility fuel mix, would mean emissions of 9 tons of sulfur dioxide and 4 tons of nitrogen oxide each year (AWEA 2009). While there are potential impacts from offshore wind energy development, in many cases impacts tend to be localized and temporary, whereas climate change is wide spread and on a magnitude not found from any other potential impact. For a further discussion on the emissions that may potentially be avoided with offshore wind energy development see Section 850.1. More information on the impacts of CO_2 emissions and global climate change on Rhode Island and the Ocean SAMP area see Chapter 3, Global Climate Change.

3. In addition, continued reliance of Rhode Island and the region on fossil fuels, subject consumers to continued price volatility in the energy market. Additional natural gas-fired facilities may potentially result in greater use of the Ocean SAMP area by Liquefied Natural Gas tankers. See Chapter 9, Other Future Uses for further discussion of future use of the Ocean SAMP area by Liquefied Natural Gas tankers.

Section 820. Utility-Scale Offshore Wind Energy

1. Interest in offshore wind energy as an alternative commercial energy source in the United States has increased recently. Reasons include rising energy prices, uncertainties surrounding oil supply, global climate change concerns, opportunities for local economic and employment growth, and the demonstrated viability of offshore wind farms in Europe. The New England region is particularly vulnerable to energy supply and price volatility because the region has virtually no indigenous supply of natural gas and oil, which are responsible for a large fraction of the region's energy generation (see Section 810.1).

2. Generating wind power offshore has a number of distinct advantages that has made this form of renewable energy generation attractive to states along the eastern Atlantic coast. First, offshore wind turbines can generate power close to coastal load centers where demand for energy is high, electrical rates are high, but space for new power facilities is often limited.

3. Second, placing wind turbines offshore avoids the constraints on size that onshore turbines face, allowing projects to take advantage of economies of scale and increase production efficiency (Robinson and Musial 2006). Offshore the largest wind turbines can be used, turbines much larger than those used onshore, with a much greater capacity (see Section 820.2 for more information). Turbines used offshore can be transported and delivered to a project site using large carriers and barges and, therefore, are not limited by the physical constraints of land-based transportation sytsems (Musial 2008b; Wizelius 2007).

4. Third, offshore wind is stronger and more consistent than onshore wind, further increasing the amount of power that can be produced offshore. Since the power output of wind turbines increases by the cube of wind speed, slight increases in wind speed produce large increases in the amount of potential energy production (Wizelius 2007). On land, winds can be diverted or slowed by interference with the landscape, compared to offshore where the amount of turbulence created by the physical environment is much less due to the less rough sea surface. Overall, this results in steadier wind resources and overall faster average wind speeds. More consistent, stronger winds offshore also means that power generation can better meet peak demand for the energy requirements of load centers compared to onshore wind installations.

5. Currently, there are no installed offshore wind energy facilities in the United States. However, offshore wind energy has been developed over the past two decades in Europe. This section, drawing on information from the European experience, examines the technology used in an offshore wind energy facility, provides a description of the lifecycle stages of a facility from pre-construction through decommissioning, and discusses the project costs and governmental incentives associated with installing an offshore wind energy project.

820.1. Offshore Wind Facilities

1. Offshore wind facilities are comprised of six main parts (see Figure 8.13), including foundation structures, wind turbines, nacelles, submarine cables, an offshore substation, and an onshore grid connection. Offshore wind turbines are secured to the seafloor with a foundation and convert the energy in the blowing wind to electricity through a drivetrain and electric generator housed in the nacelle. The energy produced is collected at an offshore substation where it is then transported back to shore via a submarine transmission cable and fed into the onshore utility grid. While offshore wind facilities can vary in size and design, the main components remain relatively consistent across projects.

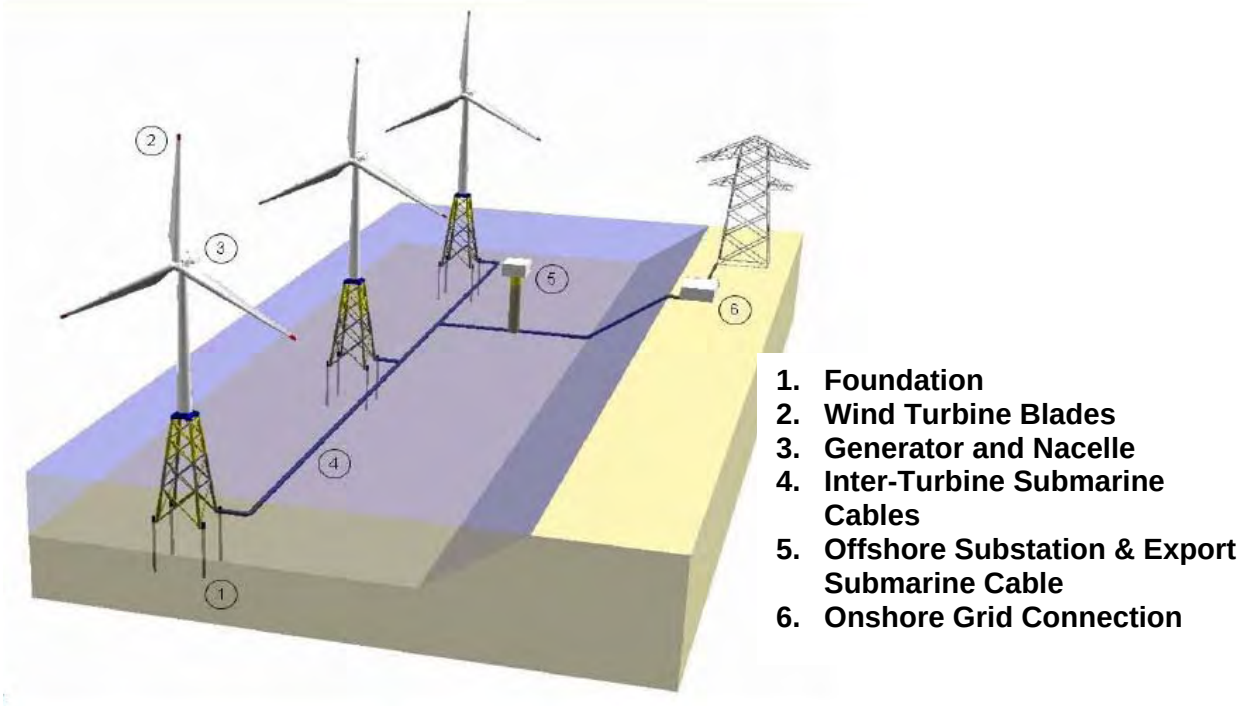


Figure 8.13. Components of an offshore wind facility (Deepwater Wind 2009).

820.2. Turbine and Foundation Technology

1. Above the water level most offshore wind turbines are similar in appearance. Current turbine technology has three evenly spaced composite blades mounted to a hub (see Figure 8.14). The blades and hub together are referred to as the rotor. The rotor spins a shaft that is connected through a drivetrain to an electric generator that converts the energy of the spinning rotor into electricity. The rotating shaft, gearbox, drivetrain and generator are all housed within a protective shell referred to as the nacelle that is fixed atop a steel tower. To use the wind efficiently, the rotor should be perpendicular to the direction from which the wind is blowing. A yaw motor, placed at the base of the nacelle, rotates the nacelle until it is optimally aligned with the wind direction (Wizelus 2007). At the base of the tower is a platform and/or boat landing used by personnel and vessels servicing the turbine. Some turbines (especially those located far offshore) are also equipped with a helicopter landing pad for personnel access. The structure used to connect the tower to the foundation is referred to as the transition piece.

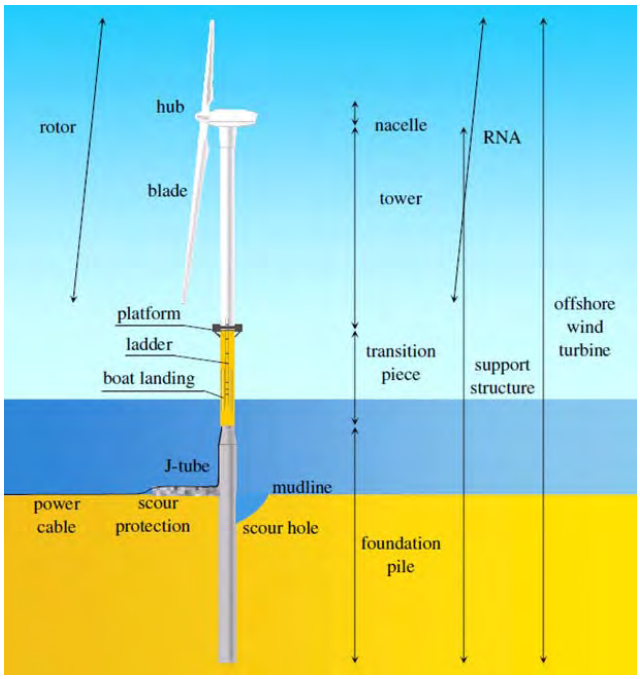
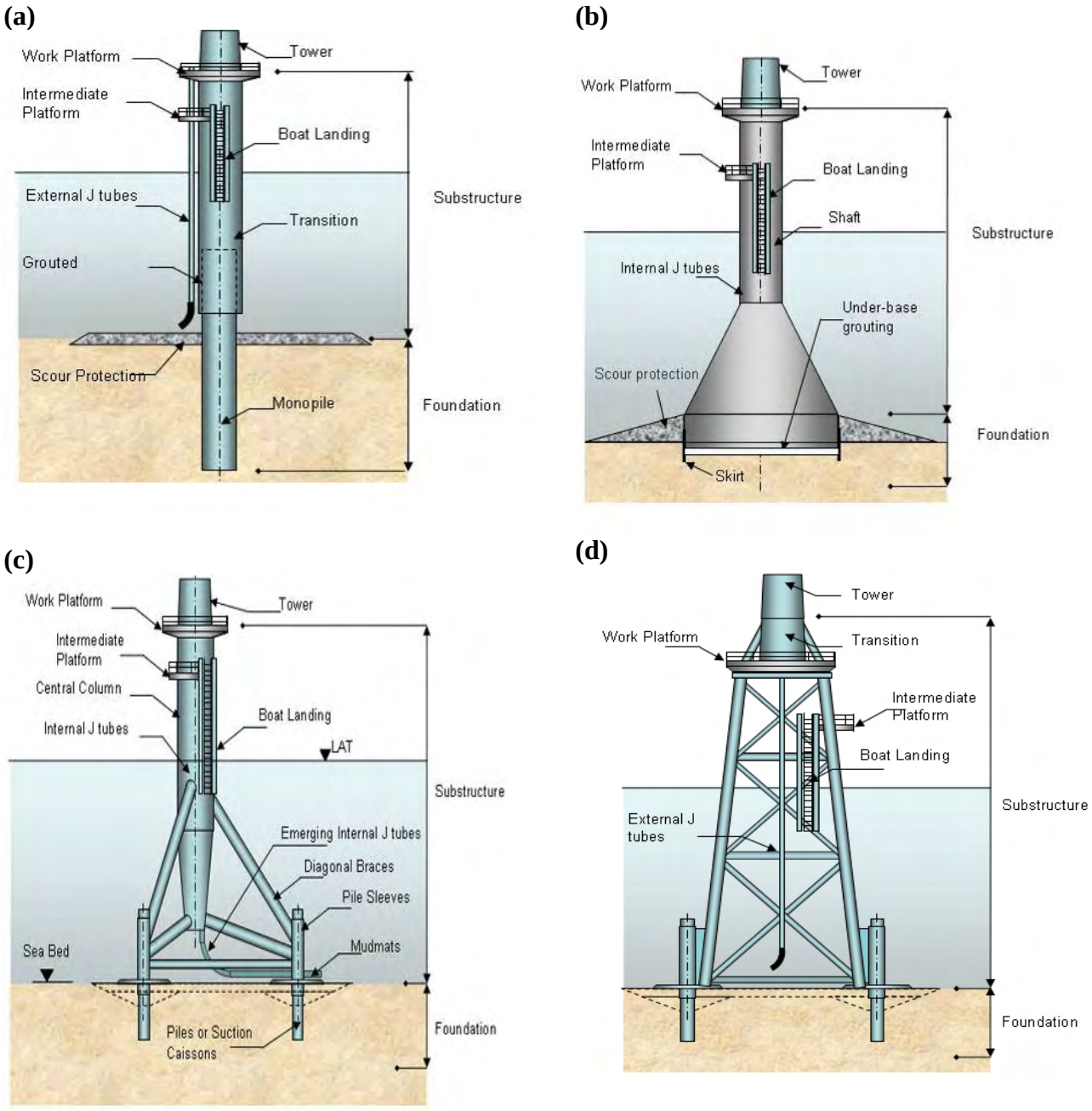


Figure 8.14. Overview of offshore wind turbine terminology (Van der Tempel 2006 as cited in Hensel 2009).

2. Below the water surface, offshore wind turbines can be affixed to the sea floor through a variety of different foundation structures (see Figure 8.15 and Figure 8.16). Foundations are designed to best suit the site-specific geology and water depth of the project site (see Table 8.6). Factors influencing the type of foundation technology used includes: water depth, seabed and sub-seabed composition, turbine loads, wave loads, manufacturing requirements and installation procedures (European Wind Energy Association 2009a). To date the majority of installed offshore wind turbines have used monopile and gravity base foundations (European Wind Energy Association 2009a). Both types of foundation structures are used primarily in shallow water depths (less than 30 meters [98.4 feet]).[15]

[15] From Musial et al. (2006): "Monopiles are depth-limited due to their inherent flexibility. This limit occurs when the natural frequency of the turbine/support structure system is lowered into a range where coalescence with excitation sources such as waves and rotor frequencies becomes unavoidable. To maintain adequate monopile stiffness in deeper waters, a volumetric (cubic) increase in mass and therefore cost is required. This means the monopile length, diameter, and thickness are all growing to accommodate greater depths. At the same time, installation equipment such as pile hammers and jack-up vessels become more specialized and expensive, and eventually the required hammer capacities and jack-up depth limits cannot be reached. These limits are thought to be somewhere between 20 and 30m." (pg.4)



***Illustrations by Garrad Hassan and Partners Ltd**

Figure 8.15. Different support structure types for offshore wind turbines (a) monopile, (b) gravity base, (c) tripod, and (d) jacket (European Wind Energy Association 2009a).

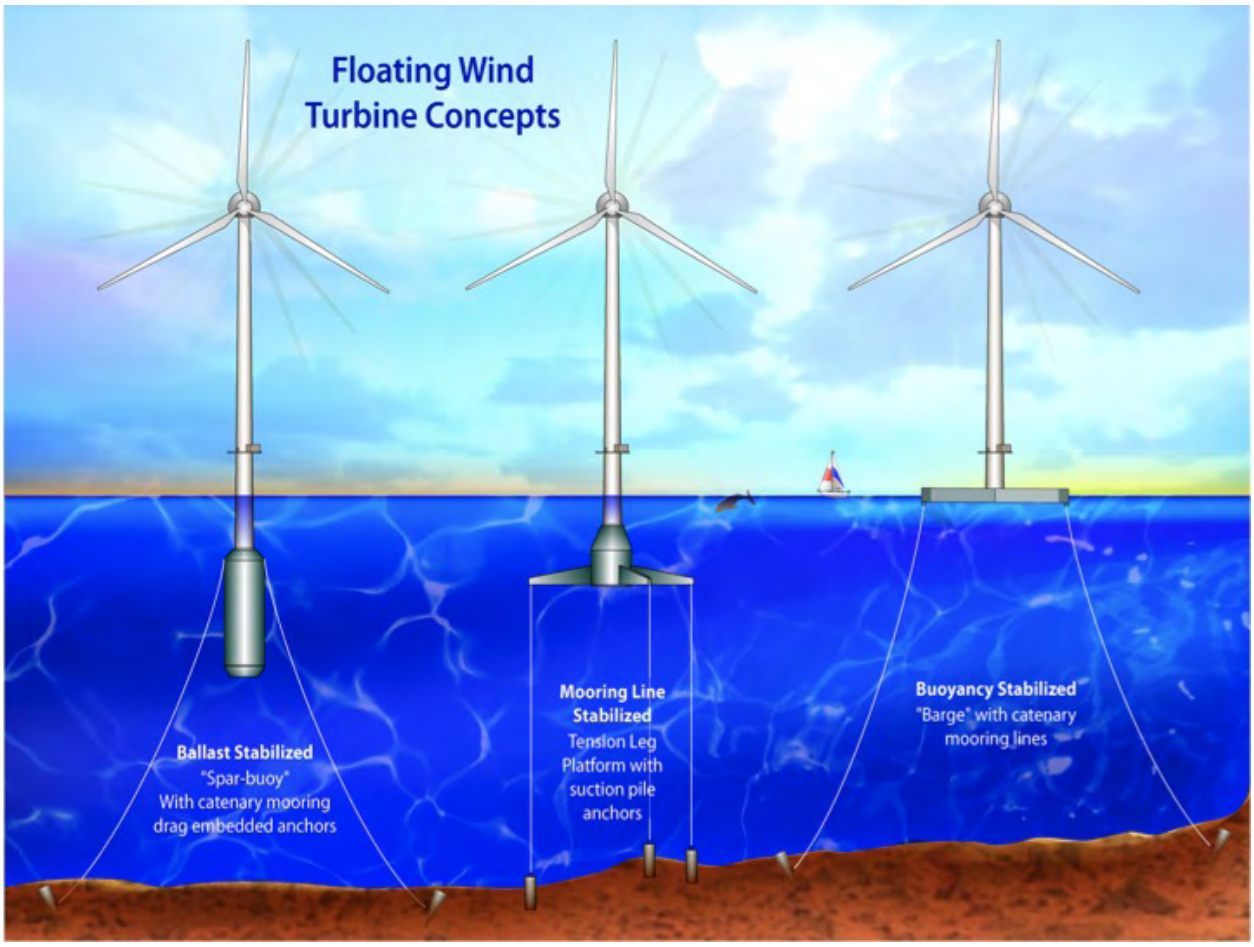


Figure 8.16. Floating wind turbine designs (Musial 2008b).

Table 8.6. Descriptions of foundation types used to support offshore wind turbines (European Wind Energy Association 2009a and 2009b).

Type of Foundation Structure	Water Depth	Construction	Examples
Monopile	Shallow	Made from steel tubes (typical diameters 3m to 6m); Installation of the pile by drilling or driving; Connection from pile and tower with grouted transition piece	Utgrunden (Sweden); Egmond aan Zee (Netherlands); Horns Rev (Denmark); North Hoyle (UK); Barrow (UK); Blyth (UK); Scroby Sands (UK); Kentish Flats (UK); Arklow (Ireland)
Gravity Base	Shallow	Construction material: concrete or reinforced concrete; Self weight of structure resists overturning; Seabed needs sufficient load bearing capacity; Scour protection needed	Vindeby (Denmark); Tuno Knob (Denmark); Middelgrunden (Denmark); Nysted (Denmark); Lilgrund (Sweden); Thornton Bank (Belgium)
Tripod	Mid to deep water	Made from steel tubes (typical diameter 0.8m to 2.5m); Center pile connected to tower (diameter up to 5.5m); Pile or bucket foundation (piles about 2m in diameter, drilled or driven)	Alpha Ventus (Germany)
Jacket	Mid to deep water	Jacket made from steel tubes (typical diameter 0.5m to 1.5m); Pile or bucket foundation (pile diameter from 0.8m to 2.5m, drilled or driven)	Beatrice (UK)
Floating	Very deep	Still under development; Buoyancy effect used for load bearing; Held in place with anchors	Statoil (North Sea)

3. Monopile foundations are made from steel tubes, typically 3.5 to 5.5 m (12 to 18 ft) in diameter that is hammered, drilled, or vibrated 9 to 18 m (30 to 60 ft) into the seabed (MMS 2007a). The turbine is secured to the monopile with a grouted transition piece (European Wind Energy Association 2009a). Gravity foundations rely on gravity to secure the wind turbine to the sea bottom and are constructed of a large concrete structure that rests on the seafloor using weight to stabilize against any overturning moments. Although gravity foundations may be used on multiple bottom types, seabed preparation to create a smooth, flat seabed is required prior to installation to ensure uniform loading (MMS 2007a). Preparation of the seabed requires precision, assuring the surface is level within 20 mm (0.79 inches). However, installation effort is reduced once this preparation is complete. Extensive site-specific bottom analysis is required for each gravity base, to verify homogeneous soil properties and compaction, in order to minimize uneven settling (Musial et al. 2006). In addition to site specific preparation, gravity-based foundations also require shoreside facilities capable of handling the construction of these massive structures (450 to 910 MT [500 to 1,000 tons], compared with 160 MT [175 tons] for a monopile). Further, their large mass may complicate transport and installation operations (European Wind Energy Association 2009a).

4. While monopiles and gravity-based foundations are best suited for shallow water (less than 30 m), tripod and jacketed substructures are considered suitable for transitional water depths of 30 to 60 meters (98.4 to 196.9 feet) and above (Musial et al. 2006). Both tripod and jacketed structures are constructed of welded steel tubes fixed atop piling driven into the seabed. Tripod technology is secured to the bottom with 3 piles, compared to the jacketed structures which use 4 driven piles. Jacket technology has been used extensively in the oil and gas industry (Musial et al. 2006). Floating turbine technologies are beginning to be designed and prototyped for use in deeper water depths (European Wind Energy Association 2009a; Musial et al. 2006). See Figure 8.16 for an illustration of potential floating turbine designs.

5. The movement and transport of surface sediments along the seafloor by currents, tidal circulation, and storm waves can undermine foundation structures by removing sediments or 'scour' away portions of the seafloor that are supporting the structure. In cases where the erosion of sediments is strong enough to compromise the structural integrity of the offshore structure or influence coastal sediment transport, scour protection devices are installed. Scour protection devices such as boulders, grout bags, and grass mattresses may be used to minimize the effects of scouring on the seafloor topography (MMS 2007a). Section 850 contains further discussion of potential scouring action around offshore structures. For more information on storm occurrence and circulation patterns in the Ocean SAMP area see Chapter 2, Ecology of the SAMP Region.

6. While offshore wind turbines are similar in appearance to turbines used onshore, offshore turbines usually require several design modifications to withstand the more demanding offshore environment. For example, in offshore wind turbines the tower structure is reinforced to cope with the added stress from wave exposure. In addition, all components including those within the nacelle require additional protection from the corrosive nature of sea air and spray. Offshore turbines are typically equipped with corrosion protection, internal climate control, high-grade exterior paint, and built-in service cranes. Typically offshore wind turbines also have warning devices and fog signals to alert ships in foul weather and navigation and aerial warning lights. Turbines and towers are typically painted light blue or grey to help the structures blend into the horizon. However, the lower section of the support towers may be painted in bright colors to aid in navigation and to highlight the structures for passing vessels. To minimize expensive servicing, offshore turbines may have automatic greasing systems to lubricate bearings and blades, and preheating and cooling systems to maintain gear oil temperature within a narrow temperature range (MMS 2007a).

7. Wind turbines are classified based on their rated output, or nominal power rating, which is the amount of energy that the turbine is rated to produce at a set wind speed.[16] To determine how much electrical power will be produced by a particular turbine at a given wind speed a power curve is created (see Figure 8.17). Power curves also illustrate the turbines cut-in speed, or the minimum wind speed that causes the turbine to spin and produce power, and the cut-out speed, or the wind speed at which the turbine should be shut down due to a risk of breakage. When the cut-out wind speed is reached, the blades

[16] Nominal power ratings are calculated based on wind speeds of 12 or 16 m/s depending on the manufacturer specifications.

of a turbine are turned out (or feathered) to allow the wind to blow through the rotor without any rotation (Wizelus 2007).

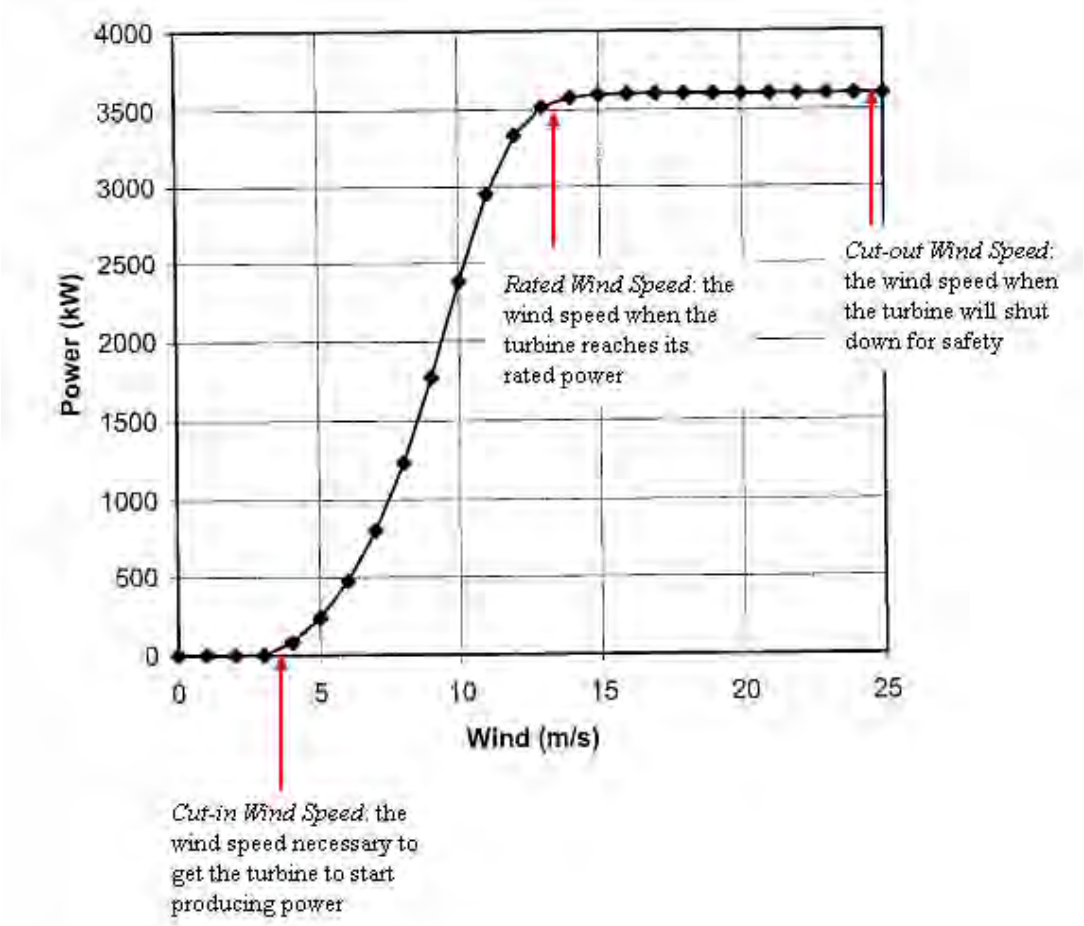


Figure 8.17. Power curve for a Siemens 3.6 MW offshore wind turbine (Seimens Wind Power A/S 2008).

8. Offshore wind turbine sizes have evolved over time to take advantage of economies of scale by increasing in size and power generating capabilities. Typical onshore turbines installed today have a tower height of about 60 to 80 m [200 to 260 ft], blades of approximately 30 to 40 m [100 to 130 ft] in length, and generating capacities of 1-2 MW. Conversely, offshore turbines may be twice that size, with towers reaching heights of 120 m [394 feet]; see Figure 8.18 (MMS 2007a; Wizelus 2007). The majority of offshore turbines installed to date have power-generating capacities of between 2 and 4 MW, with tower heights greater than 61 m [200 ft] and rotor diameters of 76 to 107 m [250 to 350 ft]. A 3.6-MW turbine weighs 290 metric tons (MT) [320 tons] and stands from 126 to 134 m [413−440 ft] tall, approximately the height of a 30-story building (MMS 2007a). Turbine size continues to increase, as turbines rated for 5 MW (with rotor diameters of up to 130 m [425 ft]) are being manufactured. Plans for 7 MW structures are being developed (European Wind Energy Association 2009a). The use of such large turbines means offshore wind facilities can generate greater amounts of electricity with fewer installed turbines, which decreases the cost per kWh of energy production (Robinson and

Musial 2006). For further discussion of the production costs associated with offshore wind energy see Section 820.5.

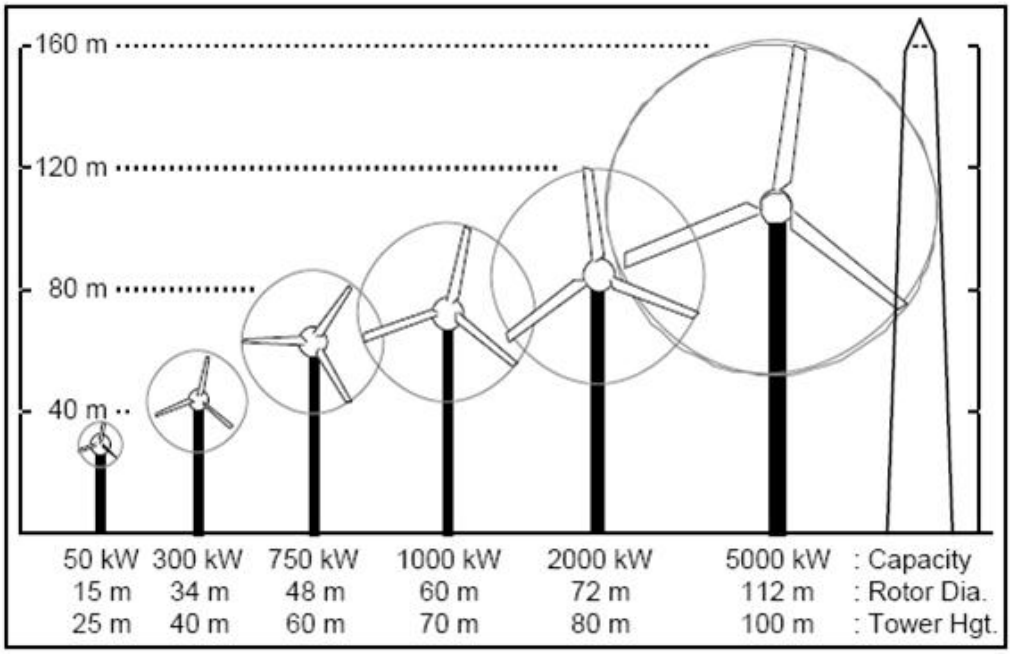


Figure 8.18. Schematic of wind turbine sizes (Connors and McGowan 2000).

9. In addition to rated output an offshore wind turbine is capable of producing, it is also important to consider the capacity factor of a turbine. The capacity factor is an indicator of how much power a particular wind turbine generates in a particular place and is one element in measuring the productivity of a wind turbine, or any other type of power production facility. It compares the facilities actual production over a given period of time with the amount of power the plant would have produced if it had run at full capacity (American Wind Energy Association 2010).

$$\textbf{Capacity Factor} = \frac{\textbf{Turbine average power output in a year}}{\textbf{Turbine rated power}}$$

A conventional utility power plant fueled by natural gas or coal runs almost continually unless it is idled by equipment problems or for maintenance. Therefore, a capacity factor of 40% to 80% is typical for these types of plants. Conversely, because an offshore wind facility is "fueled" by the wind, which blows steadily at times and not at all at other times, modern utility-scale wind turbines typically operate 65% to 90% of the time, and therefore run at less than full capacity. Offshore wind energy capacity factors commonly range between 25% and 40%, and may vary over the span of a year depending on the

intermittency of the wind resource (American Wind Energy Association 2010).[17] For example, if the capacity factor of an offshore wind energy facility is 33% and Rhode Island sets a goal of 150 MW of renewable energy production, the actual amount of installed wind capacity needs to be greater than that goal. As a result of the capacity factor of the offshore wind turbine technology, requires the installation of approximately 450 MW of wind turbine capacity to meet the 150 MW goal. The capacity factors for the European offshore wind facilities Nysted and Horns Rev were estimated to fall between 40-47% (International Energy Agency 2005).[18]

10. Turbine technologies and foundation designs are ever-changing and advancing, as engineers strive to increase the generating capacity of offshore wind turbines, expand the water depths in which structures may be placed, and aim to lower the cost of energy production. As a result, the technology available presently may differ from the technology used in future installations.

820.3. Transmission Cables and Substations

1. The current method for interconnecting offshore wind facilities with onshore utility transmission systems is through alternating current (AC) submarine cable systems. Underwater cables located between the turbines are used to collect the electricity produced from each turbine and feed it into an offshore substation, also referred to as the electric service platform, where a transformer then converts the electricity to a higher voltage before transmission to shore. The transmission cable connected to each turbine runs from the generator within the nacelle, down the length of the tower into a "J" shaped plastic tube, referred to as the J-tube (see Figure 8.14), and guides the cable into the cable trench leading to the offshore substation (European Wind Energy Association 2009a). The collection voltages within the facility typically range from 24 to 36 kV, compared to transmission voltages (from the substation to the shore), which range between 115 and 150kV (MMS 2007a).

2. Currently, offshore wind facilities are connected to onshore utility transmission systems through AC submarine cable systems, which may comprise one or more underwater cables (see Figure 8.19) each capable of carrying up to 150 or 200 MW at a high voltage such as 150 kV (Wright et al. 2002). For distances less than 30 kilometers (18.6 miles) and power levels below 200 MW, AC cable connections are considered adequate. However, for greater distances (30 to 250 km [20 to 155 mi] depending on voltage and cable type) and voltages (greater than 175kV), AC cables may be less practical and technically infeasible, as transmission losses limit the length of AC cables. For offshore wind facilities sited farther than 30 km (18.6 miles) from shore, high-voltage direct current (HVDC) cables may be a suitable alternative as this technology is able to operate safely at higher voltages, and with negligible transmission losses over longer distances

[17] The American Wind Energy Association (2010) goes on to explain that "[w]ith a very large rotor and a very small generator, a wind turbine would run at full capacity whenever the wind blew and would have a 60-80% capacity factor—but it would produce very little electricity. The most electricity per dollar of investment is gained by using a larger generator and accepting the fact that the capacity factor will be lower as a result."

[18] Due to some technical issues at the Horns Rev site in Denmark, where 30-50% of the turbines were non-operational during the year, the capacity factor for this facility during 2004 was 26% (International Energy Agency 2005).

(Wright et al. 2002). However, such a system requires an AC/DC converter station both offshore and onshore which require large installations (European Wind Energy Association 2009a). This technology shows potential as a future alternative to AC, especially as facilities are sited farther offshore; however, it has not yet been proven to be a commercially viable technology for current offshore wind energy development.

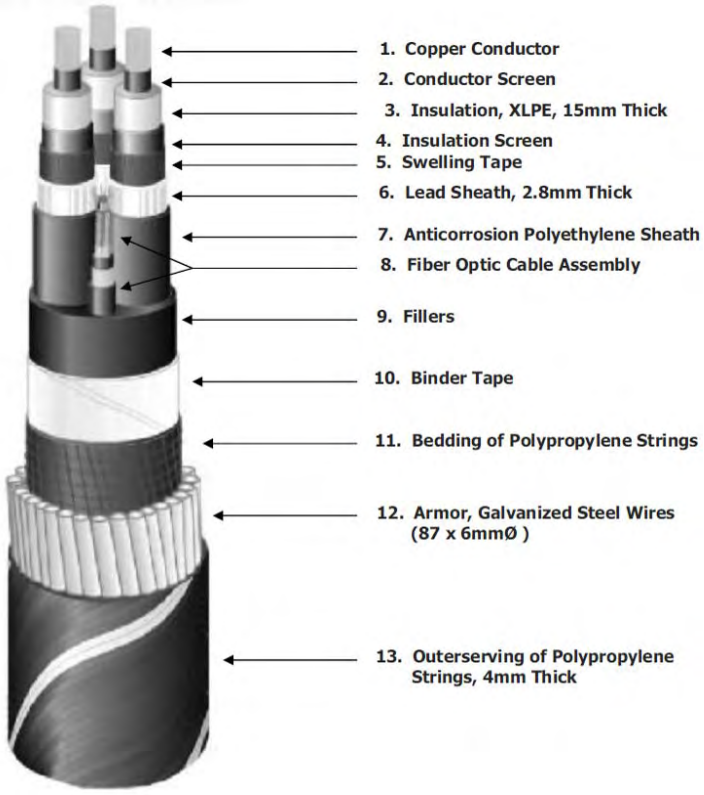


Figure 8.19. Cross-section of an AC 115kV underwater transmission cable (MMS 2009a).

3. As mentioned above, an electric service platform is a central offshore platform that provides a common electrical interconnection of all of the wind turbines in the array and serves as an offshore substation where the electrical output is combined, brought into phase, and stepped up in voltage for transmission to a land-based substation and ultimately the onshore utility grid (MMS 2007a). The purpose of these offshore substations is to reduce electrical losses that may occur along the transmission cable by increasing the voltage prior to exporting the power to shore. Generally a substation does not need to be installed if: (i) the project is small (~100 MW or less), (ii) it is close to shore (~15 km [9.3 miles] or less), or (iii) if the voltage at the grid connection is the same as the voltage being collected from the turbines (e.g. 33 kV). Many of the early offshore wind projects met some or all of these criteria, so were built without an offshore substation (European Wind Energy Association 2009a). However, most offshore wind farms being built currently are large and/or located far from shore and require one or more offshore substations. Offshore substations typically serve to step up the voltage from the voltage collected at the turbines (e.g. 30–36 kV) to a higher voltage (e.g. 100–220 kV), equivalent usually to the voltage of the utility grid connection. This step-up

reduces the number of underwater cables needed to connect to the shore side utility grid (European Wind Energy Association 2009a).

4. In addition to housing the offshore substation, the electric service platform may also provide a central service facility for the wind facility and may include a helicopter landing pad, control and instrumentation system, crane, man-overboard boat, communication unit, electrical equipment, fire extinguishing equipment, emergency back-up (diesel) generators, staff and service facilities, and temporary living quarters (for emergency periods or inclement weather when crews cannot be removed) (MMS 2007a). The electric service platform may also provide a central area to store insulating oil used in the turbine generators, potentially storing up to 150,000 L (40,000 gal) of insulating oil and 7,600 L (2,000 gal) of additional fluids such as diesel fuel and lubricating oil to support the operations of a large offshore wind facility (ASA 2006).

820.4. Stages of Development

1. There are four stages of development associated with the lifecycle of an offshore wind energy facility: pre-construction, construction, operation and decommissioning (see Table 8.7). The duration of each stage will vary between projects though the activities associated with each stage of development are similar across projects.

Table 8.7. Stages of development for an offshore wind energy facility.

Stage of Development	Approximate Duration	Associated Activities
Pre-Construction	Years	Siting of Proposed Project • Wind Resource Assessment • Seabed topography and substrate composition Facility Design • Size • Turbine Technology • Foundation and Substructure • Transmission Permitting and Review Process • Baseline Monitoring • Environmental Impact Assessments • Lease Agreements
Construction	Months – Years	Installations • Foundations and Substructure • Turbines • Electric Service Platform/ Offshore Substation • Cable Laying • Onshore Substation/Connection to Utility Grid
Operation	Expected Life of Facility: Approximately 20-25 years	Maintenance Activities • Equipment Servicing Monitoring Activities • Environmental Monitoring
Decommissioning	Months	• Removal of Structures to the Mud Line • Repowering the Project with New Turbines

2. The pre-construction stage involves all activities associated with siting the location of an offshore wind energy facility, the assessment of physical and biological characteristics specific to a site, and the permitting/review process of a project proposal by the appropriate federal, state and local agencies. The entire pre-construction period may last many years depending on the project. Meteorological towers are installed to collect continuous data on wind speed and direction, along with other weather related information to be used in estimating the potential energy output. Assessment of the wind resources and overall microclimate of a site provides vital information on potential revenue, and projected installation and operation costs, which are ultimately used to support financing agreements (Brown 2008). Developers must also investigate the seabed topography and substrate composition of a proposed site to engineer the appropriate foundation and installation techniques for the turbines and transmission lines (Hammond 2008).

3. During the pre-construction stage, project permitting on the federal, state and local levels is completed, involving substantial reviews and assessments of environmental impacts and compliance with applicable environmental legislation. The review process of an offshore wind energy project located in state waters is led by the U.S. Army Corps of Engineers, as opposed to projects located in federal waters, whose review process is led by BOEMRE (see Chapter 10, Existing Statutes, Regulations, and Policies for a description of federal versus state waters). The National Environmental Policy Act (NEPA)[19] mandates that an environmental analysis be prepared prior to the issuance of federal action (e.g. permits or approvals) for offshore wind farms. Based on the project, the environmental review may consist of an Environmental Assessment or a more extensive review in the form of an Environmental Impact Statement. The review process includes: an analysis of alternatives, an assessment of all environmental, social, and existing use impacts (i.e. ecological, navigational, economic, community-related, etc.), a review for regulatory consistency with other applicable federal laws and the implementation of mitigation measures. Concurrent with the preparation of the final Environmental Impact Statement or other NEPA documentation, a consistency review (under the Coastal Zone Management Act) and subsequent Consistency Determination (CD) is completed relative to each affected State's federally approved coastal zone management program. Each CD includes a review of each State plan, analyzes the potential impacts of the proposed lease sale in relation to program requirements, and makes an assessment of consistency with the enforceable policies of each State's plan (MMS 2009b). It should be noted that even if a project is sited in federal waters, the installation of a transmission cable within state waters or upland areas will trigger all applicable state permitting requirements.[20] See Chapter 10, Existing Statutes,

[19] 42 U.S.C. §4332

[20] Other forms of offshore development, such as offshore LNG terminals, are subject to the Deepwater Port Act (DWPA) of 1974 (33 U.S.C 29 §§1501 *et seq.*) as amended by the Maritime Transportation Security Act of 2002 (Pub.L. 107-295), which establishes a licensing system for ownership, construction, operation and decommissioning of deepwater port structures located beyond the U.S. territorial sea. The DWPA sets out conditions that applicants for licenses must meet, including minimization of adverse impact on the marine environment and submission of detailed plans for construction, operation and decommissioning of deepwater ports. The DWPA also sets out detailed procedures for the issuance of licenses by the Secretary of Transportation and prohibits the issuance of a license without the approval of the Governors of the adjacent coastal states. The Secretary of Transportation is required to establish environmental review criteria consistent with the National Environmental Policy Act.

Regulations, and Policies for more information on state and federal reviews and regulations relevant to offshore wind energy development.

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4. Prior to construction, a developer must first obtain a lease from the appropriate state or federal agency for the land on which facility will be sited. For projects located in Rhode Island waters, the CRMC has the authority to issue the lease or license of offshore lands. Projects located in federal waters must obtain a lease from the U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). The lease process will vary depending on if there is a competitive interest for the same area by multiple developers. BOEMRE may use a general Request for Interest to gauge interest in renewable energy leasing anywhere on the outer continental shelf, or a specific Request for Interest to assess interest in specific areas after receiving an unsolicited leasing proposal from a developer. Any Request for Interest will be published in the Federal Register (MMS 2009b). If BOEMRE determines there is a competitive interest, the lease may be awarded based on a competitive lease process. If only one developer expresses interest, a noncompetitive lease process may be followed (see Figure 8.20).

5. BOEMRE also has the authority to issue leases for other forms of offshore renewable energy development such as hydrokinetic projects. Hydrokenetic projects, such as wave or tidal energy, require approval from the Federal Energy Regulatory Commission (FERC), which has exclusive jurisdiction to issue licenses for hydrokinetic projects under Part I of the Federal Power Act[21] and issue exemptions from licensing under Section 405 and 408 of the Public Utility Regulatory Policies Act of 1978[22] for the construction and operation of hydrokinetic projects on the Outer Continental Shelf. However, no FERC license or exemption for a hydrokinetic project on the OCS shall be issued before BOEMRE issues a lease, easement, or right-of-way.

[21] 16 USC 791 *et seq*.
[22] Pub. L. 95-617.

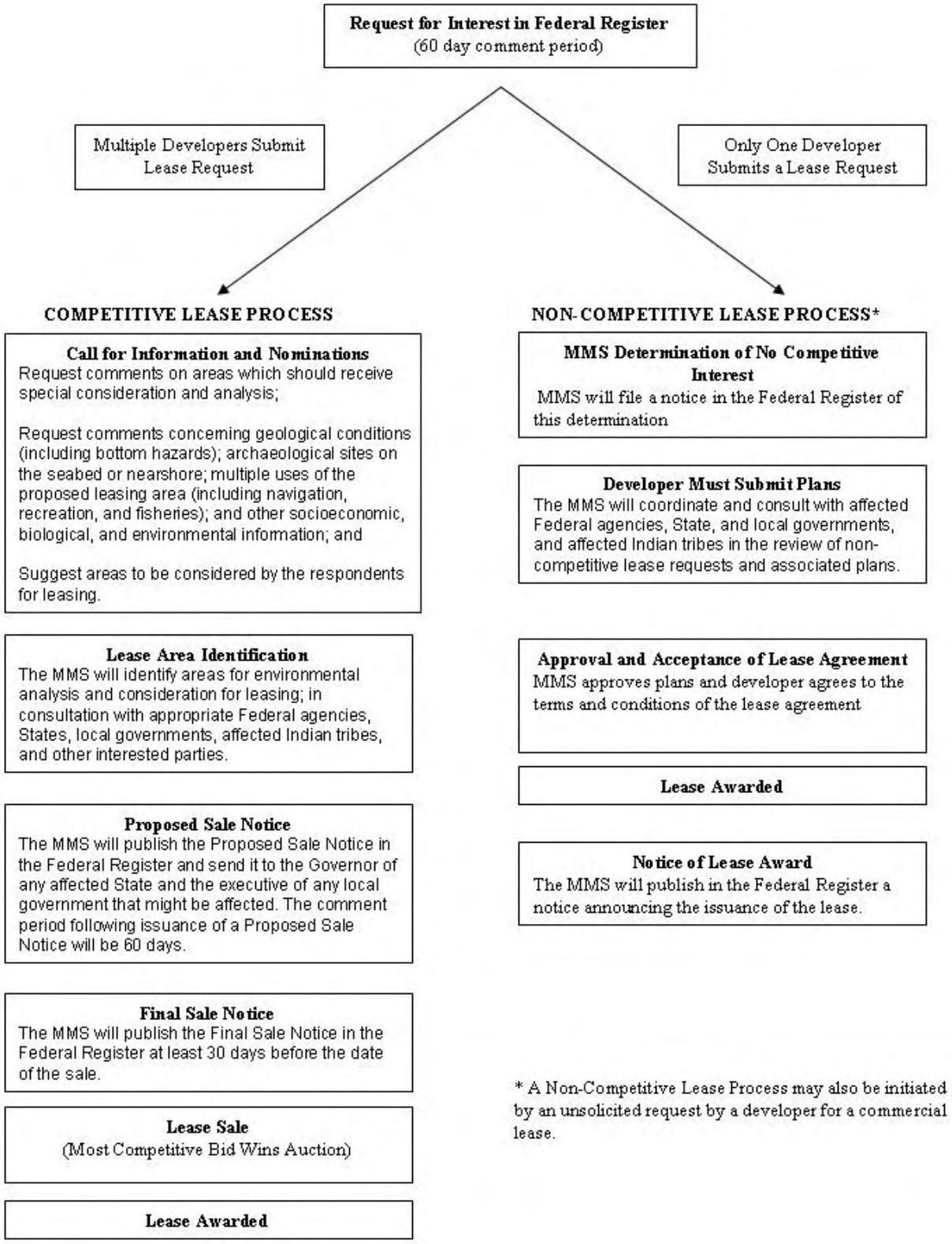


Figure 8.20. U.S. Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) process for awarding leases for offshore renewable energy development (MMS 2009b).

6. Once a lease is awarded by BOEMRE, there are a series of plans and reports that must be submitted prior to construction, including the Site Assessment Plan (SAP) and the Construction and Operation Plan (COP). The requirements of each plan are described in detail in 30 C.F.R. 285. Each of these plans will undergo a NEPA review and consistency review under the CZMA, where appropriate, prior to approval by BOEMRE. A SAP describes the site assessment activities (e.g., installation of meteorological towers, meteorological buoys) a developer plans to conduct at a lease site. A COP and GAP describes all the proposed construction activities, operations and conceptual decommissioning plans a developer intends to follow when installing and operating an offshore wind energy facility. These plans include not only the offshore installations, but also the plans for onshore support facilities. In conjunction with the COP, a developer must also submit a facilities design report, and a fabrication and installation report as outlines in 30 C.F.R. 285.701 and 285.702. Following the approval of these plans, a developer of a federal lease area may then commence the construction stage of development. Similar developer requirements will be outlined in Section 860 and Chapter 11, The Policies of the Ocean SAMP for projects proposed in state waters in the Ocean SAMP.

7. The construction stage of development is the period in which the turbines, substructures and foundations, cables and offshore substations are installed at the project site. For each of these installations various construction vessels, barges and equipment are required, some of which are specialized for the construction of offshore wind farm. Transport barges are used to carry towers, blades, nacelles, scour protection and foundation structures from the onshore staging areas to the project site. In some cases, certain assemblies may occur onshore to reduce installation time offshore. For example, the developer of the Beatrice Wind Farm Demonstration Project (a jacketed offshore wind project) transported the turbine fully assembled to the project site. The tower and rotor had been assembled onshore, transported via barge and lifted onto the jacketed substructure by crane (Talisman Energy et al. 2007) (see Section 840.1 for further discussion). Foundations, substructures, towers and rotors are installed using a jack-up barge outfitted with a crane which lifts and positions structures into place. To stabilize the position of the jack-up barge, four to six legs may be deployed. These legs allow the barge to be raised up to a suitable working elevation (MMS 2009a). Vessels equipped with pile driving rams or vibratory hammers embed the foundation piles to specified depths. Alternatively, in areas where pile driving is not possible, drilling techniques such as augering may also be used to create holes within the seabed for the piles to be placed.

8. Cable laying activities are performed by vessels towing a jet-plowing device which uses pressurized sea water to carve a trench in the sediments. The jet-plow creates the trench and lays the cable within the trench allowing the disturbed sediments to settle atop the cable. This technique is used for both the inner-array of cables that connect the turbines to the offshore substation and the longer transmission cables that connect the entire facility to the shore side utility grid. The transmission cables connecting the offshore wind facility to shore may be embedded from three to ten feet below the seafloor surface (MMS 2007a). Once the transmission cable reaches the shore, it is run through a buried conduit installed to protect the cable in the coastal zone. In addition, to the vessels directly involved in laying the cables, multiple small auxiliary vessels may be present to

provide support and assistance. Cable laying activities may occur continuously, on a 24 hour basis (MMS 2009a).

9. Because the transport, placement, and installation of the wind turbine structures requires acceptable weather conditions and sea states, the duration of construction activities will vary dependent on the local weather (U.K. Department of Trade and Industry 2007). In areas prone to inclement weather or rough sea conditions, construction activities may require much more time to be completed. See Chapter 2, Ecology of the SAMP Region for more information on storm occurrence in the Ocean SAMP area.

10. Offshore wind energy facilities have been designed to operate without the attendance of any operator (MMS 2009a). Therefore, once installed the majority of day-to-day operations and monitoring of turbine functions are conducted remotely. Sensors within the turbine's nacelle gather and transmit data on the performance of the generator and other equipment, as well as current weather conditions, wind speed and direction to onshore control centers. Remote control centers would also have the ability to shut down a turbine if necessary. Prior to operation, a project must obtain the appropriate operating licenses and permits from the Federal Energy Regulatory Commission.

11. While monitoring and daily operations may be controlled remotely, periodic maintenance visits to the facility by service vessels and crews are required. Periodic maintenance activities may include: regular inspections of all installed structures, preventative maintenance on all equipment, or repairs to any malfunctioning equipment. According to BOEMRE (MMS 2009a), approximately five days per year per turbine may be anticipated for both planned and unplanned maintenance activities. However, the number of maintenance visits will likely be influenced by the dependability of the technology employed.

12. The final stage of an offshore wind energy facility is its decommissioning, in which installed structures are removed from the project site. Decommissioning of a wind facility involves the dismantling and removal of infrastructure from each wind turbine platform to 15 meters [49.2 feet] below the mud line, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal. The decommissioning process is largely the reverse of the installation process and uses similar vessels employed during the facility's construction. Cranes would be used to lift away structures, whereas piles may be removed using one or a combination of acetylene cutting torches, mechanical cutting devices, or high pressure water jets (MMS 2009a; MMS 2007a). Piles are required to be removed to 15 meters [49.2 feet] below the mud line; therefore, the section of the piles below that depth will remain in the seabed after decommissioning. Explosive techniques may also be used for the removal of some platforms if permitted (MMS 2007a). Alternatively, BOEMRE may allow structures to be left in place to serve as an alternate use, such as an artificial reef. However, such a determination will be made on a case-by-case basis. While the typical life-span of an offshore wind energy facility is approximately 20-25 years, there is the potential for a site lease to be extended for longer use if approved by BOEMRE (MMS 2009b).

820.5. Project Costs

1. The cost of constructing an offshore wind energy facility will vary based on site specific conditions and the timing of installation. Figure 8.21 illustrates the estimated breakdown of capital costs for an offshore wind farm in the United Kingdom, based on a compilation of primary data on constructed U.K. projects performed by the U.K. Department of Trade and Industry (2007). These percentages differ among projects.

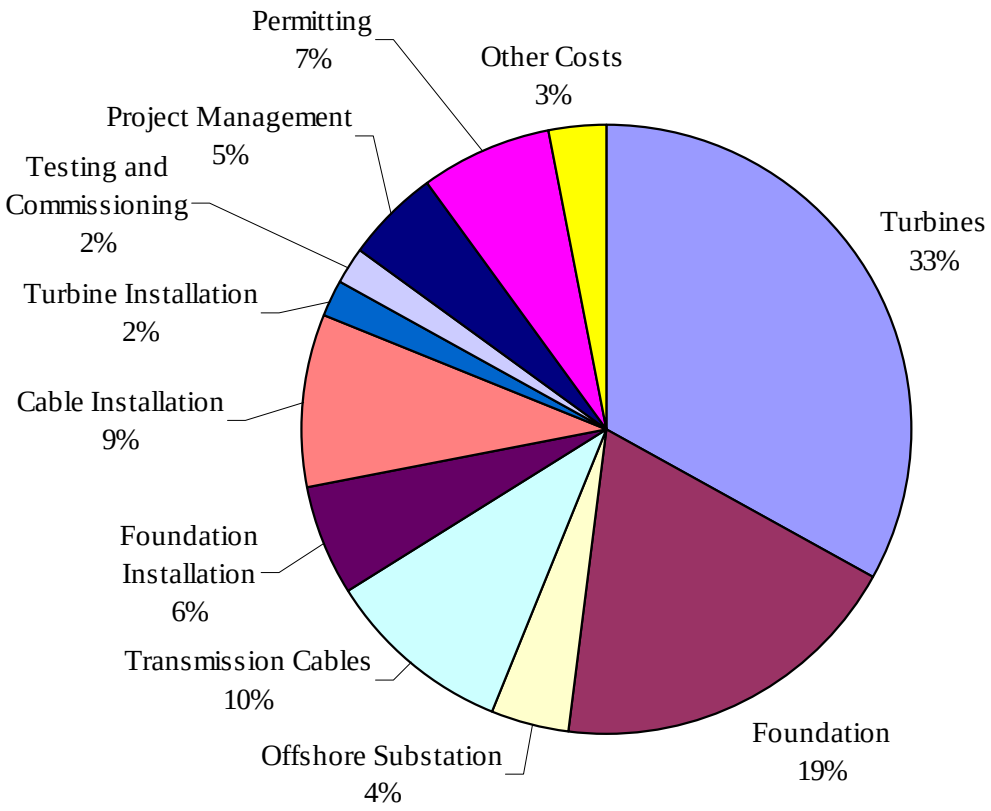


Figure 8.21. Estimated capital costs of an offshore wind energy facility (U.K. Department of Trade and Industry 2007).

2. Due to the large cost of offshore structures, foundations, installation, and grid connection, the current cost of constructing offshore wind energy facilities tend to be much more expensive than onshore wind energy facilities (Blanco 2009). For example, a study performed by the U.K. Department of Trade and Industry (2007) estimated that per megawatt of installed capacity, offshore wind energy facilities cost 78% more than onshore projects.[23] The high project costs for offshore wind energy facilities may be due in part to the high capital costs associated with the turbines and foundation structures. Foundations for offshore turbines may cost two to three and a half times more than onshore foundations as they are much larger, because they must accommodate the force

[23] The U.K. Department of Trade and Industry study (2007) estimated that per megawatt of installed capacity onshore projects cost approximately £0.9 million, compared to offshore which was estimated to cost £1.6 million.

of the spinning turbine, as well as forces from ocean currents and waves. In addition, foundation structures require additional installation costs compared to onshore projects (U.K. Department of Trade and Industry 2007). Offshore installation costs may also be amplified due to acquiring expensive, specialized vessels or the potential for delays from poor weather and sea conditions. The U.K. Department of Trade and Industry (2007) study concluded that developers typically factor in an addition 20 to 25% of time needed for construction due to anticipated downtime during the construction phase as a result of poor weather. While the actual costs vary widely between projects, industry analysts predict that as technology advances and installation procedures are improved the cost of developing offshore wind energy projects may decrease (U.K. Department of Trade and Industry 2007; Concerted Action on Offshore Wind Energy in Europe and the European Commission 2001).

3. The cost of operation and maintenance (O&M) activities, which may include regular maintenance for the turbines and other structures, repairs, insurance, management, royalty and lease payments, also contributes to the cost of an offshore wind energy facility. The relative percentage of O&M costs will vary between projects and between technologies and because current offshore turbines are not more than 20 years old, long-term O&M data is not available. Manufacturers, however, are continuously aiming to shrink these costs through the development of new turbine designs requiring less regular service visits and, therefore, reduced downtime (Blanco 2008). During the initial years of operation, manufacturers offer warranties to cover malfunctions and part replacements, but after the warranty period those costs become the burden of the developer.

820.6. Federal and State Incentives for Development

1. To encourage the development of renewable energy, Rhode Island and the federal government offer incentives to encourage development. Table 8.8 summarizes all incentives currently available for renewable energy development. While additional incentives are also offered to individuals or municipalities for the installation of renewable energy technology, only incentives applicable to utility-scale projects are presented here.

2. Federal incentives for renewable energy in the U.S. have focused primarily on subsidizing the industry, through the Renewable Electricity Production Tax Credit (PTC) enacted by the Energy Policy Act of 1992.[24] Under this legislation, a tax credit of 1.5 cents/kWh (presently equals 2.1 cents/kWh but is periodically adjusted for inflation) is granted to all qualified renewable energy producers (including wind, biomass, hydroelectric, methane, and geothermal) for the first 10 years of operation. The PTC plays a central role in renewable energy proposals such that many land-based wind projects have been largely financed based on these tax savings (Astolfi et al. 2008). The American Recovery and Reinvestment Act of 2009[25] extended this incentive for three more years, allowing any new installations in service before December 31, 2012 to receive the credit. It also allowed the option for developers to receive a grant from the U.S. Treasury Department instead of taking tax credit. The cash grant from the U.S.

[24] 26 U.S.C § 45
[25] Public Law No: 111-5.

Treasury Department can be used to cover 30% of the cost of qualified property (new equipment, including tangible property, integral to the wind energy facility). However, the grant application must be filed prior to October 1, 2011 (DSIRE 2010).

3. A second federal tax credit provided under the federal Modified Accelerated Cost-Recovery System (MACRS), allows developers to recover a greater proportion of their capital investment during the early years of operation, through greater depreciation deductions on installed turbines.[26] The MACRS establishes a five-year depreciation period for wind technology placed in service after 1986, and allows a depreciation deduction of 50% of the asset cost at the time the asset is placed into service in the first year, with the remainder depreciated over the regular depreciation period. Accelerated depreciation of the fixed assets associated with a wind farm (i.e. turbines, substations, transmission cables) during the first five years of operation acts to lower a developer's federal tax liability during that period.

4. Title XVII of the federal Energy Policy Act of 2005 authorized the U.S. Department of Energy to issue loan guarantees for projects that:

   > [A]void, reduce or sequester air pollutants or anthropogenic emissions of greenhouse gases; and employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued.[27]

   As a result of the American Recovery and Reinvestment Act of 2009, this loan guarantee program has $6 billion appropriated to issue loan guarantees for energy efficiency, renewable energy, and advanced transmission and distribution projects through September 30, 2011.

5. In addition to the Renewable Energy Standard and the cap and trade system established under the Regional Greenhouse Gas Initiative (described in detail in Section 810.3), Rhode Island also offers a number of financial incentives to encourage the development of renewable energy within the state. Financial incentives within the state are funded through the Rhode Island Renewable Energy Fund (RIREF).[28] This system benefit fund is supported by a surcharge on electric customers' bills, set at $0.0023 per kWh. However, this surcharge is divided into two types of programs, renewable energy promotion and demand-side management programs. The portion of the total surcharge dedicated to renewables is $0.0003 per kWh, compared to demand-side management programs that collect $0.002 per kWh from the surcharge (DSIRE 2010). This charge will remain in effect for a 10-year period (which began on January 1, 2003) resulting in an annual budget for the fund of approximately $2.4 million; however, only the portion of the RIREF funded from the renewable surcharge can be used to support renewable development (DSIRE 2010). From the RIREF, a number of grants, recoverable grants, and loans are offered for renewable projects. Commercial projects within the state can receive up to $250,000 per year in assistance; municipal renewable energy projects can

[26] 26 USC §168
[27] 42 USC § 16511 et seq.; 10 CFR 609
[28] R.I. Gen. Laws § 39-2-1.2.

apply for up to $1 million per year in grants from the fund; and technical and feasibility studies can receive up to $200,000 per year in funding. Relative to the cost of constructing an offshore wind energy facility, these awards are small and may not provide much incentive for utility-scale development.

6. Besides the incentives provided under the RIREF, Rhode Island also offers two tax exemptions to renewable projects within the state. One is the Renewable Energy Sales Tax Exemption, which exempts wind turbines sold within the state from state sales tax (a 7% savings).[29] The second is the Jobs Development Act, which provides an incremental reduction in the corporate income tax rate (currently 9%) to companies that create new employment in Rhode Island over a three-year period.[30] A firm that creates a certain proportion of jobs relative to the company's size may permanently reduce its state income tax liability down to 3%, provided the jobs remain within the state and the employees are paid above a set wage standard (Rhode Island Economic Development Corporation 2010a).

7. As described in Section 810.2, the Long-Term Contracting Standard for Renewable Energy[31] is also meant to encourage and facilitate the creation of 'commercially reasonable' long-term contracts between electric distribution companies and developers or sponsors of newly developed renewable energy resources. In addition to stabilizing long-term energy prices, enhancing environmental quality, and creating jobs in Rhode Island in the renewable energy sector, the goals of this standard is to help facilitate the financing of renewable energy generation within the jurisdictional boundaries of the state or adjacent state or federal waters or providing direct economic benefit to the state. Power purchase agreements that result from this legislation provide assurances to developers that the power produced by a project will be purchased at a stated price, which may in turn aid a developer in obtaining financing for a project. For more information on this standard see Section 810.2 and 840.2).

8. The Ocean SAMP process may also be classified as a type of incentive as it may inform and potentially expedite the permitting and review process for proposed projects in areas determined suitable for future offshore renewable energy development. The research conducted as part of the Ocean SAMP provides baseline data on the physical, biological, ecological resources, as well as describes human uses and activities that occur in the Ocean SAMP area which may be informative in siting or reviewing proposed projects in state and federal waters. While proposed projects will still be required to collect site specific baseline data, data collected for the Ocean SAMP will provide a useful comparison when monitoring the potential effects of any future offshore renewable energy development. Furthermore, the renewable energy policies and standards outlined in the Ocean SAMP will clarify the considerations of the CRMC when evaluating future projects, as well as identify the design and monitoring protocols that will be expected of any future developers. Once approved by the National Oceanic and Atmospheric Administration as part of Rhode Island's coastal zone management program, the Ocean SAMP policies will also inform the consistency review determination of future offshore

[29] R.I.G.L § 44-18-30. Rhode Island's Sales Tax Rate equals 7% (Federation of Tax Administrators, 2008)
[30] R.I. Gen. Laws §42-64.5-1
[31] R.I. Gen. Laws §39-26.1

renewable energy development in federal waters within the Ocean SAMP boundary, as the CZMA requires federally approved projects be consistent with state coastal management program policies. For more information on federal consistency determinations, see Section 820.4, Chapter 1, Introduction, as well as Chapter 10, Existing Statues, Regulations, and Policies.

Table 8.8. Summary of federal and state incentives applicable to offshore wind energy development (Armsby 2009).

	Promotional Policies				**Financial Incentives**			
	Renewable Energy Quotas	**Cap and Trade Programs**	**Expedited Permitting Scheme**	**Long-Term Contracting Requirements**	**Investment Subsidy/ Rebate**	**Investment Credit**	**Production Credit**	**Grants/ Loans**
U.S. Federal						MACRS- Accelerated Depreciation (No expiration) Investment Credits for Projects Involving Creating Manufacturing Facilities*	Production Tax Credit (Expires: 12/31/2012*)	Department of Energy Loan Guarantee Program (Expires: 9/30/2011*) U.S. Treasury Grants (Application Deadline 10/1/2011)*
RI	16% by 2020 and a Governor Initiative to obtain 15% of state's power from wind	RGGI- CO^2 Allowance System for Conventional Power Plants (Beginning 2011)	Ocean SAMP	Long-Term Contracting Standard for Renewable Energy	Equipment Sales Tax Exemption	Jobs Development Act- reduces Corporate State Income Tax Rate based on job creation		RIREF funded grants & loans
* Represents incentives included in the American Recovery and Reinvestment Act of 2009								

Section 830. Offshore Renewable Energy in the Ocean SAMP Area

830.1. Offshore Wind Resources in the Ocean SAMP Area

1. Proper siting of offshore wind energy development in the Ocean SAMP area first requires an assessment of the offshore wind resources. As described in Section 810.3, offshore wind speeds increase as distance from shore increases. Data provided by AWS True Wind (Brower 2007) at 70 and 100 meters (230 and 328 feet) above sea level were interpolated to estimate the wind speed at a height of 80 meters (262.5 feet) throughout the Ocean SAMP area (see Figure 8.).[32] The data used to create **Error! Reference source not found.** is the same data used to produce the National Renewable Energy Laboratory map shown in Figure 8., though the resource displayed in Figure 8.22 represents winds speeds at a height of 80 meters (262.5 feet) instead of 50 meters (164 feet). Wind speed data at the height of 80 m (262.5 feet) is important, as this is the approximate hub height of an offshore wind turbine. Calculated wind speeds closest to shore ranged from 7.0-7.2 m/sec [15.7-16.1 mph], increasing steadily to 9.6 m/sec [21.5 mph] at the southern edge of the Ocean SAMP boundary.

2. Actual wind speeds vary day to day and seasonally. Winds in the Ocean SAMP region are diurnal, and seasonal, with winter winds blowing from the northwest and summer winds from the southwest (Loder et al. 1998; Spaulding et al. 2010a). In general, winter wind speeds tend to be greater than summer wind speeds (HDR Engineering Inc. 2007; Spaulding et al. 2010a). For more information on wind in the Ocean SAMP area, see Chapter 2, Ecology of the Ocean SAMP Region. In addition to daily and seasonal variation, variation in mean wind speeds has been observed over longer time periods. For more information on the observed long-term trend in wind speed in Rhode Island refer to Chapter 3, Global Climate Change.

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[32] Meteorological model predictions and mass flow analyses developed by AWS TrueWind (MesoMap) were used to predict the wind energy resource along a 200 m grid throughout the waters of Southern New England. The model calculated the mean wind speeds using 366 independent days of simulation, selected from 15 year historical record The accuracy of the model's predictions were then compared to measurements from 33 towers in the region including airports, offshore buoys and platforms, and wind measurement programs from the 1980s and 1990s. For a complete description of the AWS TrueWind methodology see Brower (2007).

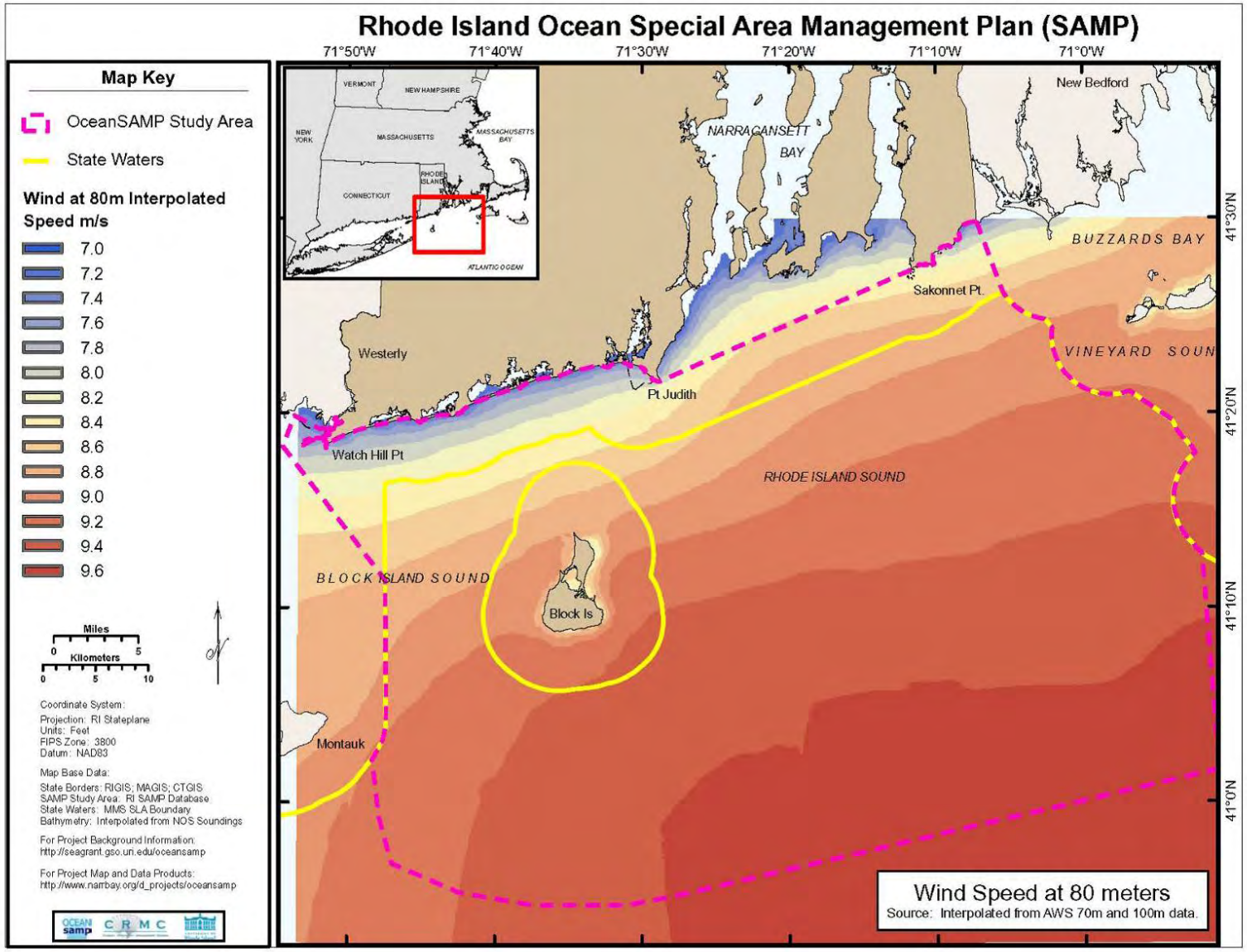


Figure 8.22. Average annual wind speeds at a height of 80 meters above sea level.

830.2. Siting Analysis- Technology Development Index

1. Selecting potential sites for the development of any form of offshore renewable energy requires the identification of areas with adequate energy resources, followed by an analysis of any constraints imposed by the physical characteristics specific to a site (e.g. water depth, geology, etc.), or other existing uses in the area. Geospatial analysis using Geographic Information System (GIS) tools is one technique whereby potential sites can be identified based on specified criteria (i.e. the potential for power production, the expense or difficulty of construction, or areas where competing uses do not occur). This systematic analysis allows sites to be selected which have the greatest potential for offshore renewable energy development, while also minimizing impacts on existing uses.

2. One new tool created to aid in the site selection process is the Technology Development Index (TDI), developed by Spaulding et al. (2010b). The TDI is defined as the ratio of the Technical Challenge Index (TCI) to the Power Production Potential (PPP). TCI is a measure of how difficult it is to construct a device (e.g. an offshore wind facility) at a given location plus a measure of the distance to the closest electrical grid connection point. This measurement can be expressed as the cost in dollars of installation, or if cost data is unavailable, as a relative estimate ranked by the level of difficulty based on professional judgment (i.e. 1 to 5, with 5 being the most difficult). The PPP is an estimate of the annual power production possible at the location measured in watts, determined from wind resource measurement. In other words, the TDI is a quantitative measure of how difficult it would be to develop a facility at a given location, taking into account construction challenges and expenses, and how much power production may be possible at a site. Sites with the lowest TDI value represent the optimum sites for development.

   $$\text{Technology Development Index (TDI)} = \frac{\text{Technical Challenge Index (TCI)}}{\text{Power Production Potential (PPP)}}$$

   $$\text{TDI} = \frac{\text{Measure of the Technology Required (e.g. foundation)} + \text{Cable Distance}}{\text{Measure of the Extractable Energy in Watts}}$$

3. To develop a TDI value for all areas within the Ocean SAMP boundary, Spaulding et al. (2010b) calculated PPP and TCI values using a 100 meter by 100 meter grid. First, the wind speed data, shown in **Error! Reference source not found.**, was converted to wind power per unit area.[33] While the mean wind speed increases gradually with distance offshore, from 7 to 9.6 m/sec (15.7 to 21.5 mph) (a 37% increase), wind power increases by a factor of 2.6. This is due to the relationship between wind speed and potential power. The power output of a wind turbine increases by the cube of wind speed, so even a small increase in wind speed can substantially increase the amount of potential power production. The TCI value was calculated using a number of assumptions: the use of

[33] Spaulding et al. (2010d) have performed a detailed comparison of model predictions to observations in the study area. The difference between predictions and measurements is normally distributed with an average value of about 0.17 m/sec and a standard deviation of 0.15 m/sec.

jacket foundations at all sites, cost estimates based on Roark (2008) and water depth measurements of the site (see Figure 8.23); and cable distance estimates calculated based on the closest straight-line distance to shore.[34] Because the effort (and cost) of installing lattice jacket structures (especially pile-driving activities) is known to be sensitive to composition of the seabed sediments within the upper 30 to 50 m (98.4 to 164.0 feet) of the sediment column, Spaulding et al. (2010b) adjusted TCI values for the impacts of seabed geology. The seabed geology in the Ocean SAMP area is dominated by glacial end moraine and lake floor sediments which were deposited in several incidents of glacial advancements and retreats (see Chapter 2, Ecology of the SAMP Region for more information). A map of construction effort (see Figure 8.24) was developed by glacial geological experts familiar with the Ocean SAMP waters, ranking areas on a scale of 1 to 5 (Boothroyd and King, pers. comm., as cited in Spaulding et al. 2010b) (for more information on the geology of the Ocean SAMP area see Chapter 2, Ecology of the SAMP Region). A low ranking indicates deposits amenable to pile driving operations, while the highest values reflect areas with shallow depth to bedrock, which would require drilling and grouting techniques to install the piles. Intermediate values (level 3) are indicative of complex end moraine sediment deposits, consisting of a mix of lake floor sediments and sand, gravel, and boulders of varying size. Figure 8.24 is an initial estimate of construction effort and will be refined as additional sub-bottom mapping and geotechnical studies of the Ocean SAMP area are completed.

4. The resulting TDI values for the entire Ocean SAMP area are shown in Figure 8.25.[35] The red shaded areas represent the most difficult locations to develop an offshore wind facility. When geology is included, the range of TDI values equal 1 to 3.5, with the largest TDI values corresponding to the areas of highest construction effort. Near the coast, TDI values are generally high in spite of low TCI values (due to shallow water depths and close proximity to shore) because the available wind energy in these areas is low. TDI values decrease with continuing distance off shore because the wind energy grows substantially, even though water depth continues to increase. Variations from this general pattern are principally a result of the bathymetric variations and the distribution of glacial end moraine and lake floor sediments deposits. For example, variations in TDI values near the Rhode Island coast, south and west of Block Island, and the shallower area in the vicinity of Cox's Ledge and Southwest Shoals in the center of Rhode Island Sound can be attributed to bathymetric variations in those areas. The optimum (lowest TDI) site in state waters is the shallow areas south and southwest of Block Island. For federal waters the optimum site, if distance to shore is considered, is the deep-water tongue located between two end moraine deposit sequences just landward of Cox Ledge and Southwest Shoals in the center of RI Sound.

[34] Roark (2008) calculated that the cost of a jacket wind turbine support structure increased from $ 3.36 million in water depths 5 to 25 m, to $ 4.48 million in water depths 25 to 45 m, to $ 5.76 million in water depths 45 to 65 m.
[35] TDI values represented were converted to a non-dimensional form by dividing by the lowest possible TDI in the study area. The non-dimensional TDI values are from 1 and higher, where values close to 1 represent optimum sites.

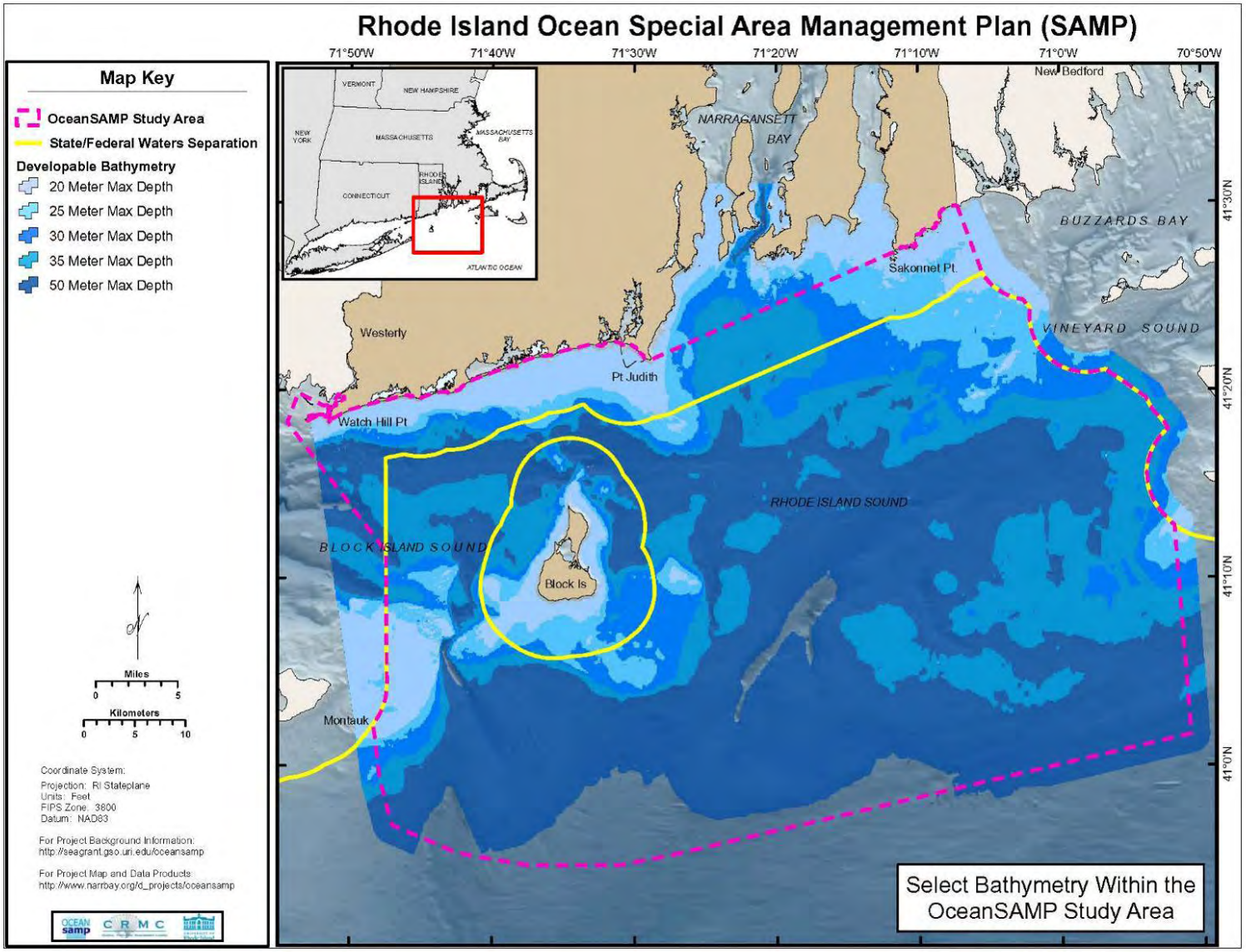

Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
OceanSAMP Study Area
State/Federal Waters Separation
Developable Bathymetry
20 Meter Max Depth
25 Meter Max Depth
30 Meter Max Depth
35 Meter Max Depth
50 Meter Max Depth
Miles
0 5
Kilometers
0 5 10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
New Bedford
NARRAGANSETT BAY
BUZZARDS BAY
Sakonnet Pt.
VINEYARD SOUND
Westerly
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Select Bathymetry Within the OceanSAMP Study Area

Figure 8.23. Ocean SAMP area bathymetry.

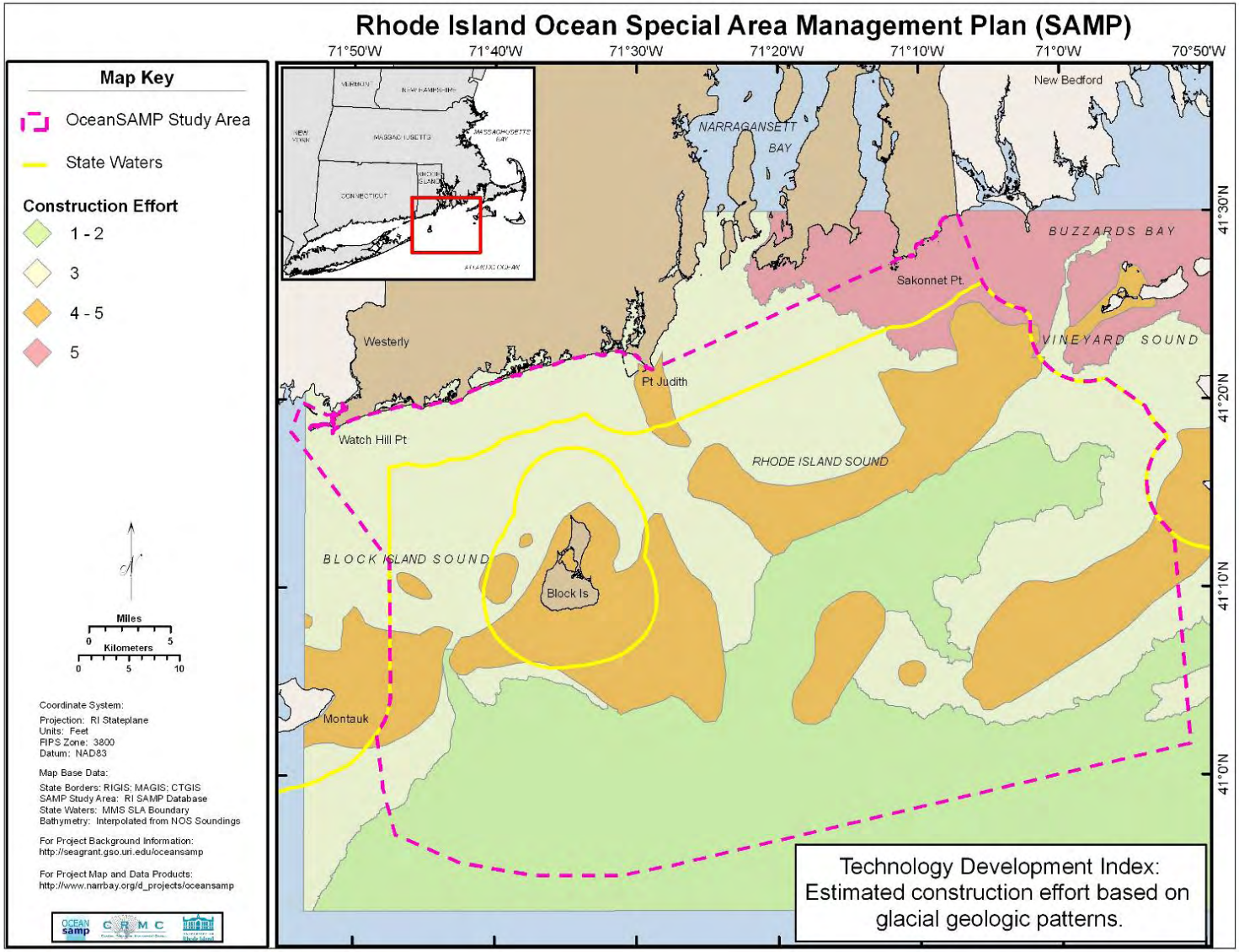


Figure 8.24. Estimated construction effort based on seabed geology and glacial deposits (Boothroyd and King as cited in Spaulding et al. 2010a).

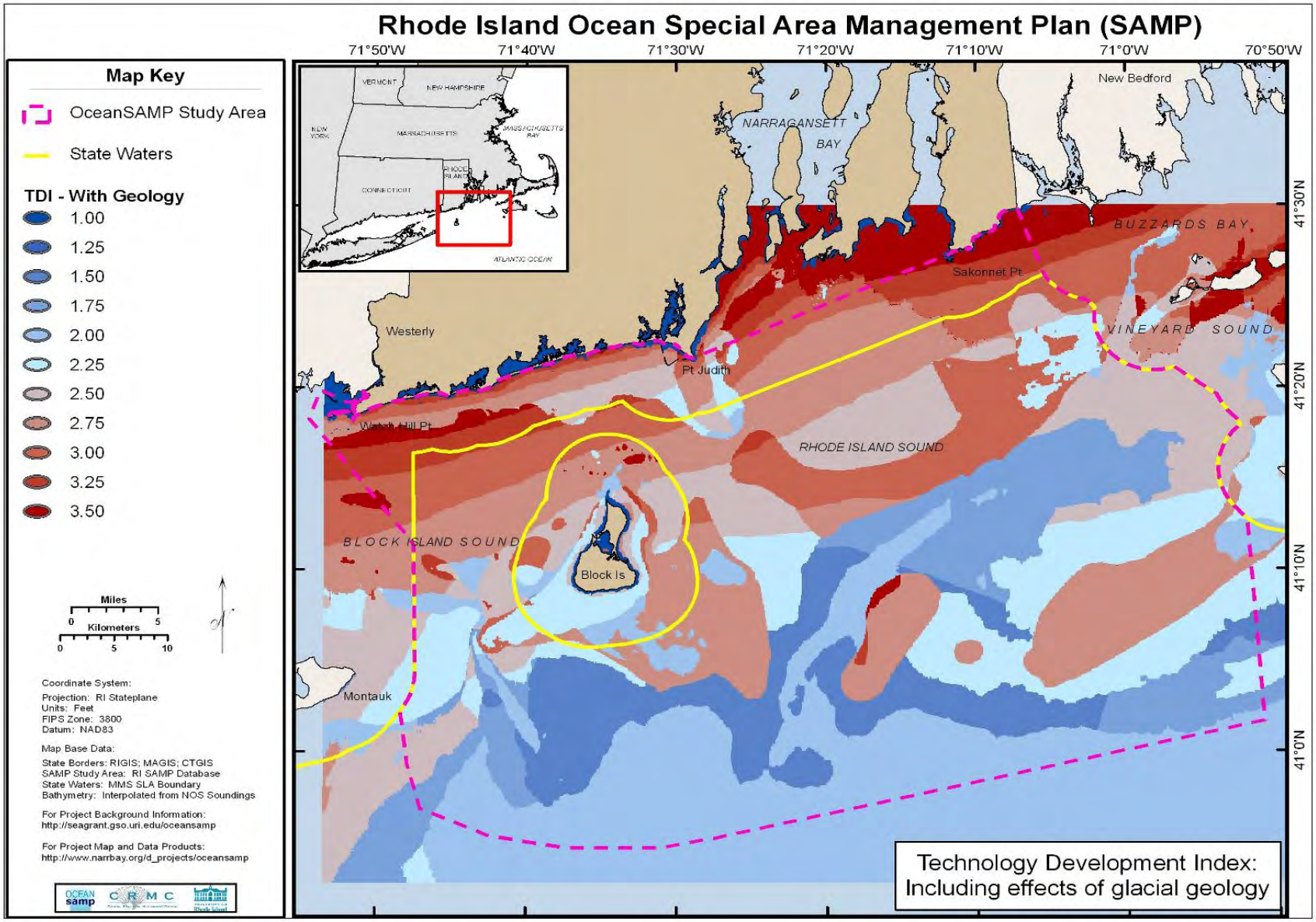

Rhode Island Ocean Special Area Management Plan (SAMP)
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
Map Key
OceanSAMP Study Area
State Waters
TDI - With Geology
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
Miles
0
5
Kilometers
0
5
10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
Map Base Data:
State Borders: RIGIS; MAGIS; CTGIS
SAMP Study Area: RI SAMP Database
State Waters: MMS SLA Boundary
Bathymetry: Interpolated from NOS Soundings
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
CRMC
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
NARRAGANSETT BAY
New Bedford
BUZZARDS BAY
Sakonnet Pt
VINEYARD SOUND
Westerly
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Technology Development Index:
Including effects of glacial geology

Figure 8.25. Ocean SAMP area non-dimensional Technology Development Index with geology.

5. Further refinement of the site selection process was conducted by Spaulding et al. (2010b) excluding areas of hard constraints or areas where incompatible uses occur. Existing uses or restrictions considered as hard constraints by Spaulding et al. (2010b) included: regulated marine transportation areas (such as shipping lanes, precautionary areas, preferred routes, ferry routes), regulated uses (disposal sites, unexploded ordnance, marine protected areas and conservations zones, military areas), areas permitted or licensed for existing developments (oil and gas, offshore renewable, aggregate extraction, aquaculture), setbacks from airports, and a coastal buffer zone (see Figure 8.26). This analysis is performed by overlaying GIS layers for each of the uses, with each layer further reducing the area considered for offshore renewable energy development.

6. 8.28 is an example of such an analysis (Tier 1 Analysis), where TDI values greater than 3.0 and the following areas were excluded:

   - Designated Shipping Lanes and Precautionary Areas
   - Recommended Vessel Routes
   - Ferry Routes
   - Areas with > 50 Records of Commercial Ship Traffic (AIS Data)[36]
   - Dredge Disposal Sites
   - Military Testing Areas
   - Unexploded Ordnances
   - Airport buffer zones[37]
   - Coastal buffer zone of 1 km (0.6 miles)[38]

   The areas remaining after the excluded areas were removed are illustrated in Figure 8.26.

[36] Automatic Identification System (AIS) is a transponder-based ship tracking system required aboard certain commercial vessels. See *Chapter 7 Marine Transportation, Navigation and Infrastructure* for more information on AIS and the data set used in this analysis. The value of vessel traffic density (i.e. > 50 Records of Commercial Ship Traffic) is not a hard constraint but instead a matter of subjective judgment. A sensitivity study was performed varying this threshold and showed that at densities higher than 50 captured the major shipping activities in the area.

[37] Airport buffer distances were determined by the Federal Aviation Administration and are based on runway size. The Block Island airport has a 10,000 ft [3,048m] buffer, and the Westerly airport has a 20,000 ft buffer, however these airport buffers overlap the 1 km coastal buffer zone and therefore were already excluded.

[38] This coastal buffer zone was set based on the fact that there is likely to be significant recreational use of the waters close to the coastline (e.g. swimming, boating, diving, fishing) that potential development may interfere with. In addition, this coastal buffer was also set in part to avoid areas where construction and maintenance support of the facilities may be difficult (e.g. sufficient draft and operational area for construction vessels, zone where waves break because of shallow water depths).

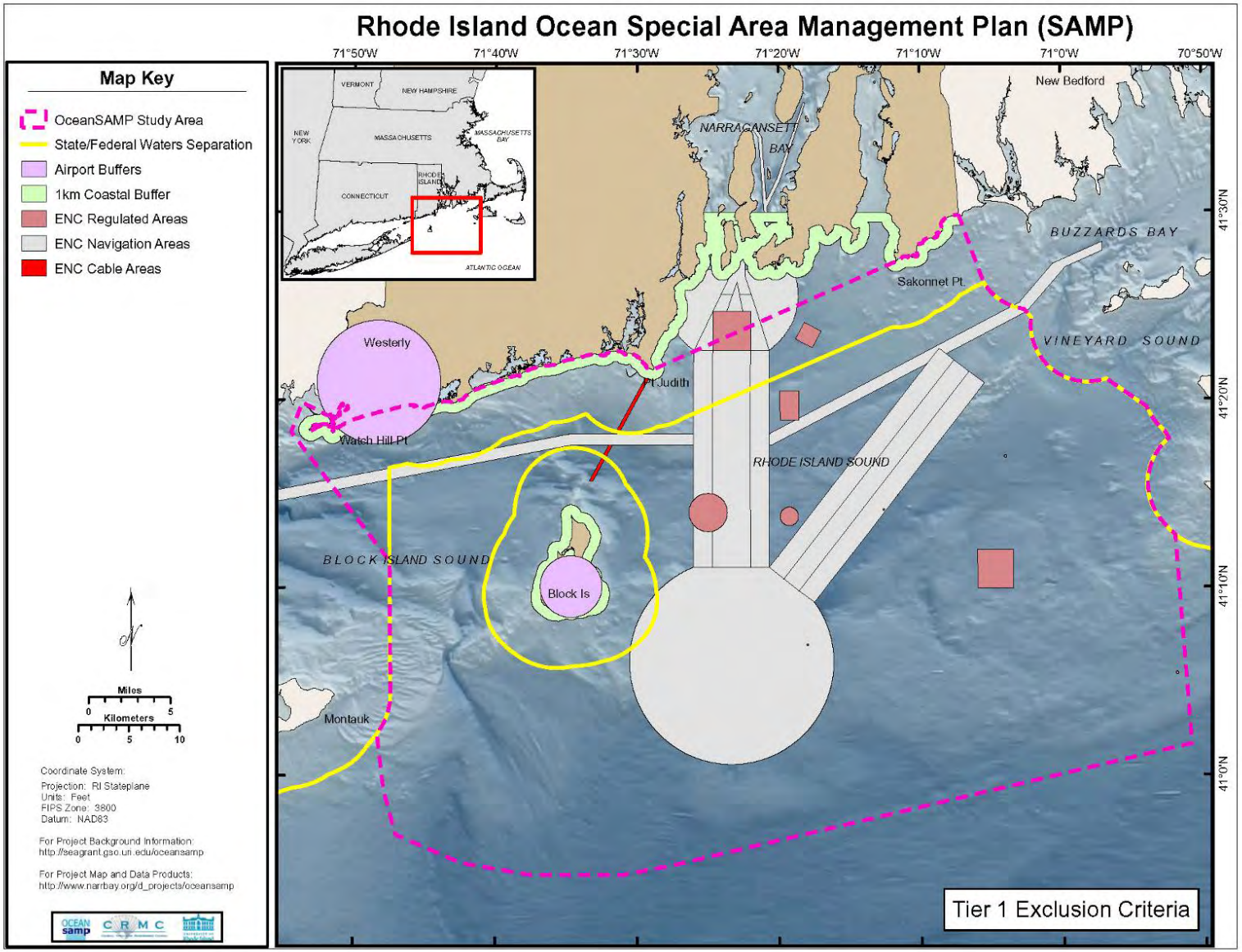
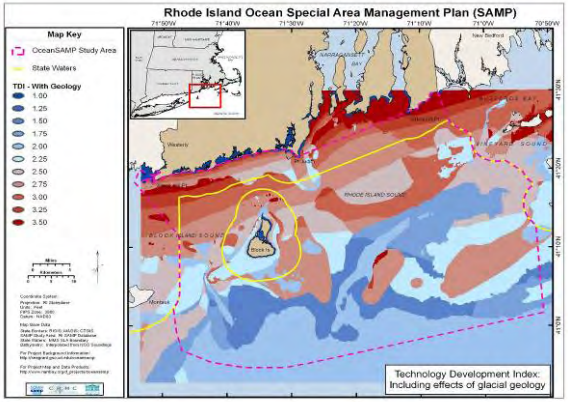
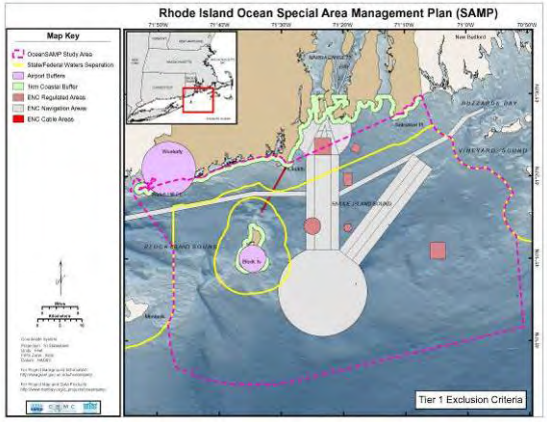
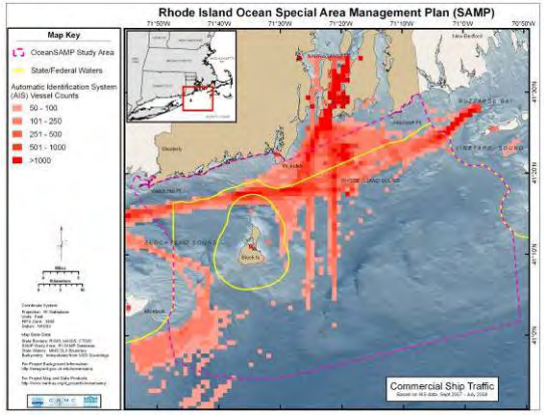

Rhode Island Ocean Special Area Management Plan (SAMP)
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
Map Key
OceanSAMP Study Area
State/Federal Waters Separation
Airport Buffers
1km Coastal Buffer
ENC Regulated Areas
ENC Navigation Areas
ENC Cable Areas
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
RHODE ISLAND
CONNECTICUT
ATLANTIC OCEAN
New Bedford
NARRAGANSETT BAY
BUZZARDS BAY
Sakonnet Pt
VINEYARD SOUND
Westerly
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Miles
0 5
Kilometers
0 5 10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
CRMC
Tier 1 Exclusion Criteria

Figure 8.26. Exclusions used in the Tier 1 Analysis by Spaulding et al. 2010b.

TDI< 3.0 - Excluded Areas - Areas AIS >50 Counts







Tier 1 Results

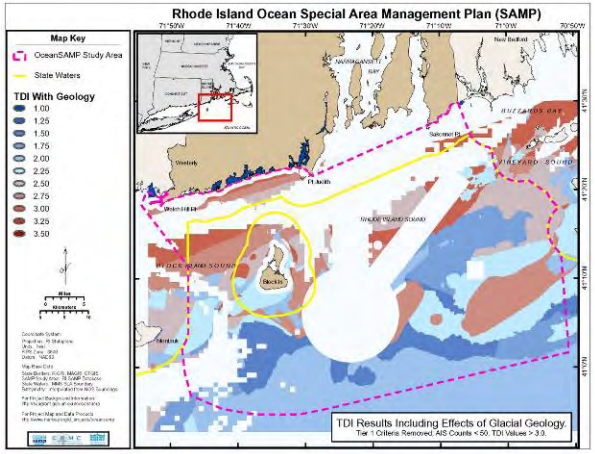


Figure 8.27. Schematic of the data layers used in the Tier 1 Analysis.

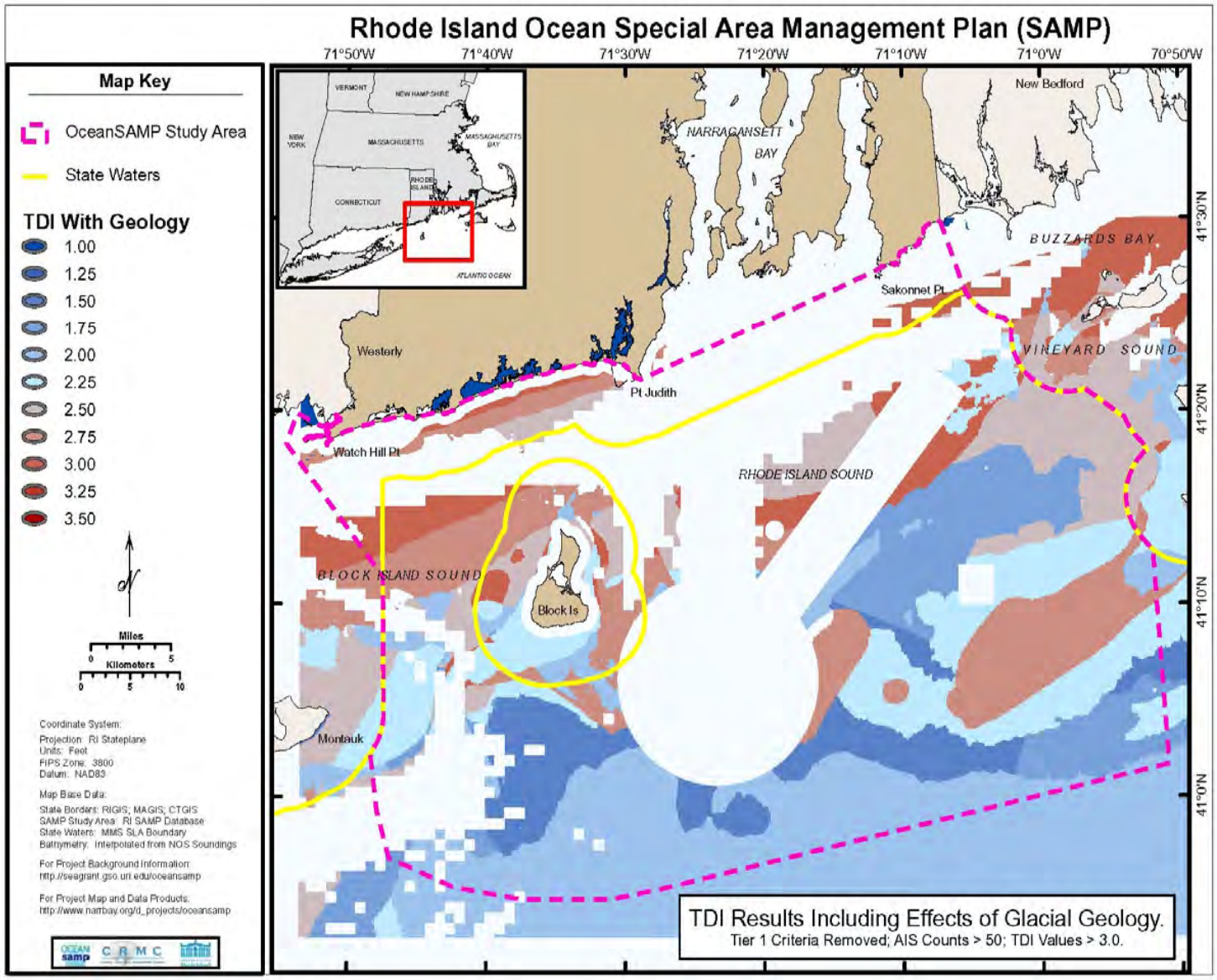

Rhode Island Ocean Special Area Management Plan (SAMP)
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
Map Key
OceanSAMP Study Area
State Waters
TDI With Geology
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
Miles
0 5
Kilometers
0 5 10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
Map Base Data:
State Borders: RIGIS; MAGIS; CTGIS
SAMP Study Area: RI SAMP Database
State Waters: MMS SLA Boundary
Bathymetry: Interpolated from NOS Soundings
For Project Background Information:
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For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
RHODE ISLAND
CONNECTICUT
ATLANTIC OCEAN
NARRAGANSETT BAY
New Bedford
BUZZARDS BAY
Sakonnet Pt
VINEYARD SOUND
Westerly
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
TDI Results Including Effects of Glacial Geology.
Tier 1 Criteria Removed; AIS Counts > 50; TDI Values > 3.0.

Figure 8.28. Map of Tier 1 Analysis of the Ocean SAMP area.

7. A review of the results of the TDI Tier I analysis, with a focus on potential sites for offshore wind development in state waters, shows that the best location is south of Block Island. The value of the TDI in this area is about 2.25 to 2.5. This compares to values of 2.75 or higher in state waters adjacent to the southern Rhode Island coastline. In this region, while water depths are generally low, and hence the technology challenge is low, the wind power is low given the proximity to land and its enhanced roughness. South of Block Island the water depths are deeper but the wind power is considerably higher and hence is the most suitable site in state waters, based on the TDI analysis.

8. A higher resolution TDI analysis was performed by Spaulding et al. (2010c) focusing on the waters south of Block Island to provide a more detailed understanding of the potential for offshore wind energy development in this area. The same type of analysis described above for the Tier I analysis was performed concentrating on the waters south of Block Island. First, the bathymetry was examined (see Figure 8.29). Next, a construction effort map was generated by University of Rhode Island researchers.[39] The map is based on high resolution (250 m [820 feet] track line spacing) side scan and sub-bottom profiling data collected by King, with interpretation of seabed surface geology by Boothroyd and Oakley and sub seabed geology by King and Pockalny. The construction effort ranged from 1 to 5 (see Figure 8.30), and was consistent with the construction effort calculations of the TDI Tier I analysis (Spaulding et al. 2010b). Due to a lack of physical data for several areas south of the state water boundary, construction effort has been estimated for these locations based on the large scale glacial geology. However, data from boring samples collected at eight sites were used to support the construction effort values generated for this area.[40] Lastly, wind speed data at 80 meters (262.5 feet) above the sea surface were mapped (see Figure 8.31) and combined with the construction effort map to generate TDI values for the area (see Figure 8.32). The TDI values for the area south of Block Island calculated during this high resolution analysis did vary from the large-scale analysis described above due to the level of detail in the data used. A second set of wind speed data was analyzed in this high resolution TDI. The results of the analysis using this alternative set of wind data illustrate very similar results and therefore are not described here, though they are presented in Spaulding et al. (2010c).

[39] URI Researchers John King and Rob Pockalny, Graduate School of Oceanography and Jon Boothroyd and Brian Oakley, Geosciences generated the construction effort maps shown.

[40] Chris Baxter, URI Ocean Engineering, reviewed data from boring logs (typically 65 m in depth) that DeepWater Wind (DWW) collected at eight sites in the study area, SE of Block Island. Based on this data and his review of the construction effort maps he has developed a scaling factor of 1 for CE 1-2, 1.5 for CE-3, 1.8 for CE 4-5, and 2.2 for CE 5.

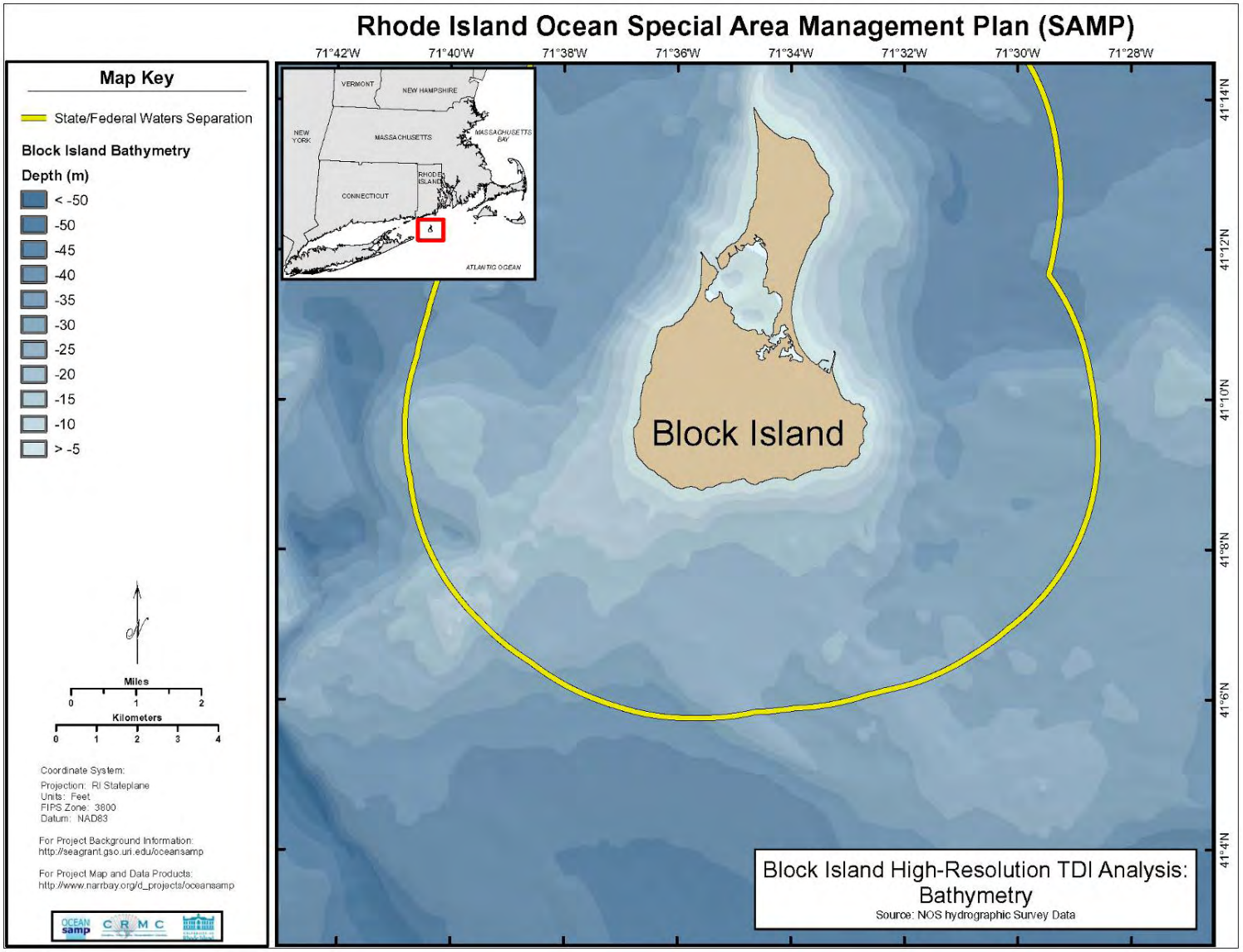


Figure 8.29. Bathymetry of the area south of Block Island.

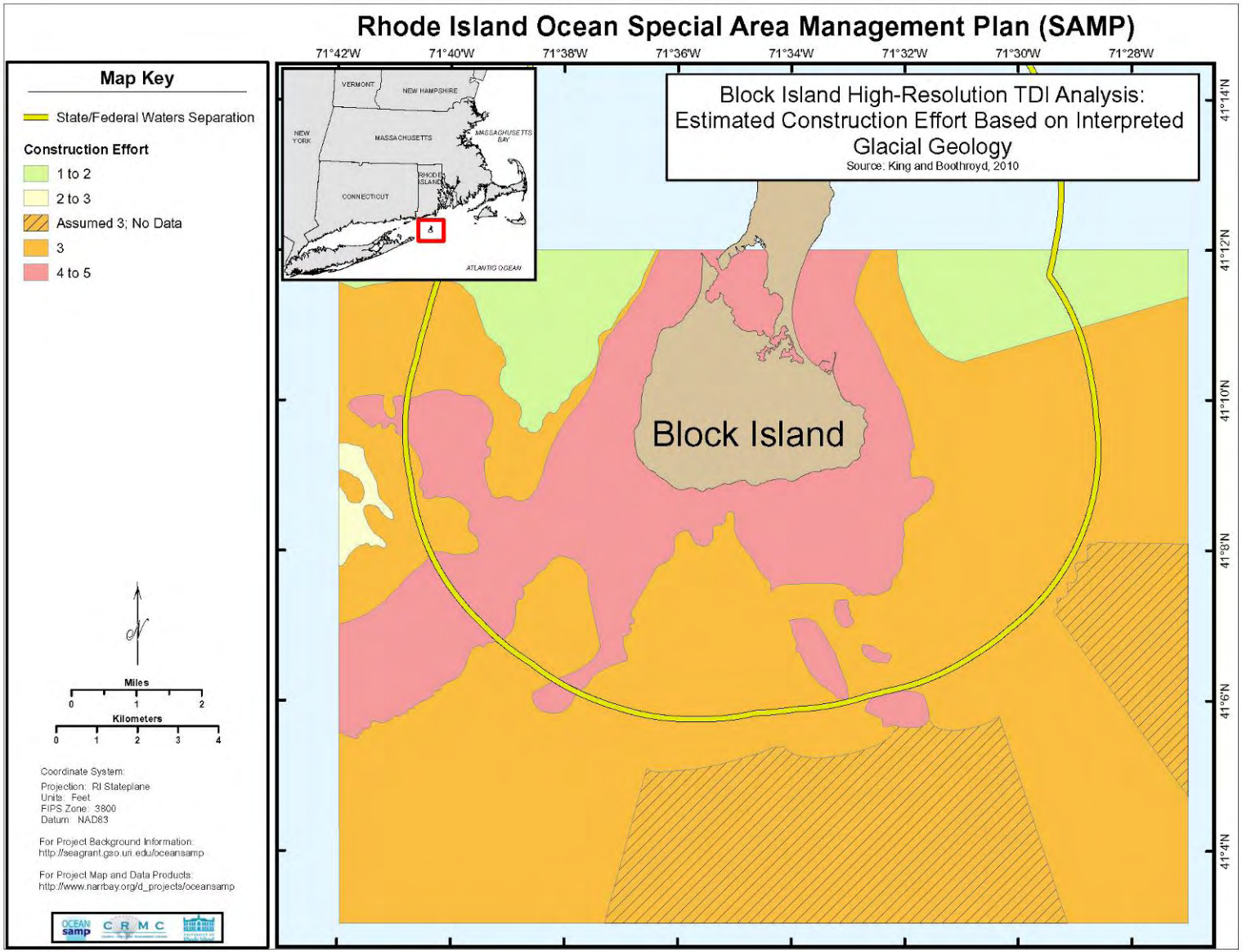

Rhode Island Ocean Special Area Management Plan (SAMP)
71°42'W
71°40'W
71°38'W
71°36'W
71°34'W
71°32'W
71°30'W
71°28'W
41°14'N
41°12'N
41°10'N
41°8'N
41°6'N
41°4'N
Map Key
State/Federal Waters Separation
Construction Effort
1 to 2
2 to 3
Assumed 3; No Data
3
4 to 5
Block Island High-Resolution TDI Analysis:
Estimated Construction Effort Based on Interpreted Glacial Geology
Source: King and Boothroyd, 2010
Block Island
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
Miles
0 1 2
Kilometers
0 1 2 3 4
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
CRMC

Figure 8.30. Estimated construction effort of the area south of Block Island based on interpreted glacial geology.

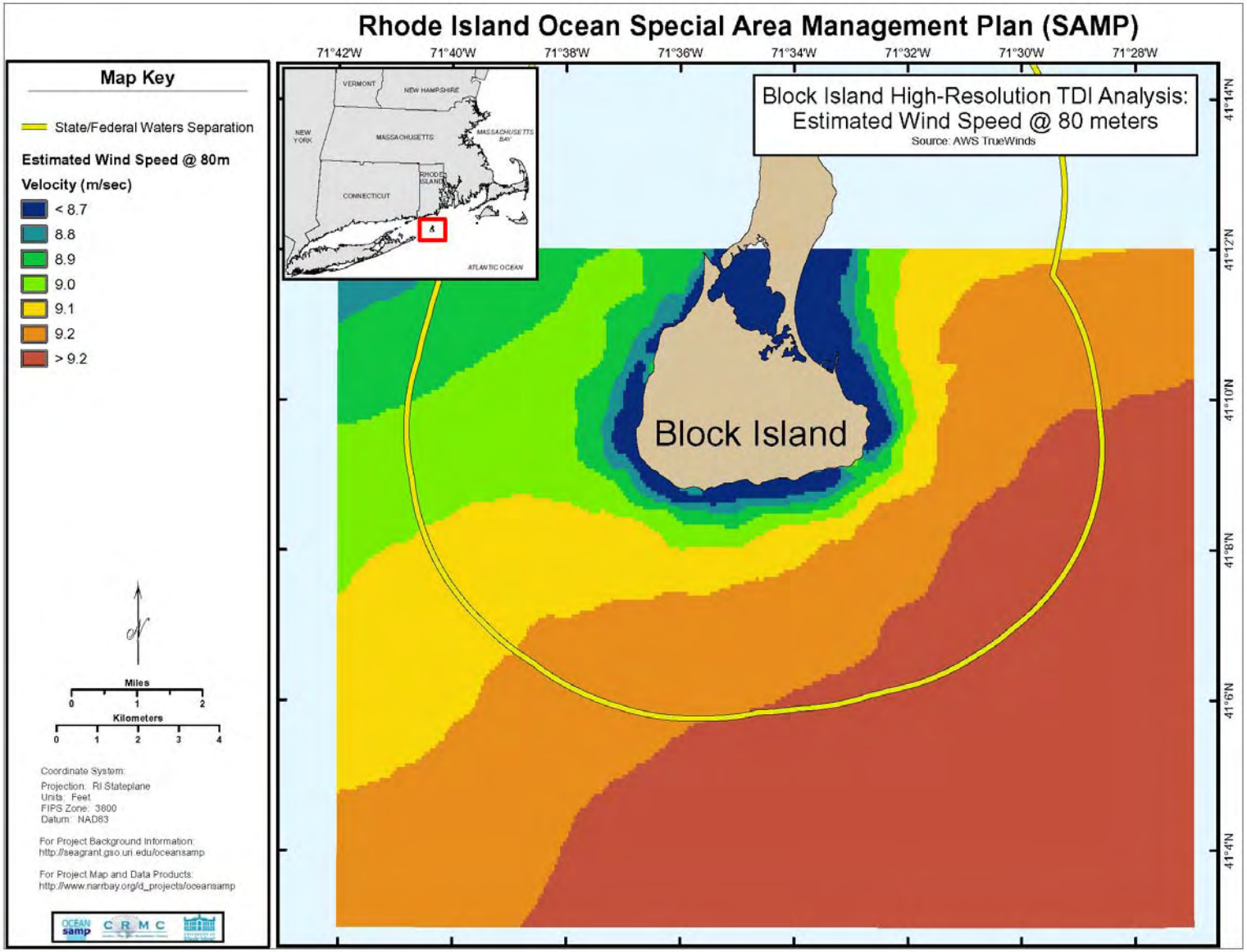

Rhode Island Ocean Special Area Management Plan (SAMP)
71°42'W
71°40'W
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71°34'W
71°32'W
71°30'W
71°28'W
41°14'N
41°12'N
41°10'N
41°8'N
41°6'N
41°4'N
Map Key
State/Federal Waters Separation
Estimated Wind Speed @ 80m
Velocity (m/sec)
< 8.7
8.8
8.9
9.0
9.1
9.2
> 9.2
Block Island High-Resolution TDI Analysis:
Estimated Wind Speed @ 80 meters
Source: AWS TrueWinds
Block Island
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
Miles
0 1 2
Kilometers
0 1 2 3 4
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
CRMC

Figure 8.31. Estimated wind speed south of Block Island at 80 meters above the sea surface.

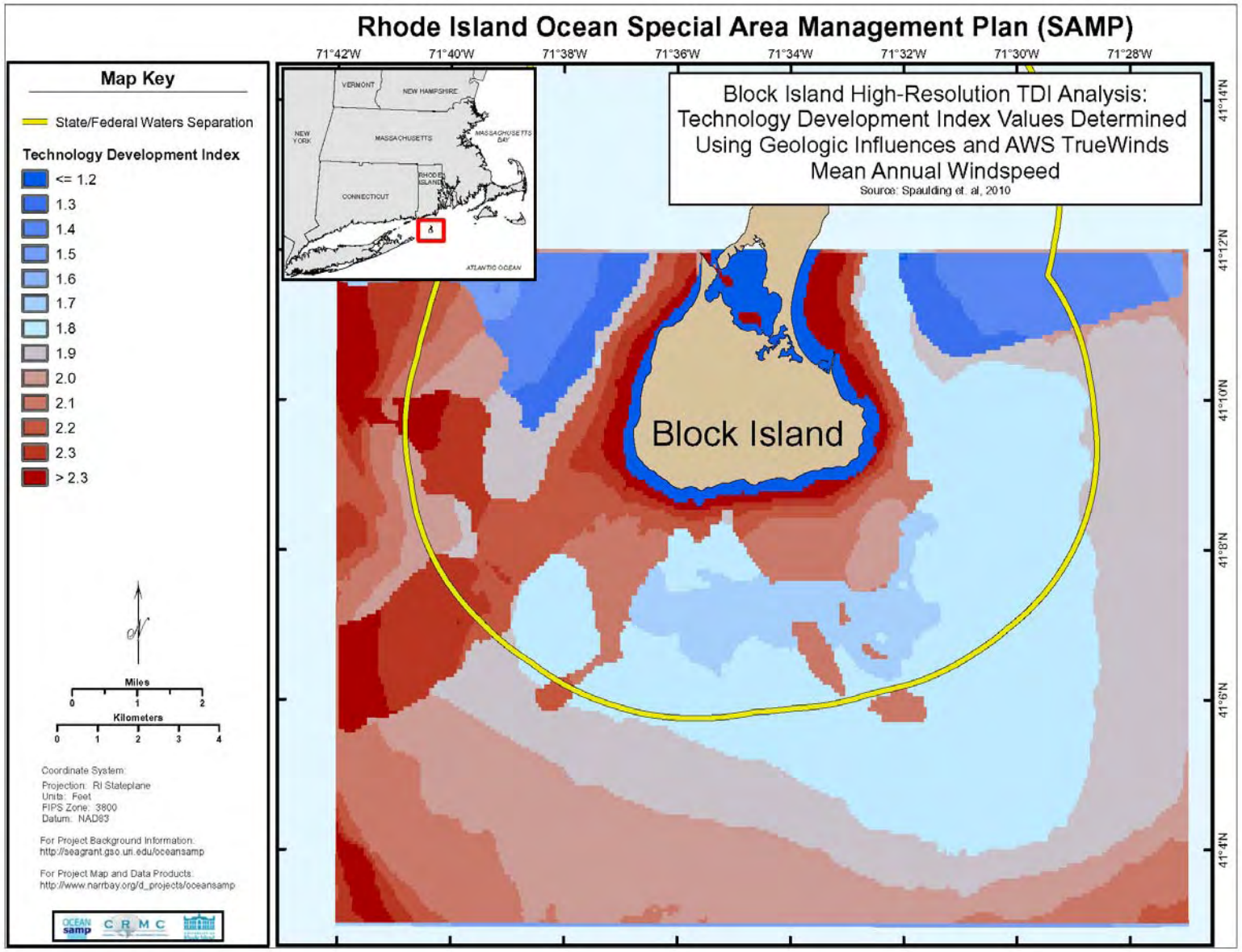

Rhode Island Ocean Special Area Management Plan (SAMP)
71°42'W
71°40'W
71°38'W
71°36'W
71°34'W
71°32'W
71°30'W
71°28'W
41°14'N
41°12'N
41°10'N
41°8'N
41°6'N
41°4'N
Map Key
State/Federal Waters Separation
Technology Development Index
<= 1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
> 2.3
Block Island High-Resolution TDI Analysis: Technology Development Index Values Determined Using Geologic Influences and AWS TrueWinds Mean Annual Windspeed
Source: Spaulding et. al, 2010
Block Island
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
RHODE ISLAND
CONNECTICUT
ATLANTIC OCEAN
Miles
0 1 2
Kilometers
0 1 2 3 4
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
C R M C

Figure 8.32. Non-dimensional TDI values for the area south of Block Island.

9. Similar to the analysis performed in the Tier I TDI analysis, areas with hard constraints were excluded (see description above). As the only hard constraint relevant to this area was the exclusion of the precautionary area and areas with more than 50 records of commercial ship traffic an analysis of AIS data was conducted. Figure 8.33 shows the excluded areas where AIS data taken over one year recorded over 50 commercial vessels. After excluding areas of high commercial ship traffic and the designated precautionary area (see Figure 8.34), the remaining areas south of Block Island with low TDI values provide the basis for establishing a suitable zone for offshore renewable energy development. While some of this area may not be viable due to environmental considerations, the TDI analysis has narrowed down the waters within the Ocean SAMP area to be considered for offshore renewable energy development. For further discussion of the selection of a renewable energy zone in the Ocean SAMP area see Section 830.4.

10. Tools such as the TDI, can be applied to the site selection process conducted for any type of development project. Spaulding et al. (2010b and 2010c) apply the TDI analysis to offshore wind energy development, though this process may help to inform a multitude of future uses in the Ocean SAMP area. In addition, the criteria used in the Tier 1 analysis may be modified or expanded to best reflect areas that should be excluded from future development. A complete description of the formation and application of the TDI can be found in Spaulding et al. 2010b and 2010c.

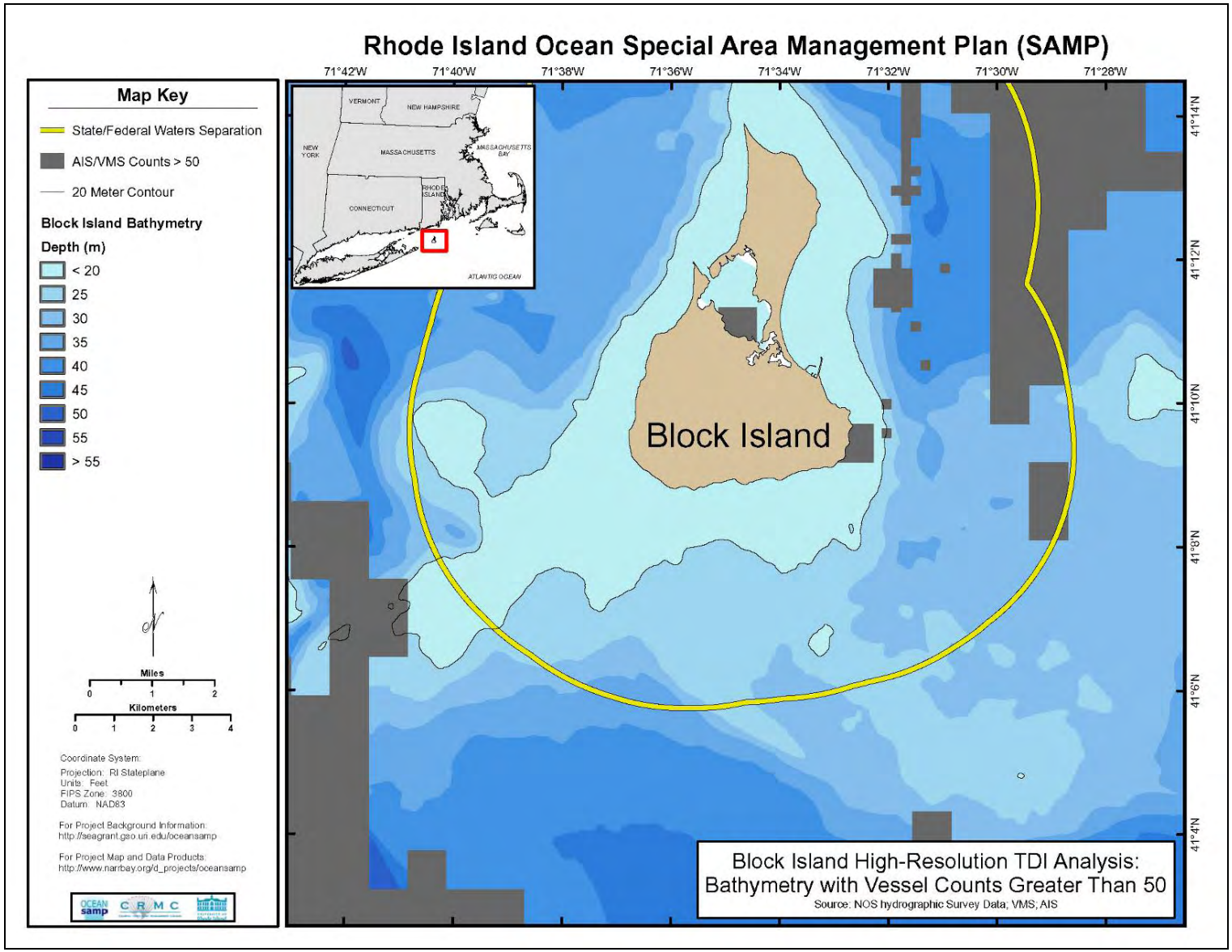

Rhode Island Ocean Special Area Management Plan (SAMP)
71°42'W
71°40'W
71°38'W
71°36'W
71°34'W
71°32'W
71°30'W
71°28'W
41°14'N
41°12'N
41°10'N
41°8'N
41°6'N
41°4'N
Map Key
State/Federal Waters Separation
AIS/VMS Counts > 50
20 Meter Contour
Block Island Bathymetry
Depth (m)
< 20
25
30
35
40
45
50
55
> 55
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
Block Island
Miles
0 1 2
Kilometers
0 1 2 3 4
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
CRMC
Block Island High-Resolution TDI Analysis:
Bathymetry with Vessel Counts Greater Than 50
Source: NOS hydrographic Survey Data; VMS; AIS

Figure 8.33. Areas south of Block Island with AIS vessel counts greater than 50.

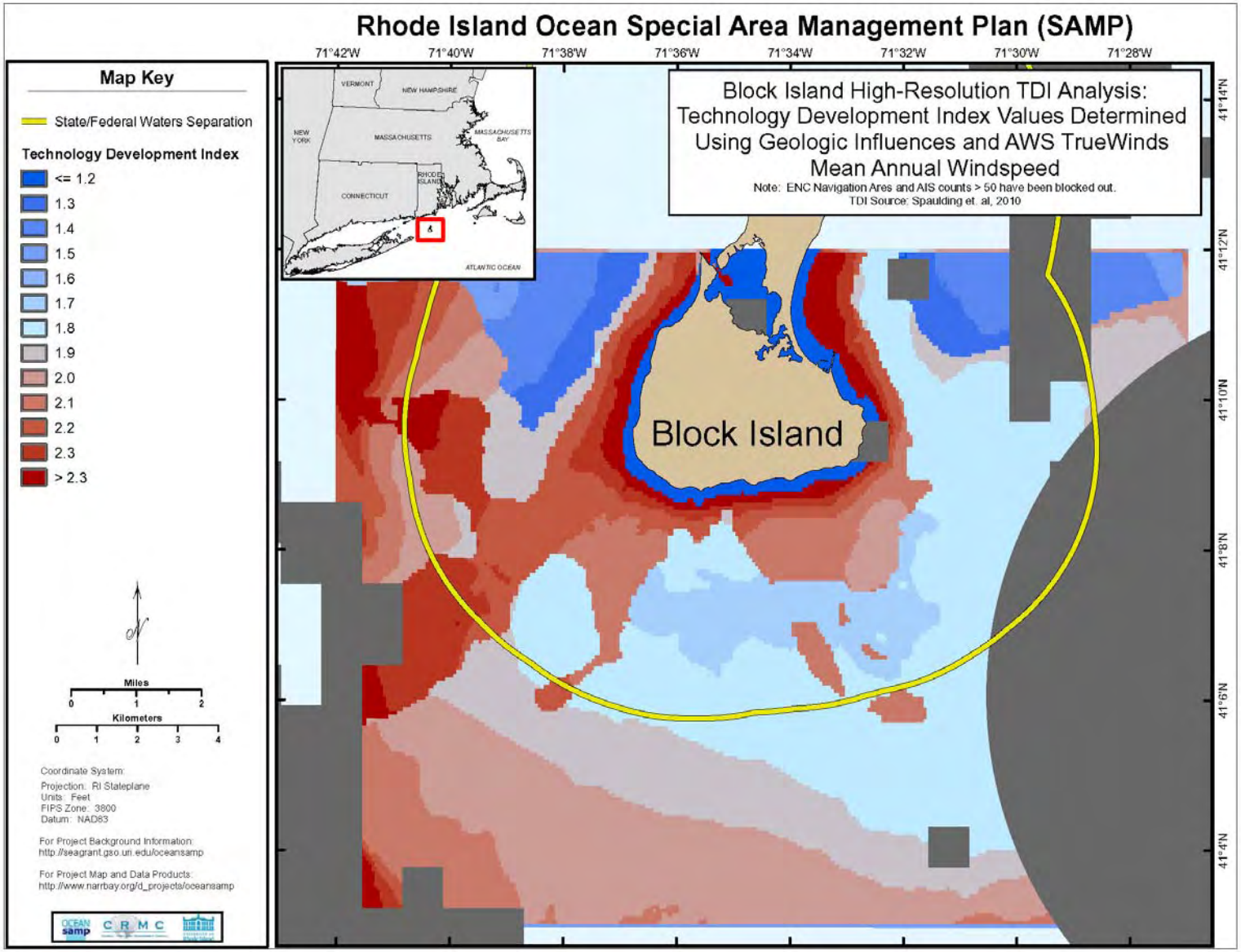

Rhode Island Ocean Special Area Management Plan (SAMP)
71°42'W
71°40'W
71°38'W
71°36'W
71°34'W
71°32'W
71°30'W
71°28'W
41°14'N
41°12'N
41°10'N
41°8'N
41°6'N
41°4'N
Map Key
State/Federal Waters Separation
Technology Development Index
<= 1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
> 2.3
Block Island High-Resolution TDI Analysis:
Technology Development Index Values Determined
Using Geologic Influences and AWS TrueWinds
Mean Annual Windspeed
Note: ENC Navigation Ares and AIS counts > 50 have been blocked out.
TDI Source: Spaulding et. al, 2010
Block Island
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
Miles
0 1 2
Kilometers
0 1 2 3 4
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
C R M C

Figure 8.34. Non-dimensional TDI Analysis of the area south of Block Island with exclusions.

830.3. Selection of Suitable Sites

1. The results of the TDI analysis, described in Section 830.2, identified the waters south of Block Island as a potentially viable site for offshore renewable energy development. This area has the fastest mean wind speeds at 80 meters and the lowest TDI value within state waters. The focus of this section is on suitable sites for offshore wind energy within state waters because these are the waters in the Ocean SAMP area where the CRMC is authorized to "grant licenses, permits and easments for the use of coastal resources."[41] Other suitable sites may exist in federal waters, though the leasing of those potential sites for offshore wind energy development falls under the jurisdiction of BOEMRE (see Section 820.4 and Chapter 10, Existing Statutes, Regulations and Policies for further discussion)

2. In establishing the location of the Renewable Energy Zone in the Ocean SAMP area, consideration was given to minimizing the potential impact to natural resources (benthic ecology, birds, marine mammals, sea turtles, fisheries resources and habitat) and existing human uses (commercial and recreational fishing, cultural and historic sites, recreation and tourism, marine transportation, navigation and infrastructure). For more information on the potential effects considered when siting an offshore renewable energy facility see Section 850. In addition to considering the wind resources, bathymetry, geology, and the hard constraints of the TDI analysis (described in Section 830.2), the Renewable Energy Zone was established considering areas identified within the Ocean SAMP area as Areas of Particular Concern, Areas Designated for Preservation, or other areas including: historic shipwrecks, archeological or historic sites; offshore dive sites; fish habitat areas; navigation and military use areas, and areas with existing infrastructure; sea duck foraging habitat; and areas of high intensity commercial ship traffic. For more information on Areas of Particular Concern, Areas Designated for Preservation, and other areas idenitified within the Ocean SAMP area see Section 860.2.2, 860.2.3, and 860.2.4.

3. A Renewable Energy Zone, approximately 2 km wide (landward from state water boundary), extending from a location east to southwest of Block Island has been selected as the most suitable area for offshore renewable energy development in the Ocean SAMP area. This zone is graphically depicted in Figure 8.35. The latitude and longitude locations of the corner points are provided below (see Table 8.9):

Table 8.9. Coordinates of the Ocean SAMP Renewable Energy Zone.
(Note: Coordinates in table differ from Figure 8.36 which is expressed in Decimal Degrees)

Coordinates of the Northern Boundary of the Ocean SAMP Renewable Energy Zone	41° 7' 29.208"	-71° 37' 58.26"
	41° 7' 25.0212"	-71° 31' 46.6032"
	41° 10' 7.2042"	-71° 30' 7.6788"
Coordinates of the Southern Boundary of the Ocean SAMP Renewable Energy Zone	41° 6' 50.907"	-71° 39' 12.366"
	41° 6' 45.8994"	-71° 30' 28.533"
	41° 9' 45.8634"	-71° 28' 37.4118"

[41] R.I. Gen. Law § 46-23-6(4)(iii)

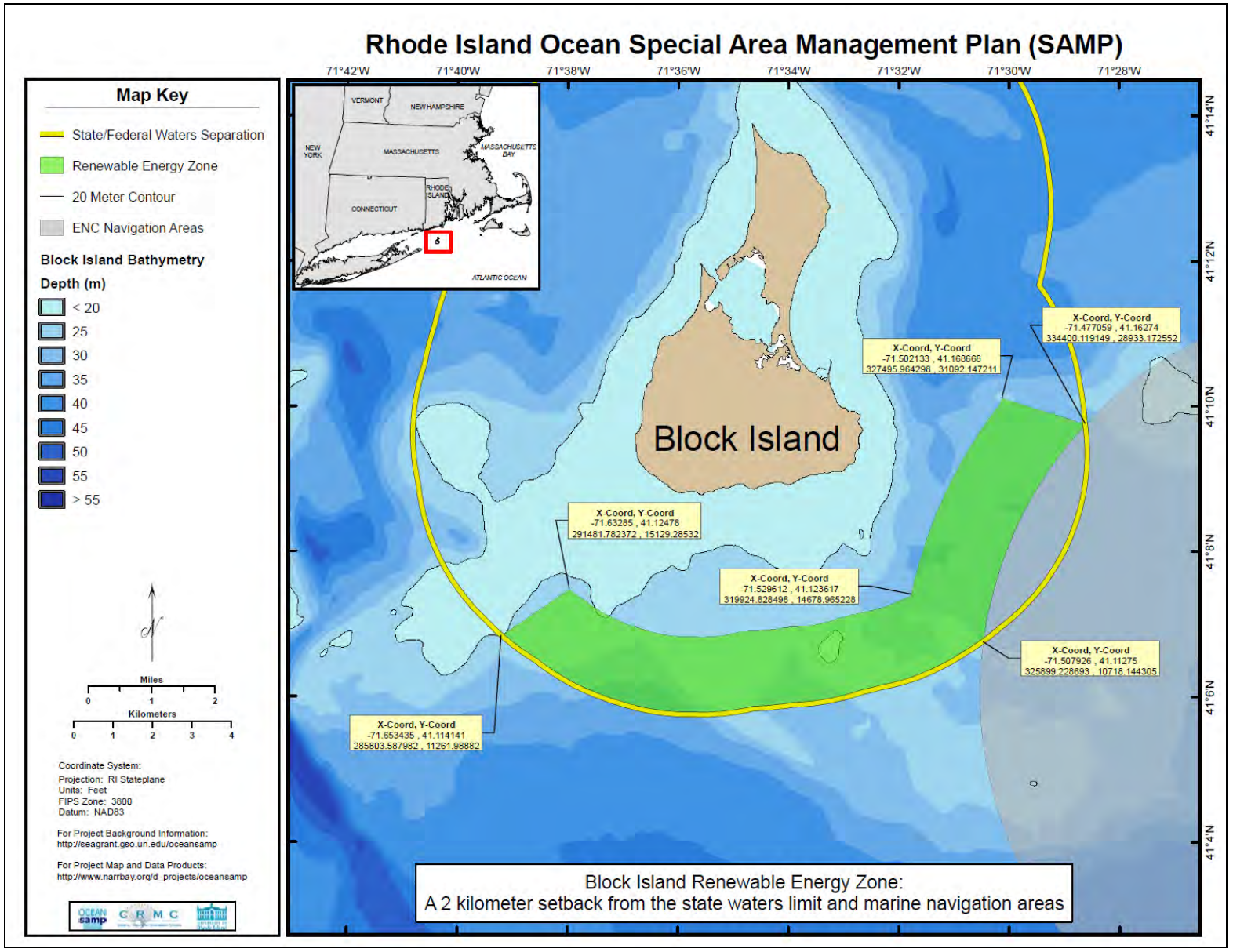

Rhode Island Ocean Special Area Management Plan (SAMP)
71°42'W
71°40'W
71°38'W
71°36'W
71°34'W
71°32'W
71°30'W
71°28'W
41°14'N
41°12'N
41°10'N
41°8'N
41°6'N
41°4'N
Map Key
State/Federal Waters Separation
Renewable Energy Zone
20 Meter Contour
ENC Navigation Areas
Block Island Bathymetry
Depth (m)
< 20
25
30
35
40
45
50
55
> 55
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
RHODE ISLAND
CONNECTICUT
ATLANTIC OCEAN
Block Island
X-Coord, Y-Coord
-71.477059 , 41.16274
334400.119149 , 28933.172552
X-Coord, Y-Coord
-71.502133 , 41.168668
327495.964298 , 31092.147211
X-Coord, Y-Coord
-71.63285 , 41.12478
291481.782372 , 15129.28532
X-Coord, Y-Coord
-71.529612 , 41.123617
319924.828498 , 14678.965228
X-Coord, Y-Coord
-71.507926 , 41.11275
325899.228693 , 10718.144305
X-Coord, Y-Coord
-71.653435 , 41.114141
285803.587982 , 11261.98882
Miles
0 1 2
Kilometers
0 1 2 3 4
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
Block Island Renewable Energy Zone:
A 2 kilometer setback from the state waters limit and marine navigation areas

Figure 8.35. Renewable Energy Zone south of Block Island (Note: Coordinates expressed in Decimal Degrees).

Section 840. Potential Economic Effects of Offshore Renewable Energy in the Ocean SAMP Area

840.1. Port Development and Job Creation

1. The Port of Quonset/Davisville has the potential to become a staging area for offshore wind energy construction activities. The port features include deep-water capacity (a depth of 30 feet [9.1 m]), and two piers that are 1,200 feet [365.9 m] in length. These features may allow it to accommodate the construction and transport vessels used during the facility's installation. In addition to the draft and length of its piers, the load bearing capacity of Pier 2 exceeds 1,000 pounds per square foot [4,890 kg/m^2] which makes it capable of holding the weight of the large offshore structures (MMS 2009a). Future use of local port facilities for the construction staging areas may also result in improvements or upgrades to current infrastructure.[42] See Chapter 7, Marine Transportation, Navigation and Infrastructure for more information on Quonset/Davisville.

2. If Quonset/Davisville were to become a staging area for offshore wind energy construction activities, the economic impact of these activities may contribute to local economies as well as Rhode Island's economy as a whole. Direct economic impacts would result from the hiring of manufacture, assembly, construction and operations workers, and the purchase of non-labor goods and services. Goods and services that may be purchased in Rhode Island to directly support the construction and operation of an offshore wind energy facility may include: concrete, steel, barge services, purchase or lease of vessels and equipment. Indirect and induced economic effects may result from activities such as local vendors replacing their inventory, or the spending of new hires (MMS 2009a).

3. While the impact of offshore wind energy development on Rhode Island's economy will vary depending on the project, Table 8.10 provides one example of the scale of economic impact the construction and operation of an offshore wind energy facility may have on surrounding communities. While these figures cannot be applied directly to offshore wind energy development in the Ocean SAMP area, it does suggest that large, utility-scale offshore wind projects have the potential to generate millions of dollars in economic activity and support a number of new jobs.

[42] Waterside improvements proposed as part of constructing the wind facility may be subject to additional state and federal permitting.

Table 8.10. Total economic impact of the Cape Wind Energy Project on the local, state and regional economies (Global Insight 2003; MMS 2009a).

Construction and Installation Phase	• 597 - 1,013 direct, indirect, and induced full-time jobs created o 391 direct full-time jobs o 206-622 indirect and induced jobs • Total State economic output will increase $85 - $137 million annually o Value added will increase $44 - $71 million annually • Wages of $32 - $52 million annually • $9.2- $14.8 million annually in increased property income (rent, dividends and interest, corporate profits) • $4.8-$7.8 million in increased personal income tax revenue • $1.3-2.6 million in increased corporate income tax revenue
Operational Phase	• Approximately 50 direct jobs, and 104 indirect and induced jobs • Wages of approximately $6.9 million annually • $21.8 million in State output, $10.2 million in value added • $16 million in annual purchases to maintain facility

4. Because Quonset/Davisville have been considered as a potential staging area for proposed offshore wind energy projects outside the Ocean SAMP area (e.g. the Cape Wind Energy Project), Rhode Island may also benefit from the economic impact of any regional offshore renewable energy development. The Cape Wind Energy Project, Final Environmental Impact Statement (MMS 2009a) estimated that the Rhode Island economic impact from the manufacturing, assembly, construction and installation of this project would include:

   - 237 Rhode Island jobs directly related to manufacturing, assembly, construction and installation activities;
   - $32.4 million in wages over 27 months;
   - $360 – 410 million in purchases of non-labor goods and services;
   - $180.6 – 292 million annual increase in total output for Rhode Island;
   - $93.3- 151 million annual increase in value-added;
   - $19.6 – 31.5 million annual increase in Rhode Island property income (rent, dividends and interest, corporate profits); and
   - $2.8 – 4.5 million in increased revenue from corporate income taxes.

5. In February 2010, Quonset Development Corporation was awarded a $22.3 million Transportation Investment Generating Economic Recovery (TIGER) grant from the US Department of Transportation (Rhode Island Economic Development Corporation 2010b). The grant will be used to support infrastructure improvements to the Port of Davisville piers and terminals in the Quonset Business Park including activities such as pier repairs, deck surfacing and marine hardware, rebuilding of rail tracks in the port area, terminal improvements, construction of crane platforms and the purchase of a

crane suitable to load and off load offshore wind turbine components, substructures and foundations. The projects are designed to further support the potential role of Quonset/Davisville as a hub for the emerging offshore wind energy industry (Rhode Island Economic Development Corporation 2010b).

840.2. Electricity Rates

1. Under Rhode Island's Long-Term Contracting Standard for Renewable Energy, energy distributors (i.e. National Grid) are required to sign 10- to 15-year contracts to buy a minimum of 90 MW of its electricity load from renewable developers and up to 150 megawatts from utility-scale offshore wind energy facilities developed off the coast of Rhode Island (see Section 810.2).[43] These long-term contracts, referred to as Power Purchase Agreements, outline how much, and at what price, energy from a renewable energy producer will be purchased by a utility company. Power purchase agreements provide assurances to developers that the power produced by a project will be purchased at a stated price, which may in turn aid a developer in obtaining financing for a project. In addition, power purchase agreements define the purchase price of the renewable energy over many years, allowing utility companies to identify energy costs well in advance. The cost of conventional fuel sources, such as natural gas, varies with the market and result in greater volatility in energy prices. Depending on the prices agreed upon in the power purchase agreement, the effect of offshore renewable energy development in the Ocean SAMP area may result in higher or lower electricity rates for Rhode Island residents.

2. One argument is that offshore wind energy may exert downward pressure on electricity rates in Rhode Island and the entire New England region, resulting in overall lower energy prices. The U.S. Department of Energy (2004) notes that as renewable energy generation increases, the demand for natural gas in the electric generation sector is reduced, resulting in overall lower demands for this finite resource. Lower demand may put downward pressure on natural gas prices overall and result in an economic benefit to consumers in both the electricity and natural gas end-user markets. Likewise, the electric industry has also called for greater fuel diversity to alleviate its reliance on limited fuel sources in an effort to reduce electricity prices (U.S. Department of Energy 2004). While the amount of potential reduction in energy prices will vary depending on the project, a recent analysis of the impact the Cape Wind Energy Project would have on New England electricity prices determined that:
    - Adding Cape Wind would lead to a reduction in the wholesale cost of power averaging $185 million annually over the 2013-2037 time period, resulting in an aggregate savings of $4.6 billion over 25 years.
    - With Cape Wind in service, over the 2013-2037 time period, the price of power in the New England wholesale market would be on average $1.22/MWh lower (Charles Rivers Associates 2010).

[43] R.I. Gen. Law §39-26.1

3. Potential benefits of lower electricity rates from offshore renewable energy development in the Ocean SAMP area may be most pronounced on Block Island, as residents there currently experience the highest electricity rates in Rhode Island (see also Section 810.1). The electricity rates on Block Island have recently hovered between 30 cents and 40 cents a kilowatt-hour, but in the summer of 2008 it went as high as 62 cents (see Table 8.11) (Rhode Island Public Utilities Commission 2010a). The average rate for residential customers in Rhode Island during 2008 was calculated to equal 17.45 ¢/kWh (see Figure 8.36) (U.S. Energy Information Administration 2008a). Offshore wind energy development in the Ocean SAMP area may provide a cheaper form of energy to Block Island residents, or it may facilitate a connection to the mainland utility grid and access to lower electricity rates through the installation of an underwater transmission cable.

Table 8.11. Summary of Block Island residential electric rates, January 2008- December 2009 (Rhode Island Public Utilities Commission 2010b).

Month	Total Charge for Electricity (¢/kWh)*
Jan-08	34.23
Feb-08	33.57
Mar-08	34.55
Apr-08	40.59
May-08	40.20
Jun-08	61.07
Jul-08	62.18
Aug-08	56.77
Sep-08	54.18
Oct-08	37.57
Nov-08	32.99
Dec-08	29.99
Jan-09	24.92
Feb-09	21.15
Mar-09	23.90
Apr-09	23.32
May-09	24.10
Jun-09	41.37
Jul-09	41.55
Aug-09	43.68
Sep-09	42.40
Oct-09	27.42
Nov-09	30.24
Dec-09	29.99
* Total Charge for Electricity (¢/kWh) includes all customer, energy and fuel charges.	

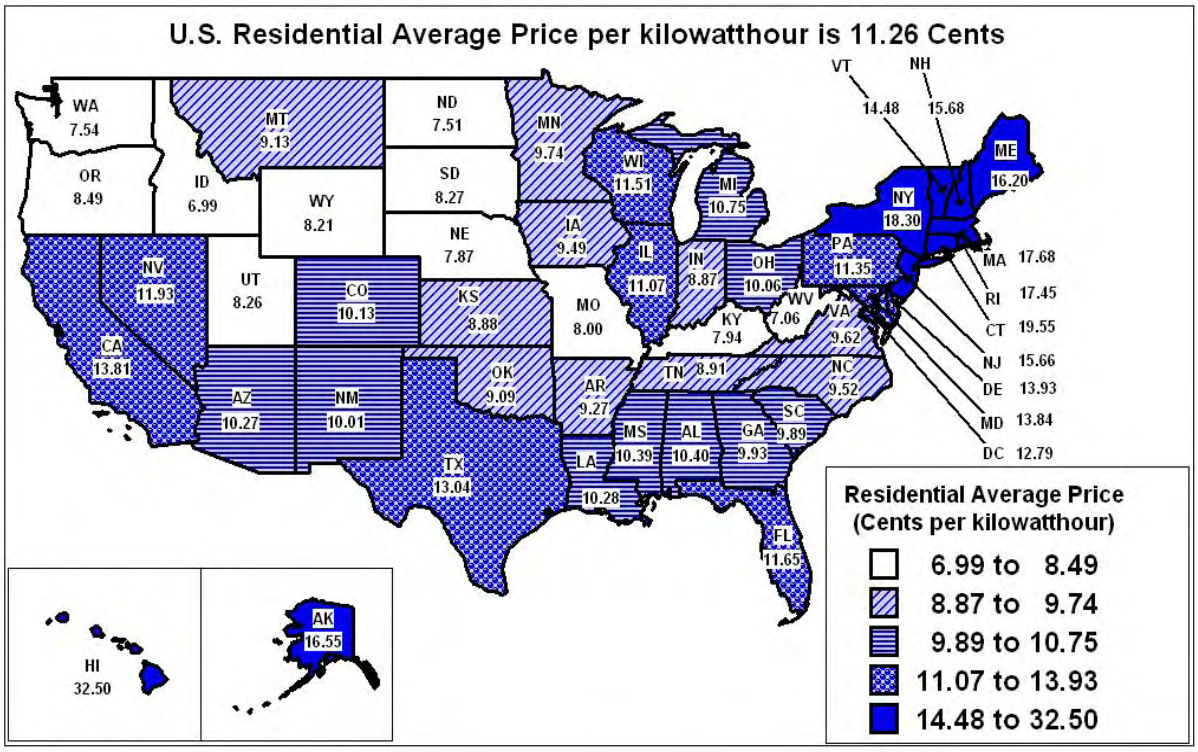


Figure 8.36. Average U.S. residential electricity rates in 2008 (U.S. Energy Information Administration 2008a).

4. Alternatively, the energy produced from an offshore wind energy facility may result in higher electricity rates, especially as the offshore renewable energy industry in the U.S. is just beginning to develop. The price per kilowatt hour of electricity produced from on offshore renewable energy facility will vary between projects.

840.3. Potential Revenue Sharing

1. In addition to the economic impacts associated with an offshore wind facility's construction and operation activities, Rhode Island may also receive a portion of any federal leasing or operating fees charged for use of public submerged lands.

2. Offshore wind energy facilities installed in U.S. federal waters are subject to annual lease payments and operating fees as determined by BOEMRE (formerly called the Minerals Management Service). Revenues subject to distribution to eligible States, as described in detail in the Mineral Management Service's Final Rule[44], include all bonuses and acquisition fees associated with the lease, rental fees and operating fees derived from the entire qualified project area and associated project easements (e.g. area used for the transmission cable) (see Table 8.12). Royalty payments are shared between the state (27%) and federal government (73%) when a coastal State's coastline

[44]30 CFR Parts 250, 285, and 290.

is located within 15 miles (24.1 km) of the calculated geographic center of the qualified project area. If more than one coastal state is within 15 miles (24.1 km) of a project, revenues will be shared between the states based on proximity to the project.

Table 8.12. Rental and operating fee equations used by BOEMRE for offshore renewable energy project (30 CFR Parts 250, 285, and 290).

Rental Fee = $3.00 * Total Acreage of Project
Operating Fee = Annual Energy Output (MWh) *Avg. Wholesale Electric Power Price ($/MWh) *2%

840.4. Non-Market Value

1. Beyond the economic effects associated with the development of offshore wind energy, future developments may also contribute non-market values to Rhode Island such as a reduction in greenhouse gas emissions from fossil fuels, support for clean energy development, and diversifying the state's energy resources. The reduction in greenhouse gases would have a mitigating impact on global change—reducing harmful environmental impacts at the source. This would also result in cutting back on—but not eliminating—adaptation techniques designed to reduce the inevitable impacts of climate change projections, such as sea level rise. This has a ripple effect on owners of homes and businesses along the coast who are facing problems such as sea level rise and erosion which result in more costly home designs and future required setbacks. For more information on the effects of global climate change to Rhode Island and the Ocean SAMP area see Chapter 3, Global Climate Change.

Section 850. Potential Effects on Existing Resources and Uses in the Ocean SAMP Area

1. Offshore renewable energy may potentially affect the natural resources and existing human uses of the Ocean SAMP area. Some effects may be negative, resulting in adverse impacts on these resources and uses. Alternatively, other effects may be neutral, producing no discernible impacts, while others may be positive, resulting in enhancements to the environment or to offshore human uses. The degree to which offshore renewable energy structures may affect the natural environment or human activities in the area varies in large part on the specific siting of a project. Careful consideration when planning the location of an offshore renewable energy facility, as well as the use of appropriate mitigation strategies during the construction, operation and decommissioning stages can minimize any potential negative impacts (MMS 2007a).

2. To date, most research on the potential effects of offshore renewable energy installations has been conducted in Europe, though some research has been conducted during the review of the proposed offshore wind farm project in Nantucket Sound by Cape Wind, LLC (MMS 2009a; U.S. Coast Guard 2009; Technology Service Corporation 2008). In anticipation of future offshore renewable energy development within the U.S., BOEMRE has identified potential impacts and enhancements of such development on marine transportation, navigation and infrastructure in the "Programmatic Environmental Impact Statement for Alternative Energy Development and Production" (PEIS) (MMS 2007a). These sources, as well as other scientific literature and relevant reports have informed this synthesis of the potential effects on existing resources and uses in the Ocean SAMP area. Where possible, research conducted as a part of the Ocean SAMP process has been incorporated to help further assess the potential for effects within the Ocean SAMP study area.

3. As presented in Section 810.3, offshore wind energy currently represents the greatest potential for utility-scale offshore renewable energy in the Ocean SAMP area. For that reason, the focus of this section is mainly on the potential effects from the development of offshore wind energy facilities. However, many of the potential effects discussed may be similar across all forms of offshore renewable energy development and offshore marine construction in general.

4. While this section is meant to provide a summary of all potential effects of offshore renewable energy development, the potential effects of a particular project will be thoroughly examined as part of the review conducted under the National Environmental Policy Act (NEPA).[45] The review process includes: an analysis of alternatives, an assessment of all environmental, social, and existing use impacts (i.e. ecological, navigational, economic, community-related, etc.), a review for regulatory consistency with other applicable federal laws and the implementation of mitigation measures. See Section 820.4 and Chapter 10, Existing Statutes, Regulations, and Policies for more

[45] 42 U.S.C. §4332

information on the NEPA review process, as well as other state and federal reviews and regulations relevant to offshore wind energy development.

5. This section begins with an examination of the potential effects of offshore renewable energy development on the physical environment through a discussion of the potential for avoided air emissions and the potential effects on coastal processes. Next, the potential effects of offshore renewable energy development on the ecological resources, including the benthic ecology, avian species, sea turtles, marine mammals and fish. Potential effects to human uses are then examined through a discussion of cultural and historic resources, commercial and recreational fishing activities, recreation and tourism and lastly marine transportation, navigation and infrastructure. The final section considers the potential cumulative effects of offshore renewable energy development.

Section 850.1. Avoided Air Emissions

1. The development of an offshore wind farm or any other offshore renewable energy project would have implications for air emissions within the state. While the development of a project will produce some air emissions (especially during the construction stage), a renewable energy project, by not burning fossil fuels, will produce far fewer emissions of carbon dioxide and conventional air pollutants. This section summarizes the effects of air emissions produced and avoided by the development of an offshore renewable energy project.

2. Air emissions produced during conventional fossil fuel energy production include carbon dioxide, sulfur dioxide, nitrogen oxides, volatile organic compounds, particulate matter, and carbon monoxide. These pollutants have been demonstrated to have detrimental impacts to human health and the environment. Exposure to poor air quality is a major health risk and health cost in the United States. Smog and particle pollution are the cause of decreased lung function, respiratory illness, cardiovascular disease, increased risk of asthma, and the risk of premature death (U.S. Department of Energy 2008). The largest sources of sulfur dioxide emissions are from fossil fuel combustion at power plants; sulfur dioxide has been linked to respiratory illnesses and is a major contributor to acid rain (U.S. EPA Office of Air and Radiation 2009). Nitrogen oxides combine with volatile organic compounds (VOCs) to form ozone, a major component of smog. Ozone can cause a number of respiratory problems in humans, and can also have detrimental effects on plants and ecosystems, including acid rain. Additionally, nitrogen dioxide has also been shown to cause adverse respiratory effects (U.S. EPA Office of Air and Radiation 2009). The effects of carbon dioxide emissions, the major contributor to global climate change, are discussed in further detail in Chapter 3, Global Climate Change.

3. The process of siting, constructing, and decommissioning an offshore renewable energy project of any kind would entail some adverse impacts to air quality through the

emission of carbon dioxide and conventional pollutants. Construction activity in the offshore environment would require the use of fossil fuel-powered equipment that will result in a certain level of air emissions from activities including pile installation, scour protection installation, cable laying, support structure and turbine installation, and other activities required for the development of a wind farm. During the pre-construction and installation stages, there would be some air emissions in the Ocean SAMP area from fossil fuel fired mobile sources such as ships, cranes, pile drivers and other equipment. Decommissioning would also result in some air emissions from the activities involved in the removal of the wind turbines, although emissions from decommissioning would be lower than those involved in construction (MMS 2009a). The size of an offshore renewable energy facility's carbon footprint will vary depending on the project, as the carbon footprint of a facility depends on project specific factors (e.g. size, location, technology, installation techniques, etc.) Any calculation of carbon footprint would include the pre-construction, construction, operation, and decommissioning phases of a project.

4. When considering the benefits of wind power displacing electricity generated from fossil fuels, the carbon dioxide (CO_2) emissions of manufacturing wind turbines and building wind plants need to be taken into account as well. White and Kulsinski (1998) found that when these emissions are analyzed on a life-cycle basis, wind energy's CO_2 emissions are extremely low—about 1% of those from coal and 2% of those from natural gas, per unit of electricity generated. The American Wind Energy Association has calculated that a single 1 MW wind turbine (operating at full capacity for one year) has the potential to displace up to 1,800 tons (1633 MT) of CO_2 per year compared with the current U.S. average utility fuel mix (made up of oil, gas, and coal) burned to produce the same amount of energy (AWEA 2009). The generation of renewable wind energy will result in avoided future emissions of CO_2 and will allow Rhode Island to meet targets set by the Regional Greenhouse Gas Initiative (RGGI) (See Section 810.1).

5. Developing offshore renewable energy sources in the form of wind turbines would have a positive impact on air emissions by displacing future air emissions caused by generating electricity. The level of avoided air emissions, and the net impact from renewable energy, will be dependent upon the future demands for electricity in Rhode Island, and the proportion of this which can be met by offshore wind farms and other renewable energy sources. At the very least, an offshore wind farm would have the effect of reducing the need for adding capacity for fossil-fuel generating plants in Rhode Island and throughout New England. At present, roughly 99% of the energy generated within Rhode Island comes from combined cycle natural gas, which is considered a marginal generator, in that it provides variable output which can easily be adjusted to meet demand (ISO New England Inc. 2009c). NO_x is the principal pollutant of concern for gas fired energy generation (MMS 2009a). Much of the electricity used within Rhode Island comes from the Brayton Point Power Station in Somerset, MA, the largest fossil-fueled generating facility in New England. The Brayton Point Power Station has three units that use coal and one that uses either natural gas or oil, for a combined output of over 1500 MW (Dominion 2010). The additional energy

production from wind turbines would be more likely to result in avoided air emissions from natural gas plants, which are marginal and would produce less energy in the event demand was lowered because of the additional output of wind turbines. Wind energy is also a marginal source, because wind speeds and thus energy output varies. The Brayton Point Power Station, which because of its reliance on coal is mostly a baseload generator, or one that does not change short term output depending on demand (because of the difficulties in doing so), would likely continue to produce energy at the same rate. Thus air emissions from this plant would not be avoided, at least in the short term.

6. A second important benefit of switching to a zero-emission energy generation technology like wind power is impact on air quality through reduced levels of nitrogen oxides, sulfur dioxide, and mercury emitted in electrical energy generation using fossil fuels. The Cape Wind FEIS determined that a wind farm would result in the net reduction in emissions of NO_x, a precursor of ozone, although only a slight reduction because of the levels of NO_x still being produced by power sources elsewhere (MMS 2009a).The emissions of sulfur dioxide and nitrogen oxides have declined significantly since the early 1990s (ISO New England Inc. 2009c). However, there still may be a benefit in terms of avoided future increases in emissions of NO_x and other pollutants if a project can meet increasing future energy demands. A reduction in these pollutants will have positive health effects for residents of the state of Rhode Island from the perspective of avoiding future respiratory illnesses.

Section 850.2. Coastal Processes and Physical Oceanography

1. The following section summarizes the general potential effects of a renewable energy project on coastal processes and physical oceanography in the Ocean SAMP area. The introduction of a number of large structures into the water column may have an effect on coastal processes such as currents, waves, and sediment transport. The potential effects to coastal processes as a result of offshore renewable energy development are dependent on the size, scale and design of the facility, as well as site specific conditions (i.e. localized currents, wave regimes and sediment transport). As a result, the potential effects will vary between projects and may even vary between different parts of a project site.

2. The potential effect of offshore renewable energy structures in the water column on currents and tides have been examined using modeling techniques. Modeling of the proposed Cape Wind project found that the turbines would be spaced far enough apart to prevent any wake effect between piles; any effects would be localized around each pile (MMS 2009a). The analysis of Cape Wind demonstrated that the flow around the monopiles (which range in diameter from 3.6-5.5 m [11.8-18.0 feet] wide) would return to 99% of its original flow rate within a distance of 4 pile diameters (approximately 14.4-22 m [47.2-72.2 feet]) from the support structure (ASA 2005). Both of these studies, however, are representative of monopile wind turbine subsurface structure and may not be directly applicable to jacket-style foundations. The potential localized effects of lattice jacket structures on the hydrodynamics are likely to be even less compared to that found with monopiles as pile diameters for lattice jackets are much smaller (1.5 m [4.9 feet]) than monopiles (4-5 m [13-16.5 feet] diameter). Furthermore, the spacing between the turbines using lattice jacket support structures will be much greater than the 4 pile diameters. However, the effects of currents may be site-specific, as there could be localized currents or other conditions that could affect or be affected by the presence of wind turbines; site specific modeling may be necessary to determine impacts.

3. One predicted potential effect of wind turbines has been changes to the wave field from diffraction caused by the monopiles, and resulting changes to longshore sediment transport (CEFAS 2005). A study of the wave effects at Scroby Bank, located in the North Sea off the U.K., found no significant effects to the wave regime (CEFAS 2005). Modeling of the effects of wind farms on waves found a reduction in wave height on average of 1.5% in the region, and maximum localized amplification of wave heights at the site of the wind farm of about 0.0158 m (0.6 inches). As the modeled wind farm was moved further from shore, the wave height amplification decreased (ABP Marine Environmental Research Ltd 2002). Modeling for the Cape Wind project found that the largest wave diffraction occurred for small waves with low bottom velocities that did not cause significant sediment transport; larger waves were not affected by the presence of the turbines. Overall, the models found that the presence of turbines would have a negligible impact on wave conditions in the area (MMS 2009a). Because there are no significant changes predicted for tides and waves, there are not expected to be

significant effects to sediment movement or deposition along the coastline (ABP Marine Environmental Research Ltd 2002).

4. Preliminary scaling estimates for the cumulative generation of water column turbulence due to wakes behind subsurface pilings, using parameters applicable to Ocean SAMP waters and a 100-turbine wind power generation field, suggests their influence on vertical mixing could be comparable to that due to bottom friction (Codiga and Ullman 2010c). The known persistence of stratification in much of the Ocean SAMP region during summertime suggests that bottom friction is relatively weak, and thus the effects of platform pilings are not expected to produce major, large scale changes in water column stratification. However, additional research is needed to address the extent to which the spatial patterns and seasonal cycle of stratification in Ocean SAMP waters could potentially be altered by the presence of arrays of various types (pilings, lattice jackets, etc) of subsurface structures as infrastructure for renewable energy generation devices.

5. The turbine foundations may increase turbulence and disrupt flow around the structures, potentially causing local erosion around the structures, or "scour". This process is caused by the orbital motion of water produced by waves and currents, and the vortices that result as the water flows around the pile of a wind turbine or another structure (MMS 2009a). Scour often results in the erosion of the sediments supporting the structure as they are transported elsewhere, forming a hole at the base. Scour can also affect sediments in areas between structures where multiple structures are present, also known as "global scour". However, because of the distances required between turbines, it has often been assumed that global scour will be limited (MMS 2007b). In addition, the use of scour protection such as boulders, grout bags or grass mattresses may be used to minimize the effects if scouring on the seafloor (MMS 2007a).

6. The seabed disturbance during construction and from scour may result in changes to sediment grain size. Smaller grains may be transported if suspended during disturbance, leaving only grains too large to be transported to remain. This could affect the structure of the benthic habitat and its associated community (MMS 2007b).

7. The placement of submarine cables will have limited and localized effects on seafloor sediments. Jet plowing, the method most likely to be used in the Ocean SAMP area, will likely result in the resuspension of bottom sediments into the water column. Heavier particles will settle in the immediate area of the activity, but finer particles are likely to travel from the disturbed area. These effects will be relatively small and short-term, however. Modeling of sedimentation during the cable laying process for the Cape Wind project found that sediment would settle within a few hundred yards of the cable route (MMS 2009a). In some cases, where suspended sediment levels are already high in the vicinity because of storms, areas of mobile surface sediment, or fishing activities such as trawling, the additional increase in sediments from cable-laying will probably not be significant. Once it is buried, the cable will not likely have any significant effect on sediments as long as it remains buried (ABP Marine Environmental Research Ltd

2002). If the cable becomes exposed, increased flow could occur above the cable, resulting in localized sediment scour (MMS 2009a).

8. The cable laying process would form a seabed scar from where the jet plow passed over. In some areas the scar may recover naturally, over a period of days to months or years depending on local tidal, current, and sediment conditions at various points along the cable route (MMS 2009a). However, depending on extent and depth of scars and the site specific conditions, areas which may not recover naturally may require the bathymetry to be restored to minimize impacts.

9. Studies on the effects of radiated heat from buried cables have found a rise in temperature directly above the cables of 0.19ºC [0.342 ºF] and an increase in the temperature of seawater of 0.000006ºC [0.0000108 ºF]. This is not believed to be significant enough to be detectable against natural fluctuations (MMS 2009a).

10. Overall, it is unlikely that wind farms will have a significant effect on wave, current, and sediment processes overall, with only small effects within the areas of the wind farms. The further to sea the wind farm is located, and the deeper water it is in, the lesser the effects to coastal processes are likely to be (ABP Marine Environmental Research Ltd 2002).

Section 850.3. Benthic Ecology

1. Offshore renewable energy development in the Ocean SAMP area, especially offshore wind energy development, may potentially affect the benthic ecology of a project site by: disturbing benthic habitat during construction activities; introducing hard substrate that may be colonized and produce reef effects, or alter community composition; generate noise or electromagnetic fields that may effect benthic species; or impacting the water quality of an area during the installation or operation of a facility. This section summarizes the general potential effects of a renewable energy project on the Ocean SAMP area's benthic ecosystem; potential effects of these phenomena on species groups (e.g. birds, marine mammals, and finfish) are detailed below in separate sections.

2. Undoubtedly, the construction of large, offshore structures will result in effects to coastal processes and to benthic habitats and species, at least in the immediate vicinity of the turbine installation. However, it may be a challenge to accurately assess changes in the benthic ecology of the Ocean SAMP area unless a good baseline is established. Studies of European offshore renewable energy projects, the PEIS (MMS 2007a) and the Cape Wind FEIS (MMS 2009a) provide some insight into the range of potential ecological effects offshore wind energy development, though the specific effects produced within the Ocean SAMP area will vary depending on site specific conditions and the size and design of the proposed project.

850.3.1. Benthic Habitat disturbance

1. The PEIS indicates that habitat disturbance may result through the construction of offshore renewable energy infrastructure (MMS 2007a). Here, habitat disturbance is used broadly to refer to sediment disturbance and settling; increased turbidity of the waters in the construction area; and the alteration or loss of habitat from installation of infrastructure including piles, anti-scour devices, and other structures.

2. Sediment disturbance caused by the installation of foundations or underwater transmission cables may result in the smothering of some benthic organisms as suspended sediments resettle onto the seafloor (MMS 2007a). Smothering would primarily affect benthic invertebrates as most finfish and mobile shellfish would move to nearby areas to avoid the construction site (MMS 2007a). The eggs and larvae of fish and other species may be particularly susceptible to burying (Gill 2005). Smaller organisms are more likely to be affected than larger ones, as larger organisms can extend feeding and respiratory organs above the sediment (BERR 2008). Sediment also has the potential to affect the filtering mechanisms of certain species through clogging of gills or damaging feeding structures; however, most species in the marine environment likely have some degree of tolerance to sediment and this effect is likely to be minimal (BERR 2008). In the Ocean SAMP area, species that may be impacted by the settling of sediments include eastern oysters (*Crassostrea virginica*) and northern quahogs (*Mercenaria mercenaria*), among others, resulting in mortality or impacts to reproduction and growth (MMS 2009a).

3. In addition to the disturbance of sediments, construction of the foundation substructure and the installation of cables may result in increased turbidity in the water column. This may in turn affect primary production of phytoplankton and the food chain; however, these effects are likely to be short-term and localized, as sediments will likely settle out after a few hours or be flushed away by tidal processes (MMS 2009a). Increased turbidity in a project area is generally temporary and will subside once construction has been completed (Johnson et al. 2008). Sediment suspension times will vary according to particle size and currents. In Nantucket Sound, sediments were predicted to remain suspended for two to eighteen hours, and the amount of sediment suspended would be minimal compared with normal sediment transport within the region due to typical tidal and current conditions (MMS 2009a). This may impact the abundance of planktonic species by decreasing the availability of light in the water column. Sediment suspended during the construction or decommissioning activities and transported by local currents may result in impacts to neighboring habitats, perhaps posing a temporary risk of smothering to nearby benthic species. Sediment transport in the Ocean SAMP area will need to be further modeled to predict the potential effects to turbidity from construction of offshore wind turbines.

4. Habitat conversion and loss may result from the physical occupation of the substrate by foundation structures or scour protection devices. Steel foundations and scour protection devices, which may be made up of rock or concrete mattresses, may modify existing habitat, or create of new habitat for colonization (Johnson et al. 2008). The direct effects of these hard structures to the seabed are likely to be limited to within one or two hundred meters of the turbine (OSPAR 2006). Additionally, cables will need to be installed between turbines, and this will require temporarily disturbing the sediment between the turbines. The total area of seabed disturbed by wind turbine foundations is relatively small compared to the total facility footprint. The scour protection suggested for the Cape Wind project around each monopile vary depending on the pile and the location, though the total scour protection area of 47.82 acres (0.19 square kilometers). Compared to the total footprint of the Cape Wind project (64 km^2 or 15,800 acres), the area affected by scour protection equals only 0.3% (MMS 2009a).

5. In addition to physically changing benthic habitat, the placement of wind turbines, especially in large arrays, may alter tidal current patterns around the structures (see Section 850.2 Coastal Processes and Physical Oceanography), which may effect the distribution of eggs and larvae (Johnson et al. 2008). However, a study of turbines in Danish waters found little to no impact on native benthic communities and sediment structure from a change in hydrodynamic regimes (DONG Energy et al. 2006). Studies conducted at wind farms in the North Sea did not find significant changes in the benthic community structure that could be related to changes in the hydrodynamics as a result of the placement of in-water wind turbine structures (DONG Energy et al. 2006). See Chapter 2, Ecology of the SAMP Region for more information on physical oceanography and primary production in the Ocean SAMP area.

6. The installation and burial of submarine cables can cause temporary habitat destruction through plowing trenches for cable placement, and may cause permanent habitat alteration if the top layers of sediment are replaced with new material during the cable-laying process, or if the cables are not sufficiently buried within the substrate. Likewise, cable repair or decommissioning can impact benthic habitats. The effect of the cables will depend on the grain size of sediments, hydrodynamics and turbidity of the area, and on the species and habitats present where the cable is being laid. Cables are usually buried in trenches 2 m (6.6 feet) wide and up to 3 m (9.8 feet) in depth (OSPAR 2008). Disturbance to the seabed during cable-laying may also result from anchor and chain damage from the installation barge, as the barge will have to repeatedly anchor along the length of the cable route (MMS 2007b). In addition, sediments disturbed in the cable-laying process may contain contaminants, and these may be dispersed in the process. However, most contaminated sediments are likely to be found close to the coast, unless the cable route passes close to a disposal site (BERR 2008).

7. In many cases, the seabed is expected to return to its pre-disturbance state after cable installation. The extent of the impacts from cable laying may depend on the amount of time it takes for the natural bathymetry to recover. Post-construction monitoring may be used to track the recovery of a project site. On rock or other hard substrates where the seabed may not recover easily, backfilling may be required, or else permanent scarring of the seabed may result. Scars along the bottom may impact migration for benthic animals. Species found in rock habitats tend to be sessile (permanently attached to a substrate), either encrusting or otherwise attached to the rock, and are therefore more susceptible to disturbance (BERR 2008). Clay, sand, and gravel habitats are typically less affected. Undersea cables can also cause damage to benthic habitat if allowed to "sweep" along the bottom while being placed in the correct location (Johnson et al. 2008). Initial re-colonization of the site by benthic invertebrates takes place rapidly, sometimes within a couple of months (BERR 2008). In deeper waters, where disturbance of the seabed occurs with less frequency, recovery to a stable benthic community can take longer than in shallow waters, sometimes years. Generally, the effect on the benthic ecology will not be significant if the cabling is done in areas where the habitat is homogenous. However, if the cabling activity takes place in areas of habitat that are rare or particularly subject to disturbance, the effects could be greater (BERR 2008). The most serious threats are to submerged aquatic vegetation, which serves as an important habitat for a wide variety of marine species. Shellfish beds and hard-bottom habitats are also especially at risk (Johnson et al. 2008). Shellfish in particular are usually not highly mobile, and cannot relocate during the cable-laying process. Biogenic reefs made up of mussels or other shellfish may become destabilized if plowing for cable-laying damages the reefs (BERR 2008).

8. The magnitude of the habitat disturbance effects depends on the duration and intensity of the disturbance, and on the resilience of species living within the sediment (Gill 2005). The expected effects are a local loss of sedentary fauna living in the substrate, with mobile bottom-dwellers being displaced from the area (Gill 2005). During the

construction and decommissioning phases of a project, the eggs and larvae of many fish species may be vulnerable to being buried or removed. After the activity has ceased, recolonization may take months or years (Gill 2005). Studies conducted on Danish wind farms found the effects on benthic communities from burial by sediment were minimal when monopiles were used, and the effects were both temporary and had limited spatial distribution. Effects to the benthic community were limited primarily to the area immediately surrounding the pile driving activity (DONG Energy et al. 2006). Studies of the effects of sediment displacement from cable laying found macro algae and benthic infauna were still recovering two years after the activity had ceased (DONG Energy et al. 2006).

9. The recovery period, or the time required for an area disturbed by construction related activities to return to its pre-construction state, will vary between sites. For example, research on the effects of trawling on the seabed have found that benthic communities in habitats already subject to high levels of natural disturbance will be less affected by trawling disturbance than more stable communities (Hiddink et al. 2006). Typically, habitats such as coarse sands are in general more dynamic in nature and therefore recover more rapidly after disturbance than more stable habitat types where physical and biological recovery is slow (Dernie et al. 2003). Disturbance from the construction of wind turbine towers and laying cable is likely to produce similar results. A few studies of dredging found that recovery times are roughly six to eight months for estuarine muds, two to three years for sand and gravel bottoms, and up to five to ten years for coarser substrates (e.g. Newell et al. 1998).

10. See below for the potential effects of benthic habitat disturbance on Ocean SAMP area species including birds, sea turtles, marine mammals, and fisheries resources.

850.3.2. Reef Effects

1. Offshore renewable energy development, especially offshore wind development, will result in the presence of man-made structures in the water column and on the seafloor. These hard structures, such as the foundation structures and scour protection devices, will introduce new habitat into the area that did not previously exist. In this way, wind turbine structures may serve as artificial reefs, in providing surfaces for non-mobile species to grow on and shelter for small fish (Wilhelmsson et al. 2006). Any man-made structure in the marine environment is usually rapidly colonized by marine organisms (Linley et al. 2007). Fouling communities will colonize the hard structure and will create new pathways for nutrients to be moved from the water column to the benthos (Gill and Kimber 2005). Once a structure such as a wind turbine has been erected, it increases the heterogeneity of the habitat. The physical structure represents more colonization opportunities for invertebrates, as they have more surface area. This in turn increases the number of food patches available, as food resources generally are not uniformly distributed in coastal waters (Gill and Kimber 2005). This will cause a fundamental shift in the overall food web dynamics of the ecosystem, and may result in further shifts in benthic community diversity, biomass and organic matter recycling

(Gill and Kimber 2005). Because some European offshore renewable energy facilities have been closed to fishing activity (see Section 850.8, Commercial and Recreational Fishing), the ecological effects observed in these facilities may be in part due to decreased fishing disturbances. Researchers in the North Sea (DONG Energy et al. 2006) found that a reduction in fishing activity complicates their ability to assess ecological change from wind farm development; there is no good information for ecosystem functioning prior to or without fishing activity impacts and therefore difficult to establish any cause-and-effect.

2. In places where the wind turbines are under threat from erosion, large boulders are often used as scour protection; these also serve as an artificial reef of their own (Petersen and Malm 2006). Scour protection also provides hard surfaces for colonization by fouling communities, as well as providing crevices and structural complexity likely to attract fish and invertebrate species seeking shelter (MMS 2007b).

3. It has been found that although colonizing communities on offshore structures may vary depending on geographic location and a number of other factors after initial colonization, the differences are likely to decrease over the years as more stable communities develop (Linley et al. 2007). Colonizing communities will develop through the process of succession, where early colonizing species are subsumed by secondary colonizers, leading to what is known as the climax community, or the stable end point in the colonization process. It may take five to six years for the climax community to develop at a given site (Whomersley and Picken 2003, in Linley et al. 2007).

4. The changes likely to be brought about by the reef effect of the turbines are not universally considered to be beneficial. The changes in abundance and species composition could degrade other components of the system, potentially pushing out other species found in the particular habitat where construction is taking place. In particular, this could affect vulnerable or endangered species through factors such as loss of habitat, increased predation, or increased competition for prey as the composition of the benthic community shifts to that of a hard bottom community (Linley et al. 2007).

5. The diversity and biomass of the colonized structures will depend in part on the choice of material, its roughness (rugosity), and overall complexity. Concrete attracts benthic organisms; however, when used in sub-marine construction, it is often coated with silane or silicone, which deters the settling of organisms. Smooth steel monopiles, which are often painted, tend to attract barnacles (*Balanus improvisus*) and filamentous algae (Petersen and Malm 2006). The scaffolding used for oil and gas rigs provides more structural complexity than monopile foundations; the same is likely to be true for a jacketed structure for a wind turbine. These rougher, complex structures offer more protection from predators and from high velocities and scour (MMS 2009a).

6. Another factor influencing the colonization of wind turbine structures will be the orientation of the structures to the prevailing currents. Current speed and direction can influence food availability, oxygen levels and the supply of larval recruits to an area. As a result, structures more exposed to local currents may be more colonized than other installations within the facility. Furthermore, structures with more complex shapes will offer a greater range of localized hydrographic conditions, offering more potential for colonization and greater biodiversity (Linley et al. 2007). Colonization of structures will be dependent on sufficient numbers of larvae present in the area, and on suitable environmental conditions (Linley et al. 2007).

7. Often barnacles are the first colonizers of the intertidal zone, while algae such as red seaweeds and kelp, along with mussels, will dominate colonization starting at 1 to 2 meters below the surface. Colonies based on mussels will also attract scavengers such as starfish and flounder. In addition to mussels, some structures may instead be colonized by a grouping of species including anemones, hydroids, and sea squirts. The larvae present in the water column will vary depending on the time of year, so colonization may be dependent on the time of year in which the structures are erected. Community structure will also be dependent on the presence of predators and on secondary colonizers (Linley et al. 2007). Other species found within the Ocean SAMP area that are likely to be early colonizers include algae, sponges, and bryozoans, and other secondary colonizers are likely to include polychaetes, oligochaetes, nematodes, nudibranchs, gastropods, and crabs (MMS 2009a). These substantial colonies of invertebrates will attract fish to the structures, resulting in a reef effect around the support structures. For more on reef effects and the attraction of fish, see Section 850.7.7 below.

8. Studies conducted in Denmark (Dong Energy et al. 2006) at two wind farms sites (Nysted, 76 turbines; Horns Rev, 80 turbines) has shown major changes in community structure of the offshore ecosystem from one based on infauna, or invertebrates that live within the substrate, to that of a hard bottom marine community and a commensurate increase in biomass by 50 to 150 times greater.

9. Wind turbines in the Baltic Sea built on monopiles are almost entirely encrusted with a monoculture of blue mussels (*Mytilus edulis*), which may be the result of a lack of predation and competition from other species (Petersen and Malm 2006), as well as from low salinity in the area where the turbines have been constructed. Mussels provide a hard substratum used by macroalgae and epifauna, and therefore have the potential to induce further change in the ecosystem by providing more surface area for colonization. Colonization of wind farms will be determined partly through zonation, the distribution of various communities of organisms at different depths in the water column. A study of the Nysted offshore wind farm found high concentrations of blue mussels on the wind turbine foundations, with mussel biomass increasing closer to the surface, although in the highest zonation, in the upper one meter of depth, the foundation was instead colonized by barnacles. The biomass of barnacles was determined, through modeling techniques, to be seven to eighteen times higher on the foundation close to

the surface than on the scour protection. The extent to which these mussels serve as an artificial reef and increase productivity and biomass will depend on the ecosystem feedback between the mussel colonies and the pelagic and benthic environments around them, such as whether other invertebrates colonize the mussels, and whether fish and other animals utilize these colonies for food and shelter (Maar et al. 2009). On oil and gas platforms in California, the structures are encrusted with mussels, at least at depths above 100 feet (30.5 m); as mussels are knocked off the platforms and accumulate at the bottom, they create shell mounds on the seafloor which provide a secondary habitat for fish and other species (Love et al. 2003).

10. A study of the effects of the Horns Rev wind farm in Denmark found a shift in the benthic community from the indigenous infaunal community to an epifouling community associated with hard bottom habitats as both the monopiles and the scour protection were colonized by algae and invertebrates. Two species of amphipods (*Jassa marmorata* and *Caprella linearis*) were the most abundant species found on the turbines, and a total of seven species of invertebrates, including the two amphipods, the common mussel (*Mytilus edulis*), a barnacle species (*Balanus cretanus*), the common starfish (*Asteria rubens*), the bristle worm (*Pomatoceros triqueter*), and the edible crab (*Cancer pagurus*) made up 94% of the total biomass on the structures. There were also eleven taxa of seaweeds found on the monopiles and the scour protection. The monopiles and scour protection were found to be hatchery or nursery grounds for a number of invertebrates, including crabs. The wind turbine substructure and scour protection were found to house two species of worms new to this area, and considered threatened elsewhere in the region. The result of this new community has been an estimated 60-fold increase in the availability of food for fish and other organisms in the area compared with the original benthic community (Leonhard and Pedersen 2005). For information on the potential future uses associated with the epifouling communities formed on offshore wind energy turbines see Chapter 9, Other Future Uses.

11. Conversely, one study conducted at the Nysted offshore wind farm in Denmark, found an overall decline in biomass measured over three years. The encrusting community at this site had evolved to become almost a monoculture of mussels. This particular area is brackish; the lack of sea stars, an important mussel predator, was attributed to the low salinity. Similar changes were observed at a test site; it was concluded that these were the result of natural variations rather than an effect of the wind turbines (MMS 2007b).

12. If scour holes form in the sea bed adjacent to the turbines, these holes may be attractive habitat to species such as crab and lobster, and to some fish species, furthering the reef effect of the structures (Rodmell and Johnson 2002). For more on effects on scour and the physical oceanography of the Ocean SAMP area from wind turbines, see Section 850.2.5.

13. If periodic cleaning of the encrusting organisms on the structure base occurs, the community will be more or less permanently in the early-colonization phase, and will not develop through succession into a more mature climax community with greater

biodiversity. Instead, after each cleaning a new community will redevelop on the structure, with the species composition varying based on the season, depending on which larval species are present in the water column at the time. Moreover, if shells are periodically removed, the discarded debris may attract scavenging animals, and may serve to create new habitat on the seafloor where they accumulate (Linley et al. 2007).

14. The reef effect is particularly relevant to fisheries resources as well as other species groups; see sections on marine mammals, fish, and sea turtles below for further discussion.

850.3.3. Changes in Community Composition

1. Wind energy and other offshore renewable energy projects could have indirect ecological effects that could affect the benthic community. A change in the type and abundance of benthic species can be expected at the turbine sites, which will change food availability for higher trophic levels. Studies of habitat disturbance resulting from fishing or dredging activity have shown effects on local species diversity and population density; the effects of offshore renewable energy projects are likely to be similar (as suggested by Gill 2005). The magnitude of these effects depends on the duration and intensity of the disturbance, and on the resistance and resilience of species living within the sediment. The expected effects are a local loss of sedentary fauna living in the substrate, with non-sedentary bottom-dwellers being displaced from the area.

2. Because the placement of wind turbines will increase habitat for benthic species, the structures will have the effect of increasing local food availability, which may bring some fish and other mobile species into the area. This may increase use of the area by immigrant fauna. More adaptable species will probably dominate the area under these new ecological conditions. The change in prey size, type, and abundance in the vicinity of the structures may also affect predators. Predators moving into the area may result in prey depletion (Gill 2005).

3. The PEIS (MMS 2007a) indicates that the removal and deposition of benthic sediments associated with construction may result in the smothering of some benthic organisms within the footprint of the towers or along the cable route. Smothering would be a problem primarily for sedentary invertebrates as most finfish and mobile shellfish would be expected to move out of the way of incoming sediment (MMS 2007a). Studies conducted on Danish wind farms found the impacts on benthic communities from burial by sediment were minimal when monopile substructures were installed, and the impacts were both temporary and had limited spatial impact (DONG Energy et al. 2006). The recolonization of an area disturbed during the construction process may take months or years (Gill 2005). Studies of the impacts of sediment displacement from cable laying found macro algae and benthic infauna were still recovering two years after the activity had ceased (DONG Energy et al. 2006).

4. If fishing pressure is reduced in the areas around the turbines as a result of fewer fishing vessels in the vicinity of the turbines, this could have impacts on the community as a whole, both from a reduction on fishing mortality of some species and a resulting increase in predation by these species on others (MMS 2007b). For example, in the Horns Rev wind farm, an increase in bivalves and worms inside of the park was attributed to a decline in predation from scoters (a waterfowl species), who were avoiding the wind turbines (Leonhard and Pedersen 2005). At the Nysted wind farm in Denmark, densities of sand eels were found to increase by 300 percent between 2002 and 2004. The increase was likely attributable to either a decrease in sand eel predation, or a decrease in fishing mortality (Jensen et al. 2004, in MMS 2007b).

5. There is also a possibility that invasive species may colonize the structures (MMS 2007a). The disturbances caused by the placement of new structures may make the area more susceptible to invasion by non-native species (Petersen and Malm 2006). Monitoring at Denmark's Horns Rev wind farm in 2004 found an invasive species of tube amphipod, *Jassa marmorata*, not previously seen in Denmark, to be the most abundant invertebrate found on hard bottom substrate in the area (DONG Energy and Vattenfall 2006).

6. *Didemnum spp.*, a particularly aggressive invasive tunicate (sea squirt) of unknown origin, arrived in the New England region in the late 1980s and has become firmly embedded in the aquatic community from Eastport, ME to Shinnecock, NY (Bullard et al. 2007). There are no known, consistent predators of this species, which grows rapidly on hard structure to depths of 80 m (262.5 feet). This sea squirt could be problematic on new subsurface structures placed in the Ocean SAMP area, potentially colonizing the structure and competing with native species for planktonic food resources. Furthermore, this species is known to be able to regenerate entire individuals from fragments (Bullard et al. 2007), such as might be formed during maintenance procedures to control biofouling on wind turbine support structures, for instance. *Didemnum* is known to grow particularly well in areas that are well-mixed (Valentine et al. 2007); it is unknown if the turbulence created downstream of subsurface structure, wind turbine pilings for instance, would further promote conditions that favor this organism. See Chapter 2, Ecology of the SAMP Region for more information on invasive species in the Ocean SAMP area.

7. One study of the North Hoyle wind farm in the UK found that variability in benthic organisms taken from surveys around the wind farm pre- and post-construction was more likely related to natural variability, such as localized sediment composition, than to any effects caused by the construction or operation of the wind farm (NWP Offshore Ltd. 2007).

8. The decommissioning of wind turbines would also have significant ecological effects, as the new habitat and accompanying species are removed. Habitat heterogeneity would be immediately reduced, removing a large component of the benthic community (Gill 2005).

9. In summary, the significant human activity resulting from the wind turbines would be likely to have significant effects upon the food web, but just what those effects are is unknown.

10. See Section 850.7.5 below for the potential effects of changes in community composition on fisheries and fishery resources.

850.3.4. Noise

1. Underwater noise may be generated during all stages of an offshore renewable energy facility, including during pre-construction, construction, operation and decommissioning. The potential affects of noise from offshore renewable energy are especially a concern for marine mammals and fish species (see Sections 850.5 and 850.7) It is not understood whether the noise generated in the construction, operation, and decommissioning of a wind turbine array would have an effect on invertebrate species in the benthic environment. Few marine invertebrates have the sensory organs to perceive sound pressure, although many can perceive sound waves (Vella et al. 2001 in MMS 2007b). Studies on the potential impact of air guns on squid have found few behavioral or psychological effects unless the organisms are within a few meters of the source (MMS 2007b). If there is any effect to these species, it is likely to be much less than any potential effects to fish or marine mammals (Linley et al. 2007).

850.3.5. Electromagnetic Fields (EMF*)*

1. Underwater transmission cables used to carry the electricity from an offshore renewable energy facility back to shore produce magnetic fields around the cables, both perpendicularly and in a lateral direction around the cable. While the design of industry standard AC cables prevents electric field emissions, magnetic field emissions are not prevented. These magnetic emissions induce localized electric fields in the marine environment as sea water moves through them. Furthermore, in AC cables the magnetic fields oscillate, and thereby also create an induced electric field in the environment around the cables, regardless of whether the cable is buried. Thus the term electromagnetic field, or EMF, refers to both of these fields (Petersen and Malm 2006). While EMF is primarily an issue for fish, sharks and rays (see Section 850.7), some invertebrate species, such as a variety of crustacean species, have demonstrated magnetic sensitivity and could be affected by EMF. These animals may become disoriented; it is not known whether this will have a small or a significant impact on these animals, although the likely impact is believed to be small (BERR 2008). For more information on the effects of electromagnetic fields, see Section 850.8 Fish and Fisheries Resources.

2. If electromagnetic fields affect the presence or behavior of species likely to colonize wind turbine structures, this could have an effect on the potential reef effects of the

structures. However, the interaction between most invertebrates and EMF is not known, and the existence of healthy communities of colonizing species on turbine structures in Europe indicates EMF will not have a significant impact on at least these species assemblages (Linley et al. 2007).

850.3.6. Water Quality Impacts

1. Offshore renewable energy facilities would result in increased vessel traffic through the site characterization, construction, operation, and decommissioning phases. The PEIS indicates that such an increase in traffic could increase the likelihood of fuel spills as a result of vessel accidents or mechanical problems, though it indicates that the likelihood of such spills is relatively small (MMS 2007a). In addition, wastewater, trash, and other debris may be generated at offshore energy sites by human activities associated with the facility during construction and maintenance activities (MMS 2007a, Johnson et al. 2008). The platforms may hold hazardous materials such as fuel, oils, greases, and coolants. The accidental discharge of these contaminants into the water column could affect the water quality around the facility; however these contaminants would likely remain at the surface and not impact benthic ecosystems (MMS 2007a). In the PEIS, BOEMRE indicates that the potential risk to water quality from offshore renewable energy development is negligible to minor (MMS 2007a).

2. Water quality may also be impacted during the construction process by re-suspending bottom sediments, increasing the turbidity within the water column. For the potential effects of water quality impacts on birds, marine mammals, and fish, see sections below.

Section 850.4. Birds

1. Offshore renewable energy may have a variety of potential effects on avian species in the Ocean SAMP area. Some effects may be negative, resulting in adverse impacts, other effects may be neutral, producing no discernible impacts, while others may be positive, resulting in enhancements. The purpose of this section is to provide an overview of all the potential effects of offshore renewable energy development on birds, including the potential for habitat displacement or modification; disturbances associated with construction activities and/or vessel traffic; avoidance behavior or changes in flight patterns; risk of collision with installed structures; the risk of exposure to pollutants accidentally discharged during construction, operation or decommissioning. Potential affects to birds in the Ocean SAMP area will vary based on the species, as well as on the particular site, and size of the project. The timing of construction or decommissioning of an offshore renewable energy facility, along with the cumulative impacts of other offshore developments will also have an effect on the degree of impact.

2. Key to measuring and understanding the effects of offshore renewable energy development on avian species requires first sufficient baseline data on the abundance, distribution, habitat use and flight patterns in the project area. Baseline studies provide an important comparison point for assessing the effects of pre-construction, construction, operation or decommissioning activities. The duration of baseline studies may vary between project areas to account for 'natural variability' observed in avian use of an area. Locations that experience large fluctuations in avian densities over time may require additional baseline monitoring to accurately assess pre-construction conditions (Fox et al. 2006).

3. Research conducted by Paton et al. (2010) for the Ocean SAMP has collected baseline data on species occurrence and distribution in the Ocean SAMP area through land-based, ship-based and aerial surveys, as well as through radar surveys from 2009 to 2010, although the exact time period of surveys varied by survey technique. The goal of this research is to assess current spatial and temporal patterns of avian abundance and movement ecology within the Ocean SAMP boundary. Preliminary analysis of the surveys conducted in nearshore habitats during land-based point counts from January 2009 to February 2010 recorded 121 species and over 460,000 detections in the nearshore portion of the Ocean SAMP area (Figure 8.37; Paton et al. 2010). Observations during these nearshore surveys have demonstrated that a wide range of birds use the Ocean SAMP area, including seaducks (e.g. eiders and scoters), other seabirds (e.g. loons, cormorants, alcids and gannets), pelagic seabirds (e.g. storm petrel and shearwaters), terns and gulls, shorebirds, passerines and other land birds (e.g. migrating species and swallows). The most abundant bird species observed in nearshore habitats in the Ocean SAMP area during land-based surveys were Common Eider (*Somateria mollissima*), Herring Gull (*Larus argentatus*), Surf Scoter (*Melanitta perspicillata*), Black Scoter (*Melanitta nigra*), Double crested Cormorant (*Phalacrocorax auritus*), Tree Swallow (*Tachycineta bicolor*), Great Black-backed

Gull (*Larus marinus*), Laughing Gull (*Leucophaeus atricilla*), and the Northern Gannet (*Morus bassanus*) (see Figure 8.37) (Paton et al. 2010). Farther offshore, more pelagic species were detected during boat-based surveys conducted from June 2009 to March 2010. During boat-based surveys, which sampled eight 4 by 5 nm grids, 55 species were detected from 10,422 detections (see Figure 8.38). In offshore areas, Herring Gulls, Wilson's Storm-Petrels (*Oceanites oceanicus*), Northern Gannets, Great Black-backed Gulls, White-winged Scoters (*Melanitta fusca*) were among the most commonly detected species.

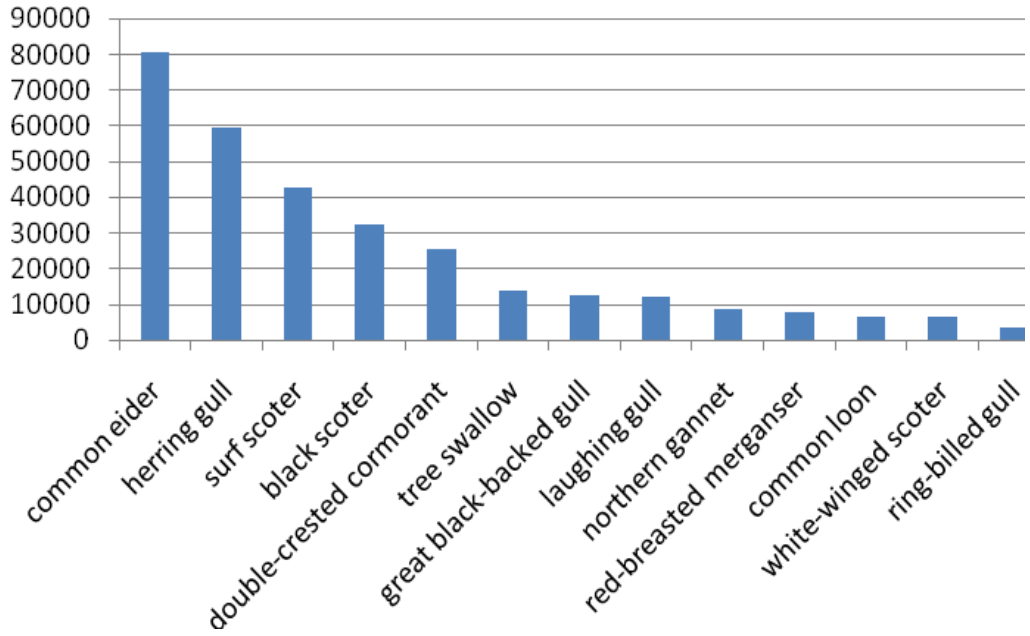


Figure 8.37 Most abundant species observed in nearshore habitats of the Ocean SAMP study area based on land-based point counts from January 2009 to January 2010 (Paton et al. 2010). (Note: Total detections= = 465,039)

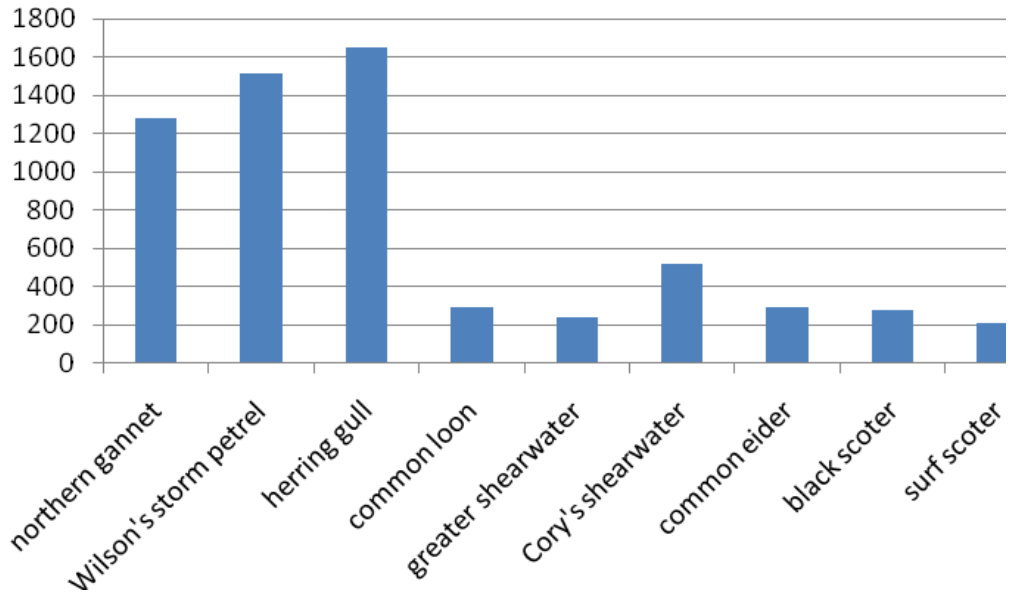


Figure 8.38. Most abundant species observed in offshore habitats based on ship-based point counts in the Ocean SAMP study area from Mar 2009–Jan 2010 (Paton et al. 2010).

4. Species distribution and abundance varied both spatially and seasonally in the Ocean SAMP area. Most birds that use the Ocean SAMP area are migratory, so that their occurrence is highly seasonal. Paton et al. (2010) have found high inter-annual variability in the abundance and distribution of avian species in the Ocean SAMP area, suggesting that the collection of long-term baseline data prior to construction and operation of an offshore renewable energy facility will be important in examining any potential effects to avian species. For further discussion of the findings of Paton et al. (2010) see Chapter 2, Ecology of the SAMP Region.

5. In addition to recording occurrence and abundance in the Ocean SAMP area, Paton et al. (2010) have also identified potential foraging habitat for avian species. Based on a literature review performed by Paton et al. (2010) nearshore habitats, with water depths of less than 20 m [66 ft], are believed to be the primary foraging habitat for seaducks (see Table 8.13). Figure 8.39 illustrates the areas within the Ocean SAMP boundary with water depths less than 20 m (66 feet) and therefore is thought to represent the primary foraging habitat for the thousands of seaducks that winter in the Ocean SAMP waters. Preferred sea duck foraging areas are strongly correlated with environmental variables such as water depth, bottom substrate, bivalve community, and bivalve density (Vaitkus and Bubinas 2001). Currently, bathymetric data (water depth, bottom substrate) of the Ocean SAMP area is well known, but relatively little is known about bivalve community and bivalve density, especially further offshore. Foraging depths of seaducks differ among species and are a function of preferred diet, but average depths tend to be less than 20 meters (66 feet) for most species. Common eiders forage in water less than 10 m (33 feet) during the winter when diving over rocky substrate and

kelp beds (Goudie et al. 2000; Guillemette et al. 1993). Preferred diet of common eider changes with season and foraging location, but mainly consists of mollusks and crustaceans (Goudie et al. 2000; Palmer 1949; Cottam 1939). Maximum diving depths of scoters are about 25 m (82 feet), although most birds probably forage in water less than 20 meters (66 feet) deep, particularly during the winter months (Vaitkus and Bubinas 2001; Bordage and Savard 1995). Scoter diet in marine environments predominantly consists of mollusks (Bordage & Savard 1995; Durinck et al. 1993; Madsen 1954; Cottam 1939). Paton et al. (2010) did detect seaducks in waters up to 25 meters (82 feet) deep during aerial surveys, although it was unclear from the aerial surveys if the seaducks were foraging or engaging in other behaviors such as roosting. Paton et al. (2010) suggest more detailed research be conducted to better understand the depths used for foraging by scoters or eiders in the Ocean SAMP area.

Table 8.13. Foraging depths of seaducks based on a literature review (Paton et al. 2010).

Species	Dive depth	Source
Common eider	0-15 m (0-49 feet).	Ydenberg and Guillemetter 1991
Surf Scoter - day	90% of dives <20 m (66 feet) depth during diurnal period – used deeper waters at night – but rarely dived at night.	Lewis et al. 2005
White-winged Scoter-day	~90% of diver <20 m (66 feet) depth - used deeper waters at night – but rarely dived at night.	Lewis et al. 2005
Black Scoter	>95% of observations were in waters <20m (66 feet) deep.	Kaiser et al. 2006
Common Eider	100% <16 m (52.5 feet) deep.	NERI Report 2006
Black Scoter	100% <20 m (66 feet) deep.	NERI Report 2006

6. Land-based surveys conducted by Paton et al. (2010) support the findings of the literature review, as large concentrations of seaducks (e.g. scoters and eiders) have been recorded in these nearshore areas, particularly off Brenton Point (see Figure 8.39). Because one potential effect of offshore renewable energy development may include permanent habitat loss, identifying and avoiding potentially important foraging habitat prior to siting future projects may help to minimize any adverse impacts.

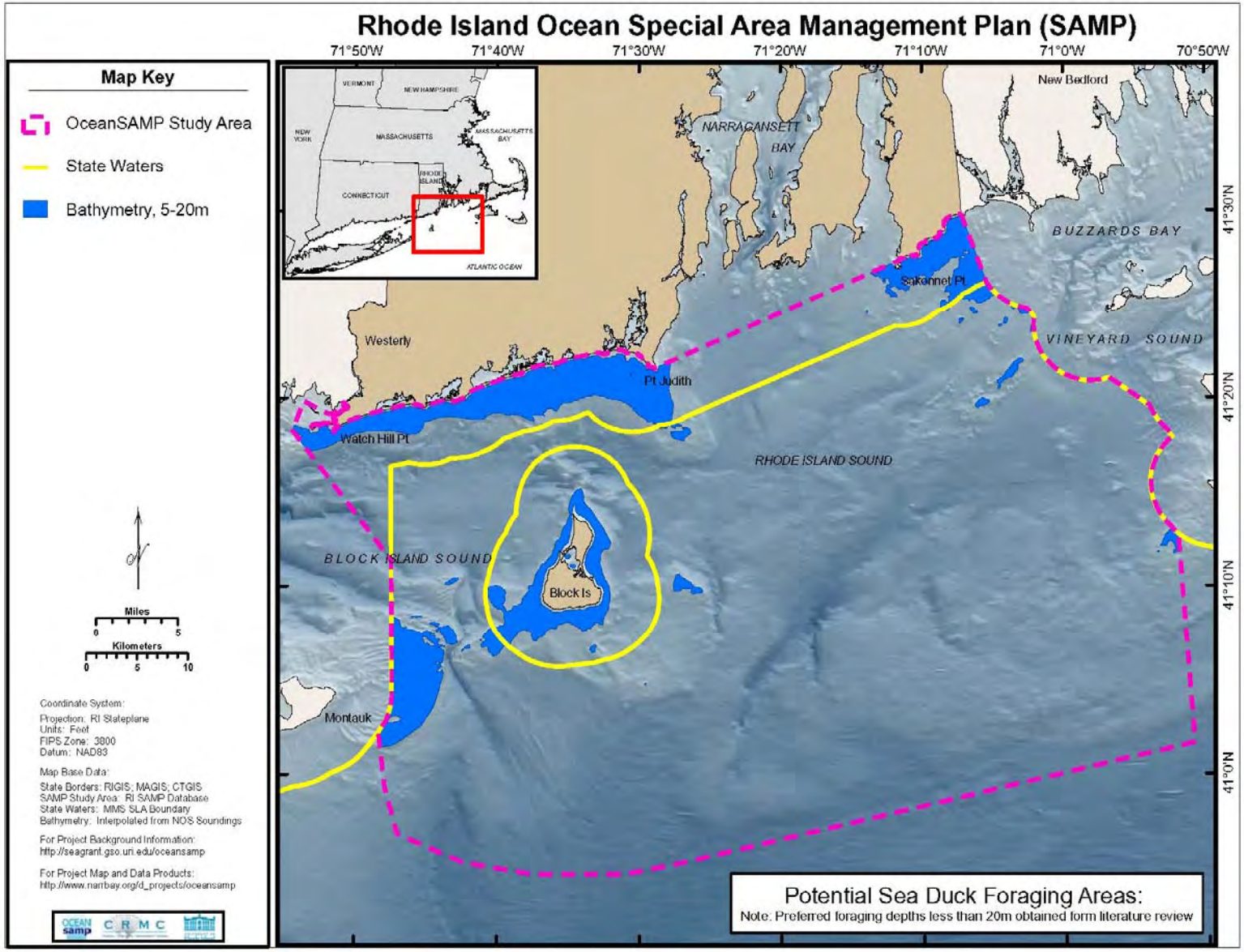

Rhode Island Ocean Special Area Management Plan (SAMP)
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
Map Key
OceanSAMP Study Area
State Waters
Bathymetry, 5-20m
Miles
0 5
Kilometers
0 5 10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
Map Base Data:
State Borders: RIGIS; MAGIS; CTGIS
SAMP Study Area: RI SAMP Database
State Waters: MMS SLA Boundary
Bathymetry: Interpolated from NOS Soundings
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
NARRAGANSETT BAY
New Bedford
BUZZARDS BAY
Sakonnet Pt
VINEYARD SOUND
Westerly
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Potential Sea Duck Foraging Areas:
Note: Preferred foraging depths less than 20m obtained form literature review

Figure 8.39. Potential foraging areas for seaducks within and adjacent to the Ocean SAMP boundary (based on a literature review by Paton et al. 2010).

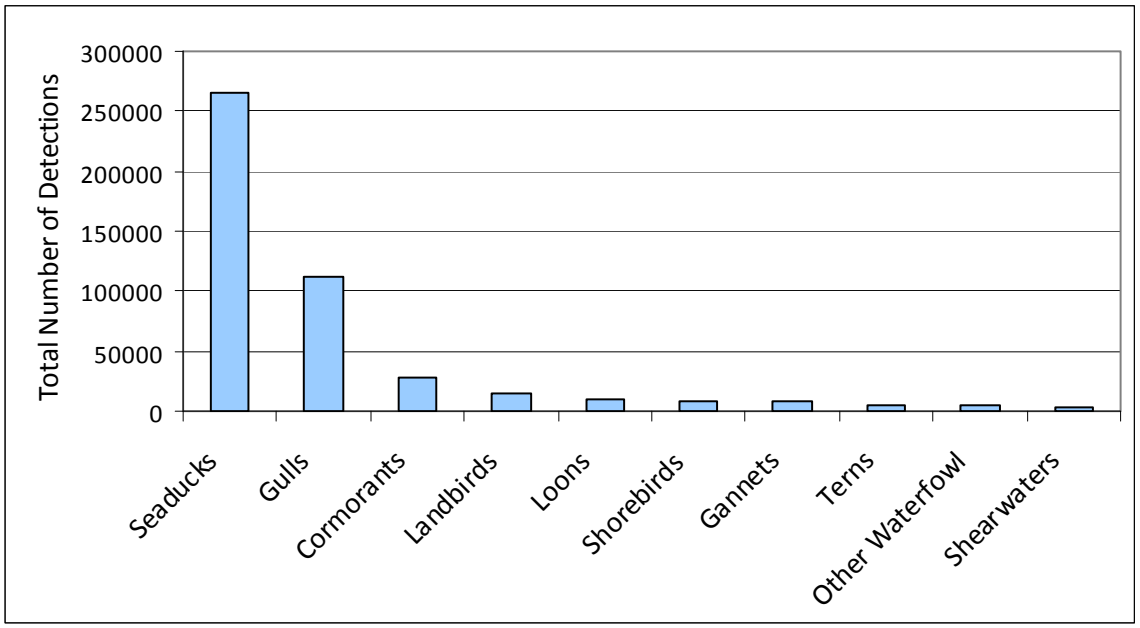


Figure 8.40. Total number of detections for the most abundant guilds observed in nearshore habitats during land-based point counts, Jan 2009-Feb 2010 (Paton et al. 2010).
(Note: Total Number of detections = 465,039; Total Number of Species Recorded= 121)

7. When assessing the potential effects of offshore renewable energy development, the impact on endangered or threatened species are of particular concern, mainly because the magnitude of the potential impact may be much more severe to these species due to their low population numbers (MMS 2007a). The one federally-listed endangered bird using the Ocean SAMP area is Roseate Tern (*Sterna dougalli dougalli*). This species is a long-distance migrant that spends the summer months in New England, including within the Ocean SAMP area (Paton et al. 2010). Although this species does not nest in Rhode Island, there are nesting colonies in Connecticut, New York, and Massachusetts that are close enough that foraging adults from nesting colonies may use Ocean SAMP waters (see Figure 8.41). Terns may travel substantial distances, 25.8 to 30.6 km [16 to 19 miles] from their breeding locations to access foraging habitat, and therefore Roseate Terns may use portions of the Ocean SAMP area (Paton et al. 2010). As of 2007, about 85% of the population was concentrated at Great Gull Island, NY (1,227 pairs); Bird Island, Marion, MA (1,111 pairs); and Ram Island, Mattapoisett, MA (463 pairs).There was a small colony (48 pairs) on Penikese Island and 26 pairs nesting on Monomoy National Wildlife Refuge (Mostello 2007). Areas located in the northeast and northwest of the Ocean SAMP area lie within the foraging range of the Roseate Tern, and may potentially be used by for foraging adults.

8. In addition to foraging activity, migrating Roseate Terns may also pass through the Ocean SAMP area on their way to and from their nesting colonies (Harris 2009). Recent studies of post-breeding staging by Roseate Terns documented 20 sites on Cape Cod where Roseate Terns congregate in the fall before migrating south. Many uniquely color-banded birds from Great Gull Island in NY at the western edge of the Ocean

SAMP area were located on Cape Cod (Harris 2009), thus it is probable that many terns are migrating through the Ocean SAMP area in July and August, but their migratory routes, the diurnal variation of this migration, and flight elevations are uncertain. Paton et al. (2010) conducted surveys specifically to record Roseate Tern use of the Ocean SAMP area during summer (July, August), and detected relatively few birds during systematic ship and land-based surveys (total detections equaled 29 and 125 observations respectively). Alternatively, observations near Great Salt Pond on Block Island during July and August of 2009 recorded relatively high numbers of individuals, with up to 100 observations per day. It is believed that these birds are likely individuals that breed in New York or Connecticut and are transiting through the Ocean SAMP area; however more research is needed on post-breeding movement of Roseate Terns (Paton et al. 2010).

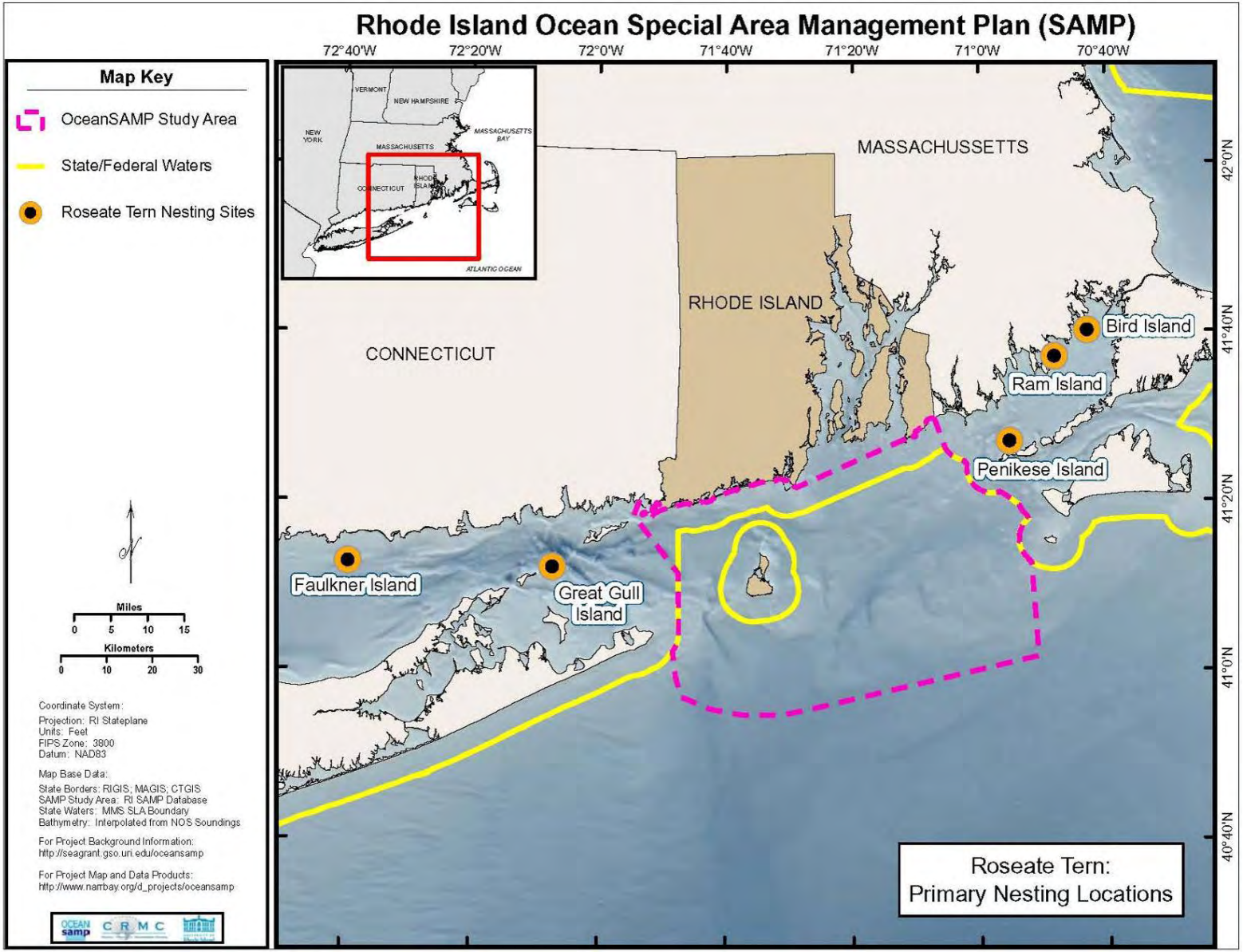

Rhode Island Ocean Special Area Management Plan (SAMP)
72°40'W
72°20'W
72°0'W
71°40'W
71°20'W
71°0'W
70°40'W
42°0'N
41°40'N
41°20'N
41°0'N
40°40'N
Map Key
OceanSAMP Study Area
State/Federal Waters
Roseate Tern Nesting Sites
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS BAY
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
MASSACHUSSETTS
RHODE ISLAND
CONNECTICUT
Bird Island
Ram Island
Penikese Island
Faulkner Island
Great Gull Island
Miles
0 5 10 15
Kilometers
0 10 20 30
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
Map Base Data:
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For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
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OCEAN samp
C R M C
Roseate Tern:
Primary Nesting Locations

Figure 8.41. Roseate tern nesting locations in Southern New England (Paton et al. 2010).

9. The Piping Plovers (*Charadrius melodus*) is another federally-listed species threatened species that nests on coastal beaches in Rhode Island and on Block Island, adjacent to the Ocean SAMP area (see Table 8.14 and Figure 8.42). While there is uncertainty surrounding the migratory routes taken by Piping Plovers, the U.S. Fish and Wildlife Service (1996) presumes that the majority of the migratory movements of Atlantic Coast Piping Plovers occur along a narrow flight corridor above the outer beaches of the coastline. Moreover, inland and offshore migratory observations are rare (U.S. Fish and Wildlife Service 1996). However, further investigation into Piping Plover movements in a project area prior to construction would help minimize the impact of avoidance behavior.

Table 8.14. 2009 Piping plover nesting sites (USFWS 2010)

Beach	Nesting	Chick
Block Island	2	0
Charlestown Beach	0	0
East Beach Watch Hill	22	53
East Matunuck	1	2
Green Hill	1	2
Napatree	10	16
Narragansett Town Beach	0	0
Narrow River	2	4
Ninigret Conservation Area	4	5
Ninigret NWR and Arnolda	2	2
Norman Bird Sanctuary	0	0
Sachuest Point National Wildlife	1	0
Sandy Point	2	4
Third Beach	1	0
Trustom Pond National Wildlife	12	9
Quonochontaug	9	8
Total	**69**	**105**

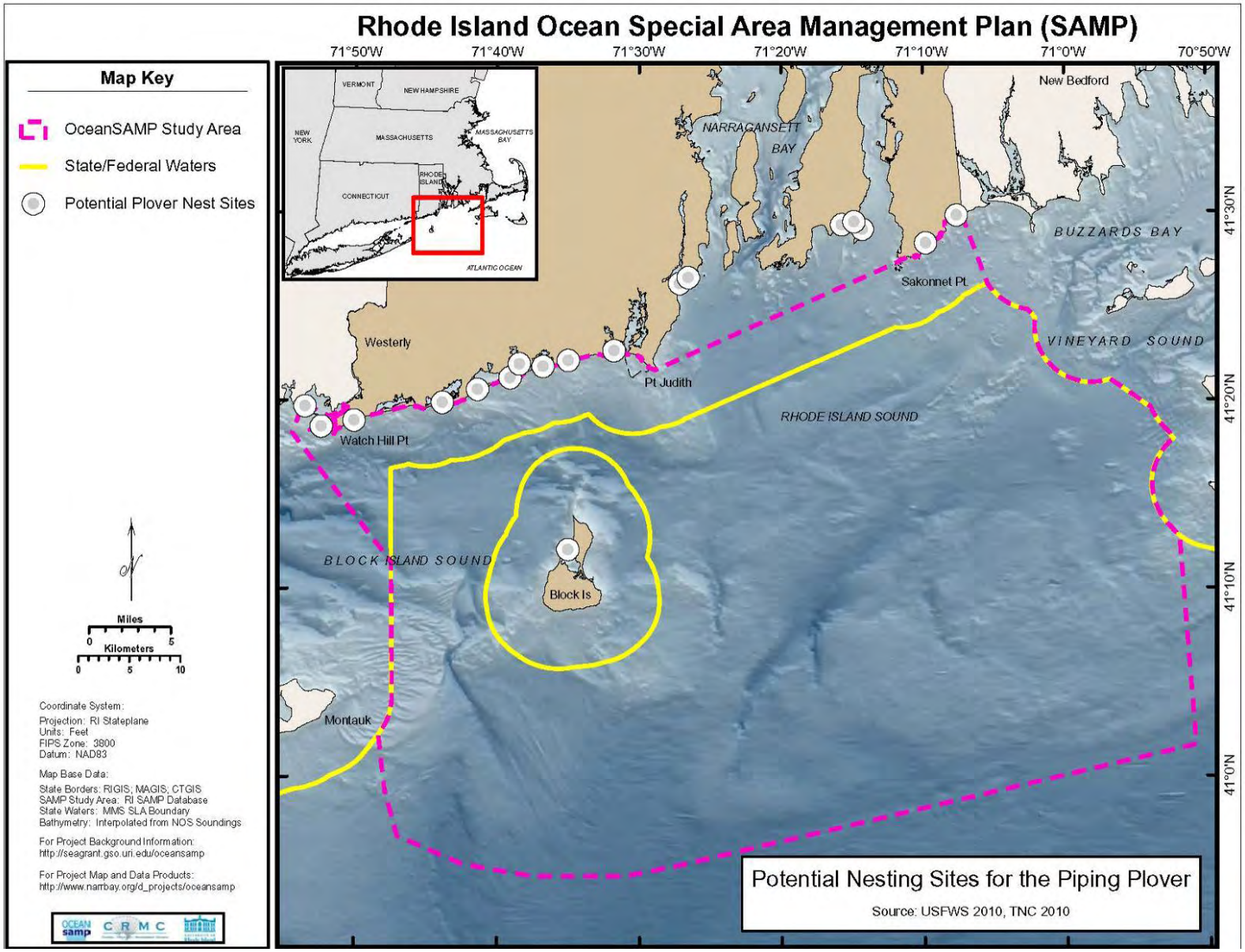

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71°50'W
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71°20'W
71°10'W
71°0'W
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41°20'N
41°10'N
41°0'N
Map Key
OceanSAMP Study Area
State/Federal Waters
Potential Plover Nest Sites
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
NARRAGANSETT BAY
New Bedford
BUZZARDS BAY
Sakonnet Pt
VINEYARD SOUND
Westerly
Pt Judith
RHODE ISLAND SOUND
Watch Hill Pt
BLOCK ISLAND SOUND
Block Is
Montauk
Miles
0 5
Kilometers
0 5 10
Coordinate System:
Projection: RI Stateplane
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OCEAN samp
C R M C
Potential Nesting Sites for the Piping Plover
Source: USFWS 2010, TNC 2010

Figure 8.42. Potential piping plover nesting sites adjacent to the Ocean SAMP boundary (Data from U.S. Fish and Wildlife Service 2010).

10. Under Section 7 of the Endangered Species Act[46] all federal agencies are directed to consult with the U.S. Fish and Wildlife Service (USFWS) to ensure that their actions do not jeopardize listed avian species or, destroy or adversely modify critical habitat of such species. If the USFWS determines that a federal action is likely to adversely affect a species, formal consultation is required, and the issues are examined thoroughly through the preparation of a Biological Assessment by the lead federal agency and a Biological Opinion by the USFWS. Each addresses whether any part of the proposed action is likely to jeopardize the existence of the listed species, and may outline any necessary binding, and/or discretionary recommendations to reduce impacts (MMS 2009a). Compliance with the ESA regulations and coordination with the USFWS ensures that project activities are conducted in a manner that greatly minimizes or eliminates impacting listed species or their habitats (MMS 2007a). See Chapter 10, Existing Statutes, Regulations and Policies for more information on the ESA.

11. Existing federal legislation also provides protection to migratory bird species under the Migratory Bird Treaty Act[47] and the Migratory Bird Executive Order 13186. Consequently, when a proposed offshore renewable energy project undergoes NEPA review, the USFWS will be consulted to determine impacts to migratory species. As a result of the Migratory Bird Executive Order 13186, BOEMRE (formerly the Minerals Management Service) and USFWS have produced a Memorandum of Understanding that identifies specific areas for cooperative action between the agencies and will inform the review process of offshore wind energy facilities in federal waters, and contribute to the conservation and management of migratory birds and their habitats (MMS and U.S. Fish and Wildlife Service 2009). For more information on the Migratory Bird Treaty Act and the Migratory Bird Executive Order 13186, see Chapter 10, Existing Statutes, Regulations and Policies.

12. Past studies have shown that passerine species use Block Island as a migratory stopover and also as a breeding area (Reinert et al. 2002). Radar surveys on Block Island as part of the research conducted by Paton et al. (2010) has supported these findings. Preliminary analysis of radar data suggests that large numbers of passerines are flying over the Ocean SAMP area, especially during the fall. Further analysis of the radar data by Paton et al. (2010) will provide some evidence of the directional movements, abundance and flight elevations. Little is known regarding offshore passerine migration, though the work of Paton et al. (2010) will provide greater insight into the use of the Ocean SAMP area.

13. The current understanding of the potential effects of offshore renewable energy development on birds is based primarily on monitoring performed at European offshore wind energy facilities, particularly Horns Rev and Nysted Offshore Wind Energy Facilities in Denmark (see Table 8.15). It should also be noted that at three of the operational sites where bird surveys have taken place (Horns Rev, Nysted and North Hoyle) bird numbers were relatively low prior to construction. Therefore, while the

[46] 16 U.S.C. 1531 et seq.
[47] 16 U.S.C. 703-712.

overall conclusions of these reports are useful in identifying potential effects, the authors caution that the results may be applicable to other sites only on a very general level (Petersen et al. 2006; Michel et al. 2007). In addition to European reports, the Final Environmental Impact Statement for the Cape Wind Energy Project, LLC (MMS 2009a) and the PEIS (MMS 2007a) have also identified potential effects of offshore wind energy development to avian species. Ultimately, the nature and magnitude of effects of offshore wind energy development on marine and coastal birds depends on the specific location of the facility and its transmission cable (e.g proximity to nesting sites or foraging habitat), the scale and design of the facility, and the timing of construction-related activities (OSPAR 2006; MMS 2007a).

Table 8.15. Summary of European monitoring of avian species.

Offshore Wind Energy Facility	Survey Years	Summary of Findings	Citation
Tuno Knob, Denmark: 10 turbines; online since 1995	1994-1997 1998-1999	Displacement/Changes in Distribution: • Common Eiders declined by 75% and Black Scoters* by more than 90% during post-construction Flight Activity/Avoidance: • Nocturnal flight activity of eiders and scoters occurred within and near the project site • Nocturnal flight activity was 3-6 times greater on moonlit nights compared to dark nights • Flight activity inside and in the vicinity the facility was lower than outside the facility	Guillemette et al. 1998, 1999 Tulp et al. 1999
Nysted, Denmark: 72 turbines; online since 2004	1999-2005	Displacement/Changes in Distribution: • Significant reduction in long-tailed duck staging in the project area post-construction • Gulls and cormorants demonstrated attraction behavior to the structures within the facility Flight Activity/Avoidance: • 91-92% of all birds recorded avoided the offshore wind energy facility • Lateral deflection averaged .5 km (0.3 miles) at night and 1.5 km (0.9 miles) or greater during the day • Moderate reactions in flight routes were observed 10-15 km (6.2-9.3 miles) outside the facility • For eiders, minor flight adjustments were made at 3 km (1.9 miles)and marked changes to orientation within 1 km of the facility Collision Risk • One collision was recorded using a Thermal Animal Detection System	Dong Energy and Vattenfall 2006

Horns Rev, Denmark: 80 turbines; online since 2002	1999-2005	Displacement/Changes in Distribution: • Loons and alcids avoided foraging and staging in the facility during construction • Gulls demonstrated attraction behavior to the structures within the facility Flight Activity/Avoidance: • Several species of seabirds showed avoidance of the facility and adjacent areas (2-4 km [1.2-2.5 miles]) post-construction, though this was not significantly different** • There was a significant decrease in the percentage of loons using the area in the vicinity of the wind farm post-construction • The number of scoters increased in the area near the wind farm post-construction; however, the distribution of scoters indicated they were avoiding the wind farm area, and were observed to avoid flying between the turbines Collision Risk: • No collisions were observed	Dong Energy and Vattenfall 2006
Utgrunden and Yttre Stengrund, Kalmar Sound, Sweden: 12 turbines total; online since 2001	1999-2003	Displacement/Changes in Distribution: • Staging waterfowl declined throughout the study period Flight Activity/Avoidance: • Eider spring migration paths were altered through the project area post-construction • Lateral deflection occurred 1-2 km (0.6-1.2 miles) away from the facility (in good visibility) • 15% of the autumn flocks and 30% of the spring flocks altered flight paths around facility Collision Risk: • Out of the 1.5 million waterfowl observed migrating through Kalmar Sound, no collisions were observed	Pettersson 2005
North Hoyle, U.K.: 30 turbines; online since 2003	2001-2004	Displacement/Changes in Distribution: • Red-throated loon and cormorant shifted their distribution toward the wind park during construction • Cormorant avoided the wind park during and after construction • No significant change in distribution was observed in the common scoter,	National Wind Power 2003

		terns, guillemots, auks***	
Blyth, U.K.: 2 turbines offshore, 9 turbines on the breakwater; offshore online since 2000; onshore online since 1993	1991-2001	Displacement/Changes in Distribution: • No evidence of significant long-term displacement of birds from their habitats (either feeding areas or flight routes). • Temporary displacement of cormorants was observed. Flight Activity/Avoidance: • Approximately 80% of observed flight activity was below rotor height • Gulls were the primary species flying at rotor height and feeding between turbines Collision Risk: • Overall collision rate from 1991-2001 was 3% • Eider collision rates declined over the monitoring period, suggesting adaptive behavior	U.K. Department of Trade and Industry 2006
Kentish Flats, U.K. 30 turbines; online since 2005	2001-2005	Displacement/Changes in Distribution: • No significant changes in abundance of bird population were observed between pre- and post-construction periods • Though not statistically significant, observational data suggested that red-throated loons and great and lesser black-backed gulls decreased in abundance, and herring gulls increased in abundance at the study site Flight Activity/Avoidance: • Observational data showed fewer common terns were observed flying through the facility (though not statistically significant)	Gill, Sales, and Beasley, 2006

* Guillemette et al. 1998 and 1999 also found decreased scoter abundance in the control site.
** Authors stated that low overall bird numbers at the Horns Rev site, high variability between surveys and limited observations during poor visibility conditions prevented sufficient observance to assess avoidance.
*** Authors stated that low overall bird numbers at North Hoyle made detecting changes in abundance difficult.

850.4.1. Habitat Displacement or Modification

1. Offshore renewable energy development may result in temporary or permanent habitat displacement or modification during the construction, operation or decommissioning of a facility. Depending on the location of the facility, birds may potentially be displaced from offshore feeding, nesting, migratory staging, or resting areas. Displacement may be caused by the visual stimulus of rotating turbines, or the boat/ helicopter traffic associated with construction or maintenance activities (Fox et al. 2006). Habitat loss or modification on avian species may result in increased energy expenditures as birds may need to fly farther to access alternate habitat (MMS 2009a). Increased energy expenditures if severe may result in decreased fitness, nesting success, or survival (MMS 2009a). Current research suggests that the permanent loss of habitat, particularly foraging habitat, has the potential to significantly impact certain avian species. However, the severity of the effects of displacement from foraging habitat depends on the amount of habitat lost, the distance to alternate habitat, and the food resources available at the nearest alternate site (MMS 2009a). Siting offshore renewable energy facilities in areas to avoid important bird foraging areas may minimize any potential adverse impacts on birds (OSPAR 2006; MMS 2007a).

2. Changes in species distribution have been observed at a number of offshore wind energy facilities in Europe. Studies of the Horns Rev and Nysted wind farms in Denmark generally found birds to demonstrate avoidance behavior of the wind farms, although the responses were highly species specific. Diving ducks, in particular, avoided the turbines, and few birds were observed in the area within the turbines (see Table 8.15). This displacement of birds represents effective habitat loss for a number of species, although it is important to evaluate habitat loss in terms of the total proportion of feeding habitat available (DONG Energy and Vattenfall 2006). One reported example of habitat displacement was found to occur at the Nysted Offshore Wind Energy Facility in Denmark. Long-tailed ducks (*Clangula hyemalis*) at this site showed statistically significant reductions in density within and 2 km (1.2 miles) around the wind farm post-construction. Prior to construction the same area had shown higher than average densities, suggesting that the facility had resulted in the displacement of this species from formerly favored feeding areas. However, the observed number of long-tailed ducks was relatively low and therefore of no significance to the overall population (DONG Energy and Vattenfall 2006).

3. At the Horns Rev Demonstration Project, Red-throated and Arctic Loons (*Gavia stellata* and *Gavia arctica*), Northern Gannets (*Sula bassana*), Black Scoters (*Melanitta nigra)*, Common Murre and Razorbills (*Uria aalge* and *Alca torda)* decreased their use of the wind farm area after the installation of the wind turbines, including also zones of 2 and 4 km (1.2 and 2.5 miles) around the wind farm (DONG Energy and Vattenfall 2006). The reason for this avoidance was unknown, though the researchers suggest that perhaps disturbance effects from the turbines or from increased human activity associated with maintenance of the facility may be possible reasons. However, changes in the distribution of food resources in the study area may have also played a role. In contrast, Herring Gulls (*Larus argentatus)* showed a decreased avoidance of the wind farm area, while Great Black-backed Gulls (*Larus marinus)*, Little Gulls (*Larus minutus)* and Arctic and Common Terns (*Sterna paradisaea/hirundo*) showed a general shift from preconstruction avoidance to post

construction preference of the wind farm area. Gulls and terns recorded within the facility were mainly observed at the edges of the wind farm and far less in the central parts of the facility. The presence of the turbines and the associated vessel activity in the area were suggested as possible reasons for increased use of the project areas by the gulls (DONG Energy and Vattenfall 2006).

4. Additional evidence of displacement or changes in distribution patterns of birds post-construction were reported in the monitoring reports from Tuno Knob (eiders and scoters), Yttre Stengrund and Utgrunden wind parks in Kalmar Sound (waterfowl), North Hoyle (shag, a species of cormorant), Blyth (cormorant), and Kentish Flats (loons and gulls) (Guillemette et al.1998; DONG Energy and Vattenfall 2006; Pettersson 2005; National Wind Power 2003; U.K. Department of Trade and Industry 2006; Gill, Sales, and Beasley 2006) though the statistical significance of displacement varied widely among studies (Michel et al. 2007) (see Table 8.15). Changes in distribution or displacement of avian species from an area as a result of an offshore renewable energy facility may be difficult to detect in some situations, especially when there is a large annual or seasonal fluctuations in densities, or when prey availability also varies spatially or temporally (Fox et al. 2006; Petersen et al. 2006).

5. Alternatively, changes in species distribution in an area may result from the attraction to an offshore wind energy facility. For species who do not avoid the project area, the reef effects caused by the underwater structures of an offshore renewable energy facility may increase prey availability. At the Nysted Offshore Wind Energy Facility observations suggested that both Great Cormorants (*Phalacrocorax carbo)* and Red-breasted Mergansers (*Mergus serrator*) were attracted to the project site. Cormorants were observed roosting on the meteorological masts and the foundation of the turbines, suggesting that this species was not avoiding the area but instead using the installed structures (DONG Energy and Vattenfall 2006). Observations of the Red-breasted Mergansers showed indications of an increased preference of the wind farm site and peripheral areas (within 4 km [2.5 miles]) after the installation of the wind farm. Increased fish availability in the area in the post-construction phase was suggested as a possible explanation for this increase (Petersen et al. 2006). For a more detailed discussion of the potential for reef effects around offshore renewable energy facilities see Section 850.3.2.

6. Temporary or permanent habitat modification may result from construction activities such as foundation or turbine installation, cable laying, or onshore installations. For example, during construction periods, installation activities associated with substructures and cable laying may increase temporarily the turbidity in the project area. Increased total suspended solids may limit a birds' ability to see under water and thereby search for food by sight, especially seaducks that depend on benthic invertebrates as food. The Cape Wind FEIS predicts that sediment suspended by the cable installation will be localized (within 457 m [1,500 ft] of the trench) and may result in levels of 20 mg/liter. However, the turbidity effects caused by cable laying and other construction related activities will be highly site specific. Any impacts to turbidity are likely to be localized and temporary (MMS 2009a).

7. Onshore construction associated with offshore renewable energy development may result in the loss or alteration of coastal habitat used by birds for foraging, roosting, nesting, migratory staging or resting. While the impacts of habitat modification on most birds would be expected to be temporary (lasting only until construction was completed), modifications to some coastal habitats (e.g. near onshore substations) may be long-term (MMS 2007a).

850.4.2. Human Disturbance

1. Construction, operation and decommissioning activities may cause a temporary or long-term disturbance to birds in the vicinity of an offshore renewable energy facility, or in coastal areas where underwater transmission cables are connected to the grid. Vessel traffic, noise associated with pile driving or other construction of above-water portions of the towers and the substation may result in the disturbance of birds offshore. Affected birds would be expected to leave the area during the construction period, and some may permanently abandon the area due to the subsequent presence and operation of the completed offshore renewable energy facility (MMS 2009a; Petersen et al. 2006). One observed example of disturbance at the Horns Rev site involved a passing service helicopter through an area outside of the wind farm where a congregation of Black Scoters was present. The helicopter activity resulted in a massive flush of birds which took to the air in avoidance. However, this reaction was only temporary as most of the disturbed birds were recorded landing in the same area after the helicopter had left (Petersen et al. 2006). Onshore, coastal construction involved in connecting the transmission cable to the grid, may disturb shorebirds in the area (MMS 2009a). Particularly sensitive species, such as the Piping Plover, may be disturbed from their nests or from foraging activities which may have consequences on individual health or breeding success (MMS 2009a). Siting onshore transmission cable connections away from known nesting habitats when possible and scheduling onshore construction activities during non-breeding seasons may minimize any potential adverse impacts to shorebirds.

850.4.3. Avoidance/Flight Barrier

1. Avoidance behavior or the alteration of flight patterns may also result from the presence of an offshore renewable energy facility, as studies have shown that some birds chose to fly outside an offshore wind energy facility rather than fly between the turbines (MMS 2007b; Fox et al. 2006; Petersen et al. 2006; Desholm and Kahlert 2005). Such avoidance behavior may reduce the risk of collision, however the offshore wind energy facility may also present a barrier to movement, increase distances to foraging habitats, or increase migratory flight distances (Tulp et al. 1999, Kahlert et al. 2004, Desholm and Kahlert 2005; Fox et al. 2006). The level of impact may depend on the size of the facility, the spacing of the turbines, the extent of extra energetic cost incurred by avoiding the area (relative to the normal flight costs pre-construction) and the ability of the bird to compensate for this degree of added energetic expenditure. In extreme conditions, increased energy exerted by a bird to avoid a project site may potentially result in a reduced physical condition (Fox et al. 2006).

2. Avoidance behavior and changes in flight orientation were reported for Tuno Knob (1 to 1.5 km [0.6 to 0.9 miles] from turbines), Nysted (0.5 to 3 km [0.3 to 1.9 miles] from turbines, and sometimes moderate adjustments were observed 10 to 15 km [6.2 to 9.3 miles] away), Horns Rev (0.2 to 1.5 km [0.1 to 0.9 miles]), and Kalmar Sound (1 to 2 km [0.6 to 1.2 miles]) (Tulp et al. 1999; DONG Energy and Vattenfall 2006; Pettersson 2005). Extra energetic costs as a result of alterations to flight paths were calculated and considered to be negligible at Nysted (0.5 to 0.7 percent) and Kalmar Sound (0.4 percent). In addition, decreased numbers of migrant flocks were observed crossing Nysted, Horns Rev, and the Kalmar Sound offshore wind energy facilities when compared to baseline periods (DONG Energy and Vattenfall 2006; Pettersson 2005). To date, all studies that have monitored lateral deflection of migrating flocks reported active avoidance of turbines (Michel et al. 2007).

3. Researchers at Tuno Knob, Nysted, Horns Rev, and Kalmar Sound also examined how the effect of reduced visibility (at night or in poor weather conditions) affected flight patterns around an offshore wind energy facility (Tulp et al. 1999; DONG Energy and Vattenfall 2006; Pettersson 2005). The researchers concluded that flight adjustments often were made closer to the edge of the wind park at night or in low visibility conditions than during the day or in clear weather. Observations using the Thermal Animal Detection Systems (TADS) at Nysted provided infra-red monitoring over extended periods of nighttime and detected no movements of birds below 120 m (393.7 feet) during the hours of darkness, even during periods of heavy migration. This suggests birds flying in the vicinity of the wind farm are doing so at higher altitudes at night (up to 1500 m (0.9 miles) altitude), and that even at heights above the rotor swept zone a lateral response can be detected amongst night migrating birds (DONG and Vattenfall 2006; Blew et al. 2006).

850.4.4. Collision with Structures

1. The risk of collision with offshore renewable energy structures, such as offshore wind turbine blades and towers, by birds is based on: the frequency of species occurrence in the project area, visibility conditions during encounters with structures, and the flight behavior or height of birds when in the vicinity of a facility (MMS 2009a, Petersen et al. 2006). Monitoring at European offshore wind energy facilities has reported relatively few collisions, perhaps in part due to the avoidance reaction many species exhibit prior to reaching the facility (Michel et al. 2007).

2. Out of a total 1.5 million migrating waterfowl observed during the monitoring of the Swedish offshore wind energy facilities in Kalmar Sound, no collisions were observed (Pettersson 2005). Similarly, no collisions were observed at the Horns Rev facility throughout the monitoring period (2002-2005). While no collisions were observed, the risk was modeled and predicted to equal approximately 14 birds per year or 1.2 birds per turbine per year at Kalmar Sound (Pettersson 2005).

3. At Nysted thermal imaging equipment was mounted to a turbine during operation to capture bird movement and collisions. One bird collision was recorded during the 2005

monitoring period which covered all four seasons of that year. However, the equipment was only stationed at one site, limiting the probability of capturing a collision (DONG Energy and Vattenfall 2006). Because not all turbines could be outfitted with thermal imaging equipment, a collision model was used to estimate the numbers of Common Eiders, the most common species in the project area, likely to collide with the sweeping turbine blades each autumn at the Nysted offshore wind farm. Using parameters derived from radar investigations and TADS, and 1,000 iterations of the model, it was predicted with 95% certainty that out of 235,000 passing birds, 0.018 to 0.020% would collide with all turbines in a single autumn (41 to 48 individuals), equivalent to less than 0.05% of the annual hunt in Denmark (currently approximately 70,000 birds) (DONG Energy and Vatenfall 2006).

4. The collision rate at Blyth Offshore Wind Energy Facility was more accurately measured since nine of the turbines are located on a breakwater and the entire facility is relatively close to shore and therefore more easily accessible. From 1991 to 1996, the collision rate was calculated to equal less than 0.01 percent. During 10 years of monitoring (1991 to 2001), only three percent of the 3,074 bird carcasses collected were directly attributed to collisions with turbines (Still et al. 1996 as cited in Michele et al. 2007). Researchers suggested that mortality events may have correlated with reduced visibility or poor weather conditions.[48] Eider collision rates declined during the monitoring period, possibly because of adaptive behavior. Approximately 80 percent of observed flight activity was below rotor height; gulls were the primary species flying at rotor height and feeding between turbines.

5. Research conducted by Paton et al. (2010) will provide baseline information on the frequency of occurrence of different avian species in the Ocean SAMP area, as well as information on the flight elevation of individuals traveling through the Ocean SAMP area. This information will help to assess the risk of bird collisions in the Ocean SAMP area if an offshore wind energy facility were to be developed.

850.4.6. Water Quality

1. Water quality around an offshore renewable energy facility may potentially be impacted if illegal dumping or accidental spills occurs from vessels or equipment. Because many marine and coastal birds follow behind vessels to forage in their wake, individuals may be exposed to accidental discharges of liquid wastes (such as bilge water, operational discharges). Dumping and oil spills are already subject to standard operating procedures and discharge regulations (30 CFR 250.300 and MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), and the discharge of any legally allowed waste is not expected to pose any threat to avian species (MMS 2007a). Substances that are legally discharged from vessels offshore are rapidly diluted and dispersed posing negligible risk to birds in the area (MMS 2007a). Accidental spills from offshore renewable energy facilities may pose a potential hazard to birds if they result in the release of large volumes of hazardous materials (MMS 2007a). For example, transformers, used to transmit energy generated

[48] Merrill (2010) reports that based on historical data sets, the Ocean SAMP typically experiences 3-4 foggy days per month during the months of March-May and October-December, and 6-10 foggy days during June, July and August.

from the offshore renewable energy facilities to shore, may contain reservoirs of electrical insulating oil or other fluids. The accidental release of these materials may impact the health and survival of waterbirds exposed to the spill, or may indirectly impact avian species by adversely affecting prey species in the area (MMS 2009a). The severity of these impacts depend on the location of the facility, the volume and timing of the spill, the toxicity of the material and the species exposed to the spill (MMS 2007a; MMS 2009a). An assessment performed on the Cape Wind Project found that the potential risk associated with accidental spills is insignificant to minor, and that precautionary measures such as developing an oil spill response plan may minimize any adverse impacts on avian species (MMS 2009a).

2. If solid waste is released, marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris, potentially resulting in strangulation, the injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly, swim or ingestion food, or release toxic chemicals (Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). These adverse impacts may potentially reduce the growth of an individual or may be lethal in severe cases (MMS 2007a). Bird species utilizing the Ocean SAMP area are already exposed to the potential risks associated with marine debris resulting from existing uses of the Ocean SAMP area.

Section 850.5. Marine Mammals

1. Offshore renewable energy may have a variety of effects on marine mammals in the Ocean SAMP area. The purpose of this section is to provide an overview of all of the potential effects of offshore renewable energy facilities on the marine mammal species that are known to occur within the Ocean SAMP area. It should be noted that these potential effects may vary widely depending on the species as well as the particular site or project. In addition, it should be noted that scientific inquiry into the interactions between offshore wind farms and marine mammals is relatively new, and in most cases still under development. This section provides an overview of the best information available to date. It is expected that this section and the entire Ocean SAMP document will be updated in the future, as new information is made available.

2. Understanding the responses of marine mammals to offshore renewable energy facilities requires sufficient data on the abundance, distribution, and behavior of marine mammals, which are difficult to observe because they spend most of their time below the sea surface (Perrin et al. 2002). Data on abundance in particular are difficult to come by; there is a lack of baseline data for many species, and some of the baseline data in use may be outdated. In order to understand the context in which a specific development site is being used by target species (e.g., for feeding, breeding or migration) baseline data should be collected before any human activity has started (OSPAR 2008). A desk-based study conducted by Kenney and Vigness-Raposa (2009) for the Ocean SAMP, has synthesized all available information on marine mammal occurrence, distribution and usage of this area, providing valuable background of the importance of this area to marine mammal species. This report also ranks marine mammal species found within the Ocean SAMP area according to conservation priority, taking into account such factors as overall abundance of the population, the likelihood of occurrence in the Ocean SAMP area, endangered or threatened status, sensitivity to specific anthropogenic activities, and the existence of other known threats to the population (Kenney and Vigness-Raposa 2009).

3. Marine mammal species in the Ocean SAMP area are either whales (cetaceans), a scientific order which includes dolphins and porpoises, or seals (pinnipeds). Marine mammals are highly mobile animals, and for most of the species, especially the migratory baleen whales, the Ocean SAMP area is used temporarily as a stopover point during their seasonal movements north or south between important feeding and breeding grounds. The Ocean SAMP area overlaps with the Right Whale Seasonal Management Area, although the typical migratory routes for right whales and other baleen whales lie further offshore and outside of the Ocean SAMP area (Kenney and Vigness-Raposa 2009; see Chapter 7, Marine Transportation, Navigation and Infrastructure). However, in one event in April 2010, nearly 100 right whales were spotted feeding in Rhode Island sound, indicating that they do sometimes appear within the Ocean SAMP boundary area (NEFSC 2010). Right whales and other baleen whales have the potential to occur in the SAMP area in any season, but would be most likely during the spring, when they are migrating northward and secondarily in the fall during the southbound migration. In most years, the whales would be expected to transit through the Ocean SAMP area or pass by just offshore of the area.

4. While the impact on any species of marine mammal within the vicinity of an offshore renewable energy facility is important, endangered or threatened species are of particular concern, mainly because the magnitude of the potential impact may be much more severe to these species due to their low population numbers (MMS 2007a). The following marine mammals are of highest concern because they are listed as endangered under the federal Endangered Species Act (ESA) and may also occur within the Ocean SAMP area: the North Atlantic Right whale (*Eubalaena glacialis*), the humpback whale (*Megaptera novaeangliae*), and the fin whale (*Balaenoptera physalus*). Other marine mammal species that occur commonly or regularly within the Ocean SAMP area are listed in Table 8.16. Three very abundant species that are likely to occur frequently in the Ocean SAMP area include the Harbor Porpoise (*Phocoena phocoena*), the Atlantic White-Sided Dolphin (*Lagenorhynchus acutus*) and the Short-Beaked Common Dolphin (*Delphinus delphis*) (Kenney and Vigness-Raposa 2009).[49]

[49] For further explanation of the terminology used to describe marine mammal abundance within the SAMP area, see Kenney and Vigness-Raposa 2009.

Table 8.16. Marine mammal species most commonly occurring in the Ocean SAMP area (Kenney and Vigness-Raposa 2009)

	Season Most Abundant in Ocean SAMP Area[†]	Comments on Distribution or Activity in the Ocean SAMP Area
North Atlantic Right Whale (*E*)	Spring & Fall	Mostly transits through outer regions of the Ocean SAMP area as individuals migrate south in the fall and north in the spring; occasionally individuals will linger for days or weeks to feed in Ocean SAMP area.
Humpback Whale (*E*)	Spring & Summer	Abundance varies year to year in response to prey distribution.
Fin Whale (*E*)	Summer	More abundant outside the Ocean SAMP boundary.
Sperm Whale (*E*)	Summer	More abundant outside the Ocean SAMP boundary, primarily in deeper water.
Harbor Porpoise	Spring	Can occur in the Ocean SAMP area during all seasons, but are most abundant in the spring when they are moving inshore and northeastward toward feeding grounds. They are among the most abundant marine mammal species within the Ocean SAMP area.
Atlantic White-Sided Dolphin	All seasons	Most abundant outside Ocean SAMP boundary.
Short-beaked Common Dolphin	All seasons	Likely to occur frequently in the Ocean SAMP area.
Harbor Seal	Fall, Winter and Spring	Regular haul-out sites along the periphery of Block Island (October through early May). These haul-out sites are thought to be used primarily by younger animals that are foraging in the area prior to migrating further north.
Sei Whale (*E*)	Spring	Irregular abundance in Ocean SAMP area.
Common Minke Whale	Spring and Summer	More abundant outside the Ocean SAMP boundary.
Long-Finned Pilot Whale	Spring	More abundant outside the Ocean SAMP boundary.
Risso's Dolphin	Spring and Summer	More abundant outside the Ocean SAMP boundary.
Bottlenose Dolphin	Summer	Likely only to be seen in outer part of Ocean SAMP area.

[†] In many cases marine mammal species may be present in all seasons. Seasons listed are those with the greatest probability of occurrence.
Seasons are defined as: Winter (December, January, February); Spring (March, April, May); Summer (June, July, August); Fall (September, October, November)
(*E)* Marine Mammal is listed as Endangered under the Endangered Species Act

4. The only species that can be classified as a seasonal resident marine mammal in the Ocean SAMP area is the Harbor Seal (*Phoca vitulina*). Harbor seals are known to regularly occupy haul-out sites on the periphery of Block Island (along with other sites outside of the Ocean SAMP area within Narragansett Bay) during the winter and early spring (Kenney and Vigness-Raposa 2009). The haul-out site used most frequently on Block Island is a wooden raft located in Cormorant Cove within the Great Salt Pond, located near the center of the island (See Figure 8.43) (Kenney and Vigness-Raposa 2009; Schroeder 2000). Because the site is at the center of the island, it is unlikely to be disturbed by activities associated with the development of offshore renewable energy.

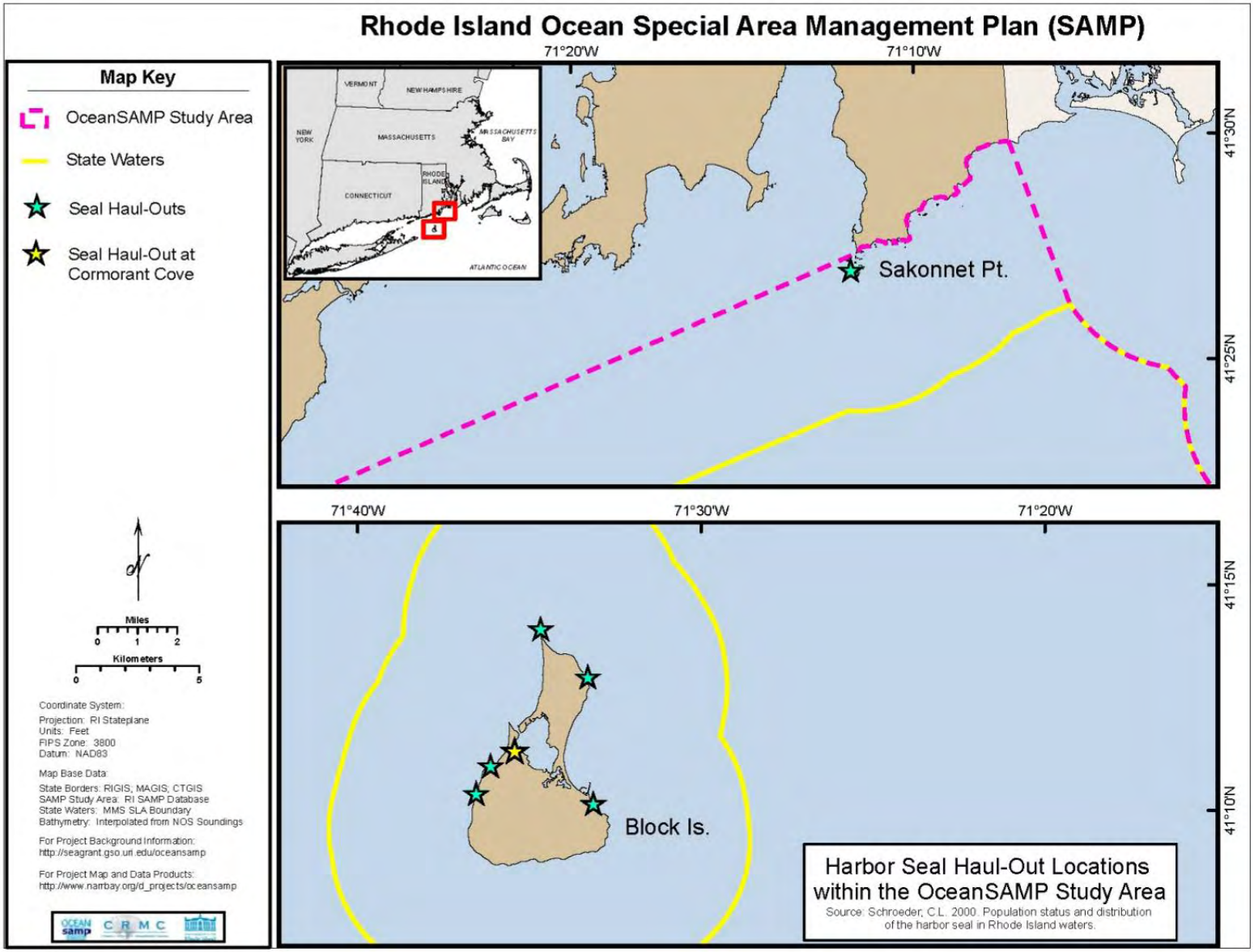

Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
OceanSAMP Study Area
State Waters
Seal Haul-Outs
Seal Haul-Out at Cormorant Cove
71°20'W
71°10'W
41°30'N
41°25'N
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
Sakonnet Pt.
71°40'W
71°30'W
71°20'W
41°15'N
41°10'N
Block Is.
Harbor Seal Haul-Out Locations within the OceanSAMP Study Area
Source: Schroeder, C.L. 2000. Population status and distribution of the harbor seal in Rhode Island waters.
Miles
0 1 2
Kilometers
0 5
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
Map Base Data:
State Borders: RIGIS, MAGIS, CTGIS
SAMP Study Area: RI SAMP Database
State Waters: MMS SLA Boundary
Bathymetry: Interpolated from NOS Soundings
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
CRMC

Figure 8.43. Seal haul-out sites in the Ocean SAMP area (Schroeder 2000; Kenney and Vigness-Raposa 2009).

5. The degree to which offshore renewable energy facilities may affect marine mammals depends in large part on the specific siting of a project, as well as the use of appropriate mitigation strategies to minimize any adverse effects (MMS 2007a). All potential adverse impacts and enhancements posed by any future project within the Ocean SAMP area to marine mammals will undergo rigorous review under the National Environmental Policy Act (NEPA)[50] to comply with the standards under the Marine Mammal Protection Act (MMPA)[51] and the Endangered Species Act (ESA).[52] Under the MMPA all marine mammals are protected, and acts that result in the taking (a take is defined as "harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal") of marine mammals in U.S. waters is prohibited without authorization from the National Marine Fisheries Service (NMFS). Further protection is granted under the ESA by the NMFS for marine mammals that are listed as threatened or endangered. The ESA prohibits any person, including private entities, from "taking" a "listed" species. "Take" is broadly defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect or to attempt to engage in any such conduct."[53] As a result, any proposed project will require consultation under the ESA and MMPA to examine all potential effects on marine mammals prior to development in order to ensure that potential adverse impacts are minimized. For more information on the MMPA and the ESA see Chapter 10, Existing Statutes, Regulations, and Policies.

6. The principle impacts identified in the PEIS include potential effects of increased underwater noise, impacts to water quality, vessel strikes and displacement (MMS 2007a). Of these potential impacts, increased underwater noise may pose the greatest risk to marine mammals, especially to baleen whales (e.g. humpback whales and the North Atlantic right whale), who are in theory most sensitive to the low frequency sounds produced during construction activities (see below for further discussion).

850.5.1. Noise

1. Marine mammals have highly-developed acoustic sensory systems, which enable individuals to communicate, navigate, orient, avoid predators, and forage in an environment where sound propagates far more efficiently than light (Perrin et al. 2002) Evaluating noise effects on marine mammals can be challenging, as information on hearing sensitivity for most marine mammal species is currently not available (Richardson et al. 1995; Southall et al. 2007). As a result, when analyzing potential noise effects from offshore renewable energy installations, the hearing sensitivities of most marine mammal species need to be inferred.

2. In principle, marine mammals can be expected to be most sensitive to sounds within the frequency range of their vocalizations (Richardson et al. 1995). For example, baleen whales produce low frequency sounds (~10Hz to 10 kHz), that travel long distances

[50] Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258, § 4(b), Sept. 13, 1982.
[51] 50 CFR 216.
[52] 7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.
[53] 16 U.S.C. § 1532(19)

under water, and therefore, it is expected that these whales would also be most acoustically sensitive at lower frequencies (Richardson et al. 1995). However, there is no data on hearing sensitivities in any baleen whale species to date, making assessments on noise effects quite difficult. It is known that smaller toothed whales can hear frequencies over a range of 12 octaves, with a hearing range that overlaps the frequency content of their echolocation clicks and their vocalizations used for communication (Hansen et al. 2008; Au 1993; Richardson et al. 1995; Southall et al. 2007). In addition, as with any mammal, hearing sensitivity varies between individuals within a species (Houser and Finneran, 2006). Consequently, as a result of the incomplete data on marine mammal hearing, it can be difficult to predict the potential impact of noise from offshore renewable energy facilities on marine mammal species. There have been a number of studies conducted in Europe on the effects of pile driving as well as the effects of noise from operating wind farms on marine mammals. However, Europe has very few species of marine mammals, and only rare occurrences of baleen whales in the wind farm areas, leaving significant data gaps in the noise effects of offshore wind energy on marine mammals.

3. Underwater noise may be generated during all stages of an offshore renewable energy facility, including during pre-construction, construction, operation and decommissioning. The strength and duration of the noise varies depending on the activity (see Table 8.17). For example, some construction activities, such as pile driving, result in short periods of intense noise generation, compared with long-term, low level noise associated with operational activities. While the intensity and duration of the noise produced by pile driving activities and operational wind turbines vary, both produce low frequency noise, and therefore potentially pose a risk in particular to large whales, such as the North Atlantic right whale, humpback whales, and fin whales, as these species are thought to be most sensitive in this frequency range (Southall et al. 2007; see Figure 8.44). In order to minimize the risk of causing hearing impairment or injury to any marine mammal during activities of high noise, monitoring the project area for the presence of marine mammals and maintenance of an exclusion zone has been required (MMS 2009a; JNCC 2009). Furthermore, scheduling construction activities to avoid periods when marine mammals may be more common in the project area is one precautionary measure to minimize any potential adverse impacts (OSPAR 2006). Information on the potential long-term impacts of displaced individuals, or on the potential effects under water noise may cause to resident marine mammal populations, is not currently available (MMS 2007a, OSPAR 2008).

Table 8.17. Above and below water noise sources associated with offshore renewable energy development (MMS 2007a; OSPAR 2009a)

Above Water Noise					
Noise Source	**Duration**	**Frequency Range**	**Frequency of Peak Level (Hz)**	**Peak Sound Intensity Level (dB re-20 µPa)**	**Reference Distance (m)**
Ship/barge/ boat[a,b,d]	Intermittent to continuous, up to several hours or days	Broadband, 20−50,000 Hz	250−2,000	68−98	Near source
Helicopter	Intermittent, short duration	Broadband with tones	10−1,000	88	Near source
Pile driving [a,d]	50-100 millisecond pulses/beat, 30−60 beats/min, 1−2 hours/pile	Broadband	200	110	15 m (49.2 feet)
Construction Equipment[d]	Intermittent to continuous	Broadband	Broadband	68–99	15 m (49.2 feet)
Underwater Noise Sources					
Noise Source	**Duration**	**Frequency Range**	**Frequency of Peak Level (Hz)**	**Peak Sound Intensity Level (dB re-1 µPa)**	**Reference Distance (m)**
Ship/barge/ boat[a,b,c,,f]	Intermittent to continuous, up to several hours or days	Broadband, 20−50,000 Hz	250−2,000	150-180 rms	1m (3.3 feet)
**Pile driving[a,d,f]	50-100 millisecond pulses/beat, 30−60 beats/min, 1−2 h/pile	Broadband 20- above 20,000 Hz	100-500	228 peak, 243-257 peak to peak	1m (3.3 feet)
Seismic air-gun array [b,f]	30-60 millisecond pulses, repeated at 10 -15 sec intervals	Mainly low frequency, but some 10-100,000 Hz	10-125	Up to 252 downward, up to 210 horizontally	1m (3.3 feet)
Seismic explosions TNT (1-100lbs)[e,f]	~1-10 milliseconds	2-1,000 Hz	6-21	272-287	1m (3.3 feet)
Dredging [c,f]	Continuous	Broadband 20-20,000 Hz	100-500	150-186	1m (3.3 feet)
Drilling [b,c,f]	Continuous	Broadband 10-10,000 Hz	20-500	154	1m (3.3 feet)
Operating Turbine (1.5 MW operating in winds of 12 m/s) [a]	Continuous		50 Hz/ 150 Hz	120-142	1m (3.3 feet)

[a] Thomsen et al. (2006). [c] Richardson et al. (1995). [e] Ross (1976).
[b] LGL (1991). [d] Washington DOT (2005). [f] OSPAR (2009a).

**(note: noise associated with pile driving will vary greatly depending on the size of the pile and hammer used)

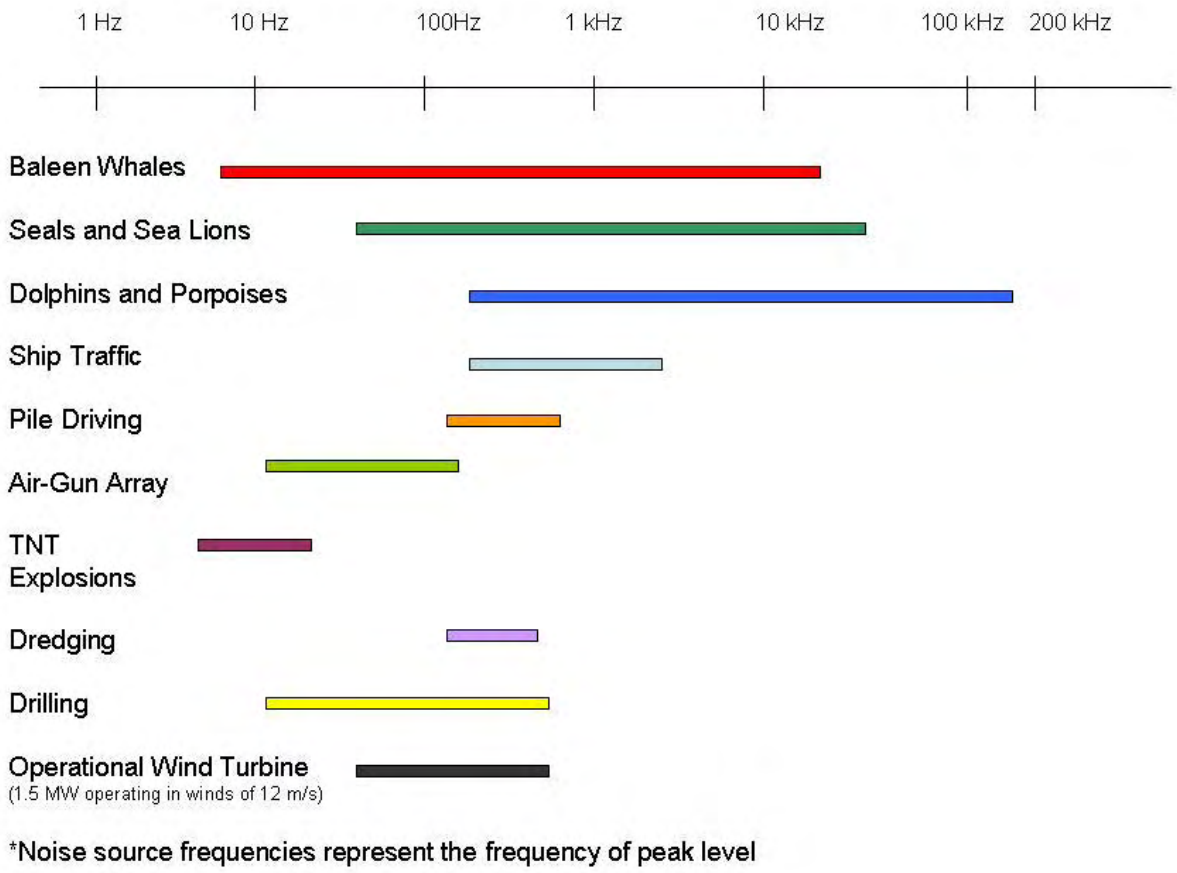


Figure 8.44. Typical frequency bands of sounds produced by marine mammals compared with the main frequencies associated with offshore renewable energy development (OSPAR 2009a).

4. When examining acoustic impacts on marine mammals, four overlapping impact zones are commonly used (see Figure 8.45; Richardson et al. 1995), corresponding to the different effect levels:
   - · the zone of hearing loss, discomfort, or injury,
   - · the zone of responsiveness,
   - · the zone of masking and,
   - · the zone of detection/ audibility.

   The zone closest to the sound source usually has the highest sound levels, which may result in physical damage or injury to a marine mammal if sound levels are sufficiently high (OSPAR 2009a). In the zone of responsiveness, noise exposure may result in behavioral reactions such as avoidance, disruption of feeding behavior, interruption of vocal activity or modifications of vocal patterns. In the zone of masking, the overlap in the frequencies of sounds produced by a sound source and those used by marine mammals has the potential to mask vocalizations, interfering with their reception and

inhibiting the efficient use of sound. The detection zone is the area in which the noise generated from the sound source is audible to a marine mammal, and above ambient noise levels (Richardson et al. 1995).

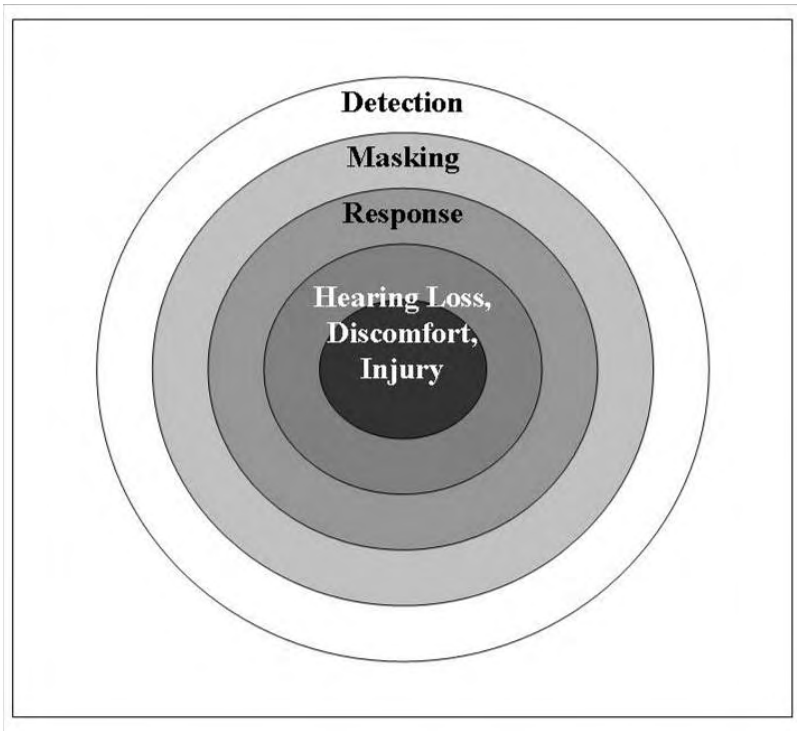


Figure 8.45. Theoretical zones of noise influence (Richardson et al. 1995).

5. Regarding the impacts of offshore renewable energy construction on marine mammals, the MMPA considers the zone of physical impairment, responsiveness and masking when determining a proposed project's compliance. Under the MMPA: "*Level A Harassment* means any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild. *Level B Harassment* means any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild." See Table 8.18 for the criteria used to define Level A and Level B affects under the MMPA.

Table 8.18. Criteria for estimating the effects of noise on marine mammals under the Marine Mammal Protection Act (U.S. Department of Commerce 2008).

Criteria	NMFS Criteria
Level A Injury (Pinnipeds)	190 dB re 1 µPa rms (impulse, e.g. pile-driving)
Level A Injury (Cetaceans)	180 dB re 1 µPa rms (impulse)
Level B Harassment/Behavior	160 dB re 1 µPa rms (impulse)
Level B Harassment/Behavior	120 dB re 1 µPa rms (non-pulse noise, e.g. vibratory pile driving)

6. Prior to construction, geophysical surveys performed to characterize ocean-bottom topography or geology may include the use of air gun arrays or side-scan sonar. Survey techniques using high-energy air gun arrays pose a greater risk to marine mammals in the vicinity of the sound source, as opposed to side-scan sonar, and may result in temporary hearing impairment or in extreme cases physical injury very close to the source. Side-scan sonar, which uses a more focused beam of sound, is the most common survey technique used in the siting of offshore wind facilities. Side-scan sonar was found to result in only temporary behavior changes, even during the more extreme cases, and is unlikely to result in any hearing impairment or physical injury (MMS 2007a; NMFS 2002a). It is possible that individual animals will leave the area or change behavior temporarily as a result of the noise disturbance (MMS 2007a). In particular, behavioral reactions of whales (cetaceans) may include: avoidance or flight from the sound source, disruption of feeding behavior, interruption of vocal activity, or modifications of vocal patterns. However, the response of an individual cetacean may be unpredictable, as it depends on the animal's current activity, its ability to move away quickly (especially a concern with regard to North Atlantic Right whales), and the animal's previous experience around vessels (MMS 2009a). It is unknown what long-term effects these changes in behavior may have on the individual animal or entire cetacean populations.

7. Seals (pinnipeds) have shown avoidance in response to noise generated by geophysical surveys (NMFS 2002b; Thomson et al. 2001; MMS 2003; OSPAR 2009a). Since harbor seals regularly haul-out on sites around Block Island (Kenney and Vigness-Raposa 2009), survey activities in these areas may cause a temporary disturbance. The PEIS states that any displacement from the study area as a result of these surveys is likely to be temporary, resulting in negligible impacts to marine mammals (MMS 2007a; MMS 2009a). Siting facilities away from important marine mammal congregation, mating or feeding areas and taking into account marine mammal activity in the area when scheduling surveys will further minimize any potential negative impacts (MMS 2007a).

8. Underwater noise from the construction of an offshore renewable energy facility is generated during the installation of the foundation piles used to support the turbines and transformer platforms. Most offshore turbines are placed on steel foundations, which are affixed to piles driven into the seabed. Piles can range in diameter from 1 to 5 m [3.3-16.4 ft], with the larger piles being used for monopile turbines and smaller piles used for jacketed structures. The piles are driven into the bottom by powerful hydraulic hammers, causing very loud noise emissions, which may be audible for marine mammals over distances of several tens of kilometers (Thomsen et al. 2006; Nedwell et al. 2007). The zone of audibility may extend beyond 80 km [49.7 mi] to perhaps hundreds of kilometers for some marine mammal species (e.g. harbor porpoises and harbor seals) (Thomsen et al. 2006). Yet pile driving for one single turbine is of relatively short duration. The level of noise emitted by pile driving operations is dependent on a variety of factors such as pile dimensions, seabed characteristics, water depth, and the strength and duration of the hammer's impact on the pile (Nedwell et al. 2007; OSPAR 2009a).

9. Research conducted by Miller et al. (2010) modeled the extent of pile-driving noise within the Ocean SAMP area and mapped the areas subject to sound intensities of concern under the MMPA (see Table 8.18 and Figure 8.46). This analysis was calculated for a 1.7 m [5.5 foot] diameter pile (similar to those used in lattice jacket structures) driven into the bottom with an impact hammer. The red shaded area represents the zone of injury, the orange area represents the zone of harassment or potential behavior response, and the yellow area represents the zone of audibility or detection by marine mammals.[54] It should be noted that this is an estimate and that the zones may be larger or smaller depending on the actual size of the pile and method of installation.

[54] Based on an attenuation rate = 17log(range from source) for a sound source at 200 Hz. See Miller et al. 2010 for more information.

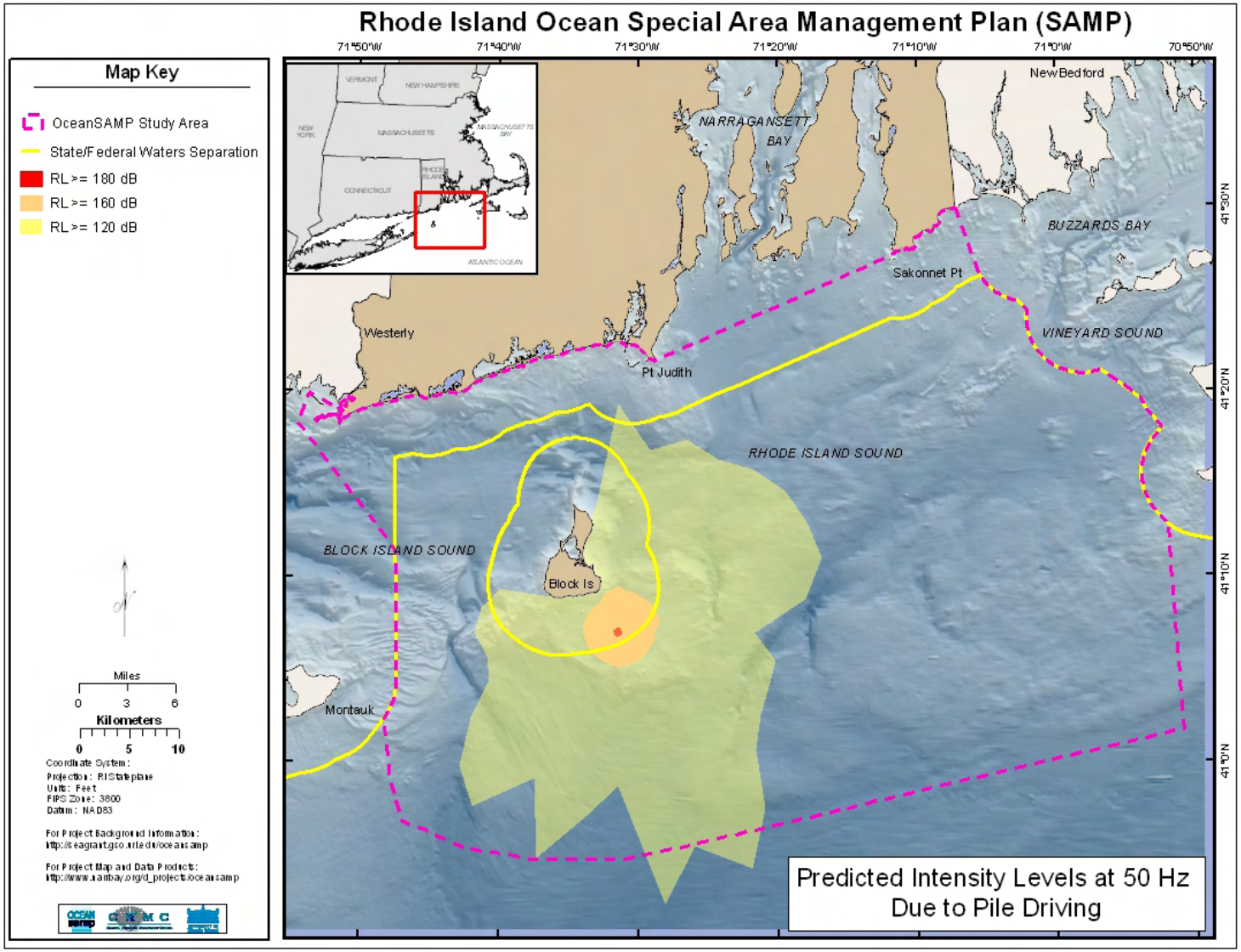


Figure 8.46. Estimate of the affected area in the vicinity of pile driving (Miller et al. 2010).

10. Pile driving may create noise that may adversely affect marine mammal feeding or social interactions, or alter or interrupt vocal activity (MMS 2007; Thomsen et al. 2006). However, these impacts will vary within, as well as between, species. Any marine mammal that remains within the project area at the start of pile driving activities are subject to the increased risk of hearing impairment that may occur within close range (Madsen et al 2006; Thomsen et al. 2006). Placing marine mammal observers onboard construction vessels and halting construction activity once a marine mammal has been spotted within a designated exclusion zone are precautionary measures that can be taken to reduce this potential risk (MMS 2007a). In addition, acoustic isolation of the ramming pile may reduce the noise level of pile driving activities. Acoustic deterrent devices and ramp-up pile-driving procedures may also help to protect individuals from impairment or injury by encouraging them to leave the construction site (Thomsen et al. 2006; Tougaard et al. 2003; Tougaard et al. 2005).
11. In Denmark, the construction of two offshore wind farms, Nysted and Horns Rev 1, have provided opportunities for monitoring the behavioral reactions of two marine mammal species, harbor porpoises and harbor seals, to pile driving activities. Evidence of temporary avoidance behavior during pile-driving at Horns Rev was found in harbor porpoises up to approximately 20 km [12.4 mi] away, both visually, through fewer observed individuals, and acoustically, through temporarily decreased acoustic activity (Tougaard et al. 2003).[55] This reduction in echolocation clicks suggests that either pile-driving affected the porpoises' behavior causing individuals to go silent, or the porpoises left the area during this activity.[56] Tougaard et al. (2003) observed a return to previous acoustic activity after 3-4 hours. At the Nysted site, where piling only occurred for a brief period of time, harbor porpoises left the area during construction and stayed away for several days (Tougaard et al. 2005). [57] Overall lower abundance of harbor porpoises was observed at the Nysted site after construction when compared to baseline data, lasting at least until the second year of operation (Tougaard et al. 2005). However, it should be noted that researchers are uncertain if the observed long-term avoidance of the Nysted site by harbor porpoises was caused by the noise effects of construction. Porpoise abundance was relatively low in the area before the start of construction, so the decrease in abundance may have been unrelated to installation activities (Thomsen et al. 2006). Edren et al. (2004) found a 10 – 60% decrease in the number of hauled out harbor seals on a sandbank 10 km [6.2 mi] away from the Nysted construction site during days of ramming activity. This effect was of short duration but does suggest that both harbor porpoises and seals demonstrate behavioral changes or avoidance during pile-driving activity, and that these effects can span large distances.

[55] Measurements made at Horns Rev during pile driving activities recorded high sound levels of about 190 dB re 1 µPa at several hundred meters away from the sound source. A best fit attenuation of 18 dB per 10 times increase in distance was used to estimate a source level of 235 dB re 1 µPa at 1 meter distance and 150 dB re 1 µPa at a distance of more than 20 km. See Tougaard et al. 2006 for more information.

[56] Thomsen et al. (2006) found pile driving noise would unlikely mask the echolocation of harbor porpoises, as the sonar signals used by harbor porpoises, are much higher in frequency (130 kHz) than pile-driving noise (below 1 kHz).

[57] Very little (approximately 25 days) piling activity occurred at the Nysted Offshore Wind Energy Facility due to the use of gravity base foundations. Piling was only involved in the usage of sheet piles to stabilize the sediment at one of the turbines.

12. In addition to surveying and pile-driving activities, noise associated with ships engaged in construction, operations and maintenance activities may potentially impact marine mammals in the project area (Köller et al. 2006; OSPAR 2009a) (see Table 8.17). Overall, the ambient noise created by marine transportation, including ships associated with the wind farms as well as other ship traffic in the area, will be of a higher intensity than what would likely be created by wind turbines (OSPAR 2009a). Shipping noise should be taken into account when considering the overall levels of ambient noise underwater where wind turbines are in place. The use of ships in servicing the turbines and other activities should be accounted for when predicting the overall noise levels from the wind farms (Wahlberg and Westerberg 2005). Shipping noise is likely to be significantly higher during the construction phase (BMT Cordah Limited 2003). It is estimated that each turbine will require one to two days of maintenance each year; depending on the size of a wind farm, ship noise could be present in the vicinity of the turbines often (Thomsen et al. 2006). However, given the existing levels of shipping in the Ocean SAMP area and resulting background noise (see Chapter 7, Marine Transportation, Navigation and Infrastructure), the added noise from maintenance vessels is likely to be negligible. Observed reactions of marine mammals to vessel noise have included apparent indifference, attraction (e.g. dolphins' attraction to moving vessels), cessation of vocalizations or feeding activity, and vessel avoidance (Richardson et al 1995; Nowacek and Wells 2001). Noise may also be caused by transit of helicopters used to support offshore renewable energy facilities far offshore (MMS 2007a). Marine mammal behavior would likely return to normal following the passage of the vessel (Richardson et al. 1995). Edren et al. (2004) conducted video monitoring during the construction of the Nysted offshore wind farm and found no discernible changes in harbor seal behavior as a result of the increased ship traffic, although ship movements were controlled to avoid the seal sanctuary. In the Ocean SAMP area, the most heavily used seal haul out site on Block Island is located within a protected cove (see Figure 8.43) and therefore would not be affected by the noise from construction traffic. However, the other haul out sites surrounding Block Island may be affected if vessel routes pass in their vicinity or during winter seasons when these sites are most frequently used (Kenney and Vigness-Raposa 2009). Prior to construction, all potential impacts (including noise impacts) to marine mammals by a proposed offshore renewable energy facility in the Ocean SAMP area will be reviewed under the MMPA to determine if incidental take or harassment authorization, or specific mitigation measures are required.

13. Underwater noise may also result from cable laying activities, including cable laying vessels or jet plowing techniques (OSPAR 2009b). Noise measurements are not available for cable laying activities in Europe associated with offshore wind energy facilities (OSPAR 2009b). However, research conducted to assess the potential noise impacts associated with the laying of submarine cables for the Cape Wind Energy Project found that the jet plowing embedment process would not add appreciable sound into the water column (MMS 2009a). However, the nature of the seabed will dictate the type of cable installation procedures used, and thus the noise profiles that will result will depend on the physical characteristics of the seafloor (MMS 2007a). In areas with unconsolidated

sediments, only the sound associated with the cable laying vessels will likely be produced, as the sediments insulate the cable laying noise (MMS 2009a).

14. Operational noise generated from offshore renewable energy structures, such as by the spinning offshore wind turbines, may be transmitted into the water column via the turbine support structures (OSPAR 2006). The level of noise emitted into the water column by an operational turbine varies based on wind speed, the speed of the spinning blades, and the type of foundation structure (Wahlberg and Westerberg 2005; Ingemansson AB 2003). The operational noise produced by wind turbines is significantly less than the levels of noise produced during the construction phase. Underwater noise generated by the turbines is mostly the result of the movement of mechanical components within the generator and gearbox, which result in vibrations in the tower, rather than sounds from the turbine blades themselves. Both the frequency and intensity of sound generated by the turbines increases with wind speed. To date, the available data on the effects of noise from operating wind turbines are sparse, but suggest that behavioral effects, if any, are likely to be minor and to occur close to the turbines (review by Madsen et al. 2006; Nedwell et al. 2007). For example, Koschinski et al. (2003) reported behavioral responses in harbor porpoises and harbor seals to playbacks of simulated offshore turbine sounds at ranges of 60-200 m [196.8-656.2 ft], suggesting that the impact zone for these species is relatively small.[58] In addition, because noise emissions from operating wind turbines are of low frequencies and low intensity (Nedwell et al. 2007), operational noise is not thought to be audible to many marine mammal species over distances greater than a few tens of meters, as the hearing abilities of most marine mammals are better at higher frequencies (Richardson et al. 1995; Southall et al. 2007). One exception may be baleen whales, such as the North Atlantic Right whale, whose hearing abilities are thought to include very low frequency sounds (Madsen et. al. 2006). Scientists predict that individuals of this species may respond to noise from operating turbines at ranges up to a few kilometers in quiet habitat (Madsen et al. 2006). However, no studies have been performed to date on the effect of noise from operational offshore wind turbines on right whales, or baleen whales in general, and these predictions have been based primarily on the results of related acoustic studies (Nowacek et al. 2004; Richardson et al. 1995; Madsen et al. 2006).

15. Recent measurements by Nedwell et al. (2007) at five operational wind farms off the U.K. indicate that wind farm sound could not be detected at a hydrophone at distances of a few kilometers outside the wind farm. Measurements taken at a range of 110 meters from a 1.5 MW monopile GE turbine in Utgruden, Sweden in water depths of approximately 10 meters found operational noise measured 118 dB re 1 mPa^2 in any 1/3 octave band at a range of 100 meters at full power production (Betke et al. 2004). Based on these measurements and measurements of the ambient noise in the waters just southwest of Block Island, Miller et al. (2010) determined that the additional noise from an operational offshore wind turbine is significantly less than noise from shipping, wind

[58] This study used amplified recordings of operational turbines that may have also contained some unintended high-frequency artifacts that the porpoises and seals may have been responding to rather than the low-frequency wind turbine noise.

and rain in the region.[59] Miller et al. (2010) calculated that the noise would be greater than the ambient noise present within 1 km of the wind turbines and at ranges of 10 km operational noise would be below the ambient noise in the region.[60]

16. The decommissioning of offshore renewable installations will also temporarily generate underwater noise. However, because an offshore renewable energy facility has not yet been decommissioned, the activities and duration of the removal is not yet known (Nedwell and Howell 2004). Abrasive jet cutting (using the force of highly pressurized water) is likely to be used to cut piles from the seafloor, while the destruction of the concrete foundations and scour protection may require some blasting or the use of pneumatic hammers, if the protective structures cannot be lifted from the seafloor after dismounting the turbine support structure. Currently, no sound measurements are available on the use of abrasive jet cutting when decommissioning offshore structures. While explosives may be a loud point source of underwater sound, and consequently pose a serious risk of physical damage to any marine mammals in the detonation area (MMS 2007a), non-explosive removal techniques are expected to cause short-term, negligible to minor impacts (MMS 2007a). Therefore, the PEIS suggests the use of these alternative methods to minimize any adverse effects (MMS 2007a). If explosives are used, following BOEMRE guidelines (NTL No. 2004-G06) may reduce the potential for negative impacts (MMS 2007a).

17. In summary, noise impacts associated with offshore renewable energy facilities are currently thought to affect marine mammals. The nature and scale of effects will depend on:
    - the hearing ability of the species and the individual animal,
    - the distance the individual is from the sound source,
    - the frequency and intensity of the noise source,
    - the activities of the marine mammals at the time of noise exposure,
    - the duration of the noise-producing activity (i.e. hours, days, months), and transmission through the area (dependent upon physical conditions of the area such as topography, geology, sea state, etc.)

    To date, only a limited number of studies have been published documenting effects of construction and operation of offshore wind energy facilities on two species of marine mammals, harbor porpoises and harbor seals (Carstensen et al. 2006; Tougaard et al. 2006; Koschinski et al. 2003). Additional studies have inferred potential effects based on theoretical models or findings from similar activities in other industries (the most comprehensive review of observed effects can be found in OSPAR 2009a). It should be noted, however, that the range of effects may vary between installations.

850.5.2. Vessel Strikes

[59] Miller et al. (2010) created an ambient noise budget for an area southwest of Block Island using a Passive Aquatic Listener device for the 1/3-octave band centered at 500 Hz. The main contributors to the noise budget at this location were shipping with 97 dB re 1 μPa and wind related noise was 97 dB re 1 μPa. Rain was next with 92 dB re 1 μPa and lastly, biological noise with 87 dB re 1 μPa.

[60] It should be noted that this research was conducted using data from a 1.5 MW monopile offshore wind turbine and the technology currently being considered for the SAMP area is 3.6 MW or larger and a lattice-jacket design.

1. Increased vessel traffic associated with the construction, operation, or decommissioning of an offshore renewable energy facility may increase the risk of ship strikes. Impacts are expected to be minor for most species, especially seals and smaller cetaceans that are agile enough to avoid collisions (MMS 2007a). Of all the whale species present within the Ocean SAMP area, the species considered at the greatest risk of vessel strikes are fin whales, humpback whales, North Atlantic right whales and sperm whales, based on the findings of the Large Whale Ship Strike Database (Jensen and Silber 2004; MMS 2007a).[61] However, the response of an individual animal to an approaching vessel may be unpredictable, as it depends on the animal's behavior at the time, as well as its previous experience around vessels (MMS 2009a).

2. Of all whale species within the Ocean SAMP area, the population-level impacts of a vessel strike would be most severe to the North Atlantic right whale (MMS 2007a). Ship strikes more commonly result in whale fatalities when a ship is travelling at speeds of 14 knots [16 mph] or more. In fact, the number of ship strikes recorded decreases significantly for vessels travelling less than 10 knots [11.5mph] (Jensen and Silber 2004), which suggests that reducing ship speeds to this level may reduce the risk of vessel strikes even further (NOAA National Marine Fisheries Service 2008). As a result of this finding, the PEIS suggests vessels reduce ship speed and maintain a safe operating distance when a marine mammal is observed (MMS 2007a; MMS 2009a). In addition, by locating offshore renewable energy installations away from migratory routes, the risk of vessel strikes is further minimized (MMS 2007a). It should also be noted that there is already a vessel speed restriction in place during parts of the Ocean SAMP area during certain times of the year to minimize the risk of right whale ship strikes; this speed restriction is part of the Right Whale Seasonal Management Area and is enforced by NMFS (NOAA National Marine Fisheries Service n.d.). See Chapter 7, Marine Transportation, Navigation, and Infrastructure for further discussion.

850.5.3. Turbidity & Sediment Resuspension

1. Water quality within a project area may be affected by the construction and decommissioning activities, including cable laying, associated with an offshore renewable energy facility. Specifically, construction or decommissioning activities may re-suspend bottom sediments, which may in turn increase concentrations of total suspended solids (TSS) in the water column (MMS 2009a; OSPAR 2008). The level of impact caused by increased TSS is primarily dependent upon the sediment composition of the project site, grain size distributions, and the hydrodynamic regime (OSPAR 2006). Areas composed of fine grained, loose sediment, accustomed to frequent increases in turbidity (associated with storms, tidal or wave action) will likely not be substantially impacted by the temporary disturbances caused by these activities (MMS 2009a). Increased TSS concentrations may impact prey abundance in an area (i.e. zooplankton or fish species), and therefore indirectly impact marine mammals which depend on those

[61] Sei and blue whales, which are also found in the SAMP area, have far fewer reported vessel strikes in U.S. waters (Jensen and Silber 2004).

species as a food source (MMS 2009a; Köeller et al. 2006). However, because individuals can move to adjoining areas not affected by the temporary increases in TSS, these impacts are not expected to pose a threat to marine mammals (MMS 2009a). In the case of the Cape Wind Project, while TSS concentrations were anticipated around construction and decommissioning time periods, the increases were predicted to be temporary and localized (MMS 2009a). Pre-construction modeling may be useful in predicting the importance of sediment resuspension at a particular site, and monitoring programs during the construction can be used to validate model predictions of the potential TSS effects (OSPAR 2006). Monitoring programs may help to ensure that TSS levels remain within an acceptable range (OSPAR 2006).

2. The PEIS also identifies the potential risk posed by re-suspending contaminated sediments into the water column (MMS 2007a). The suspension of contaminated sediments from construction activities may in some instances result in bioaccumulation of toxins in marine mammal tissue, due to the consumption of contaminated prey (MMS 2009a; see also Hooker et al. 2008)

3. Water quality around an offshore renewable energy facility may potentially be impacted if illegal dumping or accidental spills occurs from vessels or equipment. Vessel discharges and oil spills are already subject to standard operating procedures and discharge regulations (30 CFR 250.300 and MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), and the discharge of any legally discharged waste is not expected to pose any threat to marine mammals (MMS 2007a). Substances that are legally discharged from vessels offshore are rapidly diluted and dispersed posing negligible risk to marine mammals (MMS 2007a). Accidental spills from offshore renewable energy facilities may pose a potential hazard to marine mammals if they result in the release of large volumes of hazardous materials (MMS 2007a). For example, transformers, used to transmit energy generated from the offshore renewable energy facilities to shore, may contain reservoirs of electrical insulating oil or other fluids. The accidental release of these materials may impact the health and survival of marine mammals exposed to the spill, or may indirectly impact marine mammals by adversely affecting prey species in the area (MMS 2009a). The severity of these impacts depend on the location of the facility, the volume and timing of the spill, the toxicity of the material and the species exposed to the spill (MMS 2007a; MMS 2009a). An assessment performed on the Cape Wind Project found that the potential risk associated with accidental spills is insignificant to minor (MMS 2009a), and that precautionary measures such as producing an oil spill response plan may minimize any adverse impacts on marine mammals (NOAA 2009).

850.5.4. Electromagnetic Fields (EMF)

1. Cetaceans have received attention with respect to induced magnetic fields around underwater transmission cables as it is hypothesized that they use the Earth's magnetic field to navigate during migration (Gill et al. 2005). However, there is very little data supporting the theory of magnetic orientation in cetaceans. If an effect does exist, transient mammals would likely only be temporarily affected by an induced magnetic field (Gill 2005). Moreover, since migration generally occurs in open water and away

from the seabed (Kenney and Vigness-Raposa 2009), electromagnetic fields are unlikely to have a detrimental effect on whale migration (Gill et al. 2005). Research conducted by Miller et al. (2010) examined the potential electromagnetic fields that may be created from submarine cables used to support offshore renewable energy development in the Ocean SAMP area and found that the effects of EMF will be confined to within 20 meters [65.6 feet] of the cable. No adverse impacts to marine mammal behavior or navigation is expected from the undersea transmission cables (MMS 2009a; Gill 2005). EMF associated with offshore wind energy projects may have potential effects on some fisheries resources; see Section 850.7 below.

850.5.5. Habitat Alteration & Reef Effects

1. Offshore renewable energy installations sited in soft sediment might locally change the sea bed characteristics from soft, mobile sediments to a harder substrate by introducing hard structures for scour protection (rock, concrete mattresses, grout bags etc. Underwater structures are soon overgrown by sessile, benthic animals and algae which may increase the biomass locally, and attract fish and marine mammals as their predators (Wilhelmsson et al. 2006; OSPAR 2006; NOAA 2009). Similarly, the steel piles introduce a hard substrate into the water column, and provide a surface that can be colonized by species that might not ordinarily be present in soft sediment environments (OSPAR 2006). The offshore wind farm foundations at Horns Rev and Nysted have been readily colonized with epifouling communities, causing a local increase in biodiversity compared to amounts recorded prior to construction (DONG Energy et al. 2006; Bioconsult A/S 2003; Energi E2 A/S 2004). However, no evidence has been found to date to suggest that these reef effects enhance or alter the prey availability of marine mammal species in the area. For a more detailed discussion of this potential effect see Section 850.3.

Section 850.6. Sea Turtles

1. The observed effects of offshore renewable energy development on sea turtles are unknown, as sea turtles are not present in any of the areas where wind turbines are currently in place (MMS 2007a). According to Kenney and Vigness-Raposa (2009), the sea turtles that may be found in the Ocean SAMP area include the following:

Table 8.19. Abundance and conservation satus of Ocean SAMP area sea turtles *(*Kenney and Vigness-Raposa 2009)

Turtle	Status	Abundance
Leatherback Sea Turtle (*Dermochelys coriacea*)	Endangered	The sea turtle most likely to be found in Ocean SAMP area, found in Ocean SAMP area in summer and early fall when water is warmest. Dispersed; higher abundance outside Ocean SAMP area.
Loggerhead Sea Turtle (*Caretta caretta*)	Threatened	More abundant in the Northeast than Leatherbacks, but less likely to be found in the Ocean SAMP area – not often seen in cool or nearshore waters. May be seen occasionally in summer or fall.
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	Endangered	Small juveniles known to use habitats around Long Island and Cape Cod, and may pass through Ocean SAMP area but are not detected in surveys.
Green Sea Turtle (*Chelonia mydas*)	Threatened	Small juveniles known to use habitats around Long Island and Cape Cod, and may pass through Ocean SAMP area but are not detected in surveys.

2. Sea turtles may use the Ocean SAMP area for foraging. They are capable of diving to great depths, although a study of sea turtles off Long Island found them primarily foraging in waters between 16 and 49 feet (4.9 and 14.9 meters) in depth. Leatherback turtles, likely the most abundant sea turtles in the Ocean SAMP area, have been shown to dive to great depths and may spend considerable time on the bottom, sometimes holding their breath for as long as several hours. Some sea turtles, particularly green sea turtles, feed on submerged aquatic vegetation (NOAA National Marine Fisheries Service 2009). While the placement of wind turbines will be at depths greater than where this foraging takes place, if cables are placed through areas of submerged aquatic vegetation, this could have an effect on sea turtles. Similarly, many sea turtles may feed on benthic invertebrates such as sponges, bivalves, or crustaceans, all of which are likely be found in the Ocean SAMP area (NOAA National Marine Fisheries Service 2009). Sea turtles may be affected by any loss of these food species during the cable-laying process; again, turtles are unlikely to forage at the depths where the turbine bases are likely to be located. Leatherback turtles are known to consume Lion's mane jellyfish (*Cyanea capillata*) as a mainstay of their diet; these jellyfish are plentiful in the Ocean SAMP area during the summer and fall (Lazell 1980).

3. Additionally, any of these turtle species may migrate through the Ocean SAMP area as part of their northward or southward migration in spring and fall, respectively (NOAA National Marine Fisheries Service 2009). While sightings of most of these species are infrequent, sea turtles, particularly juveniles, are not routinely detected during surveys,

meaning they may be more common in the Ocean SAMP area than survey data would suggest. All of the species of sea turtles noted in the table are likely to be present in the Ocean SAMP area from late spring/early summer through late fall.

850.6.1. Noise

1. Little is known about the hearing capabilities of sea turtles. Existing data estimate the hearing bandwidth of the four species of turtles found within the Ocean SAMP area at between 50 and 1,000 Hz, with a maximum sensitivity around 200 Hz. They are thought to have very high hearing thresholds, at around 130 dB re 1 µPa (MMS 2009a). It is believed that pile driving and vessel noises are within the range of hearing of turtles, although they may have a limited capacity to detect sound underwater. Observed reactions from sea turtles exposed to high intensity sounds include startle responses such as head retraction and swimming towards the surface, as well as avoidance behavior (MMS 2007a). For more detailed information on the effects of noise within the SAMP area, see the Effects of Noise on Marine Mammals, Section 850.51.

2. The Cape Wind FEIS (MMS 2009a) predicts that no injury during the pile driving process is likely to occur to sea turtles, even if the turtle were as close as 30 m (98.4 feet) from the source. This prediction is based on noise estimates created assuming the use of monopiles, and based on the particular sound characteristics of the proposed location for the Cape Wind project; estimates for the Ocean SAMP area would differ. The noise generated by pile driving is likely to cause avoidance behavior in sea turtles, which may move to other areas. Sea turtles migrating through the area may also be affected, as they may avoid the construction area. The Cape Wind FEIS predicted these effects to be short-term and minor (MMS 2009a). The noise created during construction, and thus the effects of noise on sea turtles, may vary depending on the size of the piles and the characteristics of the particular site.

3. Any seismic surveys used in the siting process have the potential to affect individual sea turtles by exposing them to levels of sound high enough to cause disturbance if a turtle is within a certain distance of the sound source (1.5 km [0.9 miles]). While the Cape Wind EIS predicted only minimal effects to sea turtles from seismic surveys (MMS 2009a), the effects to sea turtles from seismic surveys in the Ocean SAMP area will depend on the type of survey device used, the water depths, and other factors.

4. The Cape Wind EIS predicted that levels of noise generated by construction and maintenance vessels are expected to be below the levels that would cause any behavioral reaction in sea turtles except at very short distances. Likewise, the Cape Wind EIS predicted that sound generated by wind turbines during operation is not expected to affect the behavior or abundance of sea turtles in the area (MMS 2009a).

5. The levels of sound generated by the turbines during operation could have the ability to interfere with communication, the location of prey or the orientation of sea turtles if the sounds are in the same frequency ranges heard by sea turtles. As it is not well understood

what the hearing capacity of sea turtles is, more studies would be needed to understand whether the sound generated by wind turbines would have any effect (MMS 2007a).

850.6.2. Habitat disturbance

1. Cable-laying activities may cause sea turtles to temporarily change swimming direction, and may disturb sea turtles as they typically like to rest on the bottom. The increased turbidity as a result of cable-laying and construction, however, may interfere with the ability of sea turtles to forage by obscuring or dispersing prey (MMS 2009a).

2. Sea turtles could be harmed by marine debris generated from the personnel working on the construction, operation, or decommissioning stages, particularly plastics that may be accidentally or purposely discarded, which may be mistaken for prey items by turtles, or which may cause them to become entangled (MMS 2009a). The dumping of marine debris and other waste is already strictly regulated under existing statutes (30 CFR 250.300 and MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), and if followed marine debris will likely not pose a great threat to sea turtles.

3. Sea turtles may be at increased risk of ship strike from increased vessel traffic in the Ocean SAMP area, particularly during construction activities. However, ship strikes are relatively rare, and increased vessel traffic will not necessarily lead to an increase in ship strikes. Vessels engaged in construction activities are probably moving too slowly to present a risk, as turtles can easily move to avoid them. Collision risks will be greater with vessels moving to and from the construction site (MMS 2009a). Sea turtles may avoid areas of high vessel activity, or may dive when approached by a vessel (MMS 2007a). Turtles engaged in feeding are at less of a risk for collision, as they spend most of their time submerged. Loggerhead and Kemp's ridley turtles are bottom feeders, so spend most of their time well below the surface, but leatherback turtles feed at or near the surface, and so are at greater risk of collision (MMS 2009a).

4. Lights from construction activities during non-daylight hours could affect sea turtle hatchlings, which are known to be attracted to light (MMS 2007a). However, sea turtle hatchlings are not expected to be found within the SAMP area, as sea turtles do not nest in this area.

850.6.3. Electromagnetic Fields

1. Sea turtles have been found to use the earth's geomagnetic field for orientation and migration (MMS 2007a). However, the Cape Wind FEIS anticipated no adverse impacts from electromagnetic fields on sea turtles (MMS 2009a). Electromagnetic fields may have potential effects on some fisheries resources; see Section 850.7.2 below for further information.

850.6.4. Reef Effects

1. The potential reef effects of the turbines, attracting finfish and benthic organisms to the structures, could affect sea turtles by changing prey distribution or abundance in the

Ocean SAMP area. Sea turtles that eat benthic invertebrates, particularly loggerhead and Kemp's ridley turtles, which consume crustaceans and mollusks, may be attracted to the structures as an additional food source. Sea turtles may also be attracted to wind turbine structures for shelter; loggerheads in particular have been observed using oil rig platforms for this purpose (NRC 1996 in MMS 2009a). Loggerheads are the species most likely to be attracted to the wind turbines for both food and shelter, and they are frequently observed around wrecks and underwater structures (NRC 1996 in MMS 2009a). For more on reef effects, see Section 850.3.2, Reef Effects and Benthic Ecology.

Section 850.7. Fisheries Resources and Habitat

1. Offshore renewable energy development may have several potential effects on fisheries resources and habitat. Generally, the effects of offshore renewable energy projects on fisheries resources are difficult to interpret given the lack of scientific knowledge and consensus in several relevant subject areas. Given the information available, potential effects to fisheries resources and habitat are discussed below in general terms, but it is important to note that site-specific impacts of an offshore renewable energy project in the Ocean SAMP area will require separate, in-depth evaluation as part of the permitting process. It also must be noted that if threatened or endangered species are found in the project area, additional consultation with relevant federal agencies in accordance with the Endangered Species Act would be necessary to evaluate any potential impacts to these species (MMS 2007a). For areas where Essential Fish Habitat has been designated, the Magnuson-Stevens Fishery Conservation and Management Act requires federal agencies to consult with the National Marine Fisheries Service (MMS 2007a). See Chapter 5, Comercial and Recreational Fisheries for more information on endangered or threatened fish species and on Essential Fish Habitat. See also Chapter 10, Existing Statutes, Regulations and Policies for more information on the ESA as well as the Magnuson-Stevens Fishery Conservation and Management Act.

2. With regard to fisheries resources, potential effects may take place at any phase of the project, including pre-construction testing and site characterization, construction, operation, and decommissioning. Some of these effects may include, but are not limited to: underwater sound associated with increased vessel traffic, scientific surveys, construction, operation, and decommissioning; electromagnetic fields created by the cables connecting the turbines and carrying the electricity to land; construction-related habitat disturbance; water quality impacts; changes in benthic community composition; other effects of structures, including the reef effect; and the effects of decommissioning offshore renewable energy developments.

850.7.1. Underwater Sound

1. As noted above in Section 850.5.1, an offshore renewable energy project would generate underwater sound in all phases of development. Noise generated by pile driving activities during construction may be most significant and potentially harmful to fish individuals and then onto populations. For more detailed information on sound produced in the construction and operation of an offshore wind facility, please see Section 850.5.1, The Effects of Noise on Marine Mammals.

2. Fish vary greatly in their hearing structures and auditory capabilities, so it is difficult to generalize about the effects of noise generated by wind farm construction and operation on fish. There is lack of knowledge about the hearing capacities of most fish species. Certain fish species are thought to be hearing specialists, and may have enhanced hearing sensitivity and bandwidth, while others may be hearing generalists, and may be less sensitive to sound (Popper and Hastings 2009). Similar to marine mammals, the effect of

noise will depend on the overlap between the frequency of the noise and the level of hearing of the species, and whether the sound exceeds the level of ambient noise (Thomsen et al. 2006). The impact of the sound produced will also vary greatly depending upon the environmental setting and conditions at the time and place where the sound is being produced (Popper et al. 2006).

3. The potential effects of sound from wind farm surveying, construction, decommissioning, and operation, on fish can be divided into three general categories:

    i. temporary or permanent hearing damage or other physical injury or mortality;
    ii. behavioral responses; for example, the triggering of alarm reactions, causing fish to flee or interrupting activities necessary for survival (e.g. feeding) and reproduction, and potentially inducing stress in the fish;
    iii. masking acoustic signals, which may be communication among individuals, or may be information about predators or prey (Thomsen et al. 2006).

4. As noted in Section 850.5.1, activities in the pre-construction phase generating underwater noise may include side-scan sonar and air guns used in seismic surveying. Studies on fish exposed to air gun blasts have found damage to sensory cells in the ear. While air guns are not likely to be used in the construction or operation of wind farms, they may be used in pre-construction seismic surveys for determining geological hazards and soil conditions in siting a wind farm (MMS 2007a). Side-scan sonar is likely to have little impact on fish, as it is unlikely to cause hearing impairment or physical injury (MMS 2007a).

5. The construction phase is most likely to produce levels of sound that could generate temporary and permanent hearing loss for fish near the source. Injuries of tissues or auditory organs can also occur at close range. Pile driving creates an impulsive sound when the driving hammer strikes the pile, resulting in a rapid release of energy (Hastings and Popper 2005). Peak sound levels produced by pile driving have been measured at anywhere from 228 dB re-1 μPa to 257 dB re-1 μPa, at frequency levels ranging from 20 to more than 20,000 Hz; peak sound levels will vary depending on pile size, material, and equipment used (see Table 8.17). Only a handful of studies have been conducted on fish in the vicinity of pile driving, and while some have found evidence of injury or mortality in the fish near the source of the sound, others have found no mortality or injury. One study of pile driving found fish of several different species were killed within at least 50 m [164 feet] of the pile driving activity; it also found an increase in the number of gulls in the area, indicating additional fish mortality (Caltrans 2001). Another study found that the noise levels produced by pile driving during wind tower construction and cable-laying could damage the hearing of species within 100m [328 feet] of the source (Nedwell et al. 2003).

6. Impacts to fish from sound can be in the form of damage to organs such as the swim bladder, or damage to the auditory sensor in the ears. Sound can also cause permanent or temporary threshold shift in hearing (PTS or TTS respectively), meaning fish lose all or part of their hearing, on either a permanent or temporary basis. There is some evidence

that fish, unlike mammals, can repair their sensory cells used for hearing, and may recover from hearing loss caused by underwater noise. Popper et al. (2005) found the effects from even substantial TTS to have worn off for fish within eighteen hours of exposure. However, hearing loss, even if temporary, could render the fish unable to respond to environmental sounds that indicate the presence of predators or that allow the location of prey or potential mates (Popper and Hastings 2009).

7. A review and modeling study conducted by Thomsen et al. (2006) based on measurements of wind turbines in the German Bight and Sweden found that sound levels created during pile driving for construction of wind turbines was loud enough to be heard at long distances by some fish species - perhaps as far as 80 km [49.7 mi] from the source for cod and herring, which are considered to be sensitive to sound. Salmon and dab, which have a poor sensitivity for sound pressure, could in theory detect pile driving sound over large distances as well. Flatfish might detect sound that is partly transported through the sediment. Pile driving noise may have the effect of masking other biological noises out to this distance. The nature and scale of behavioral response cannot be determined; however, behavioral responses to the construction noise might happen anywhere within the zone of audibility and could affect fish reproduction and population levels if biologically important activities such as migration, feeding, and spawning are interrupted. The authors determined that injury and mortality may occur in the vicinity of the activity (Thomsen et al. 2006). One playback study of pile driving sounds at relatively low pressure levels found sole to increase their swimming speeds during the playback, while cod were found to freeze their movements at the start of the playback (Mueller-Blenkle et al. 2010). While studies have generally found that impacts on fish will decrease the further from the source of the sound, this effect is not clearly understood because the relationship between distance and sound level is not straightforward. In some cases sound levels may be higher at some distances from the source due to propagation through the seabed and sound reflections from objects (Hastings and Popper 2005).

8. The relationship between sound exposure and physiological damage with regard to fish is not well understood, and more research is required to determine the potential effects of pile driving on fish (Thomsen et al. 2006). Little is known about potential long-term effects, including later death from injury, predation, or behavioral changes that may affect the individual fish or their populations, nor have studies examined the potential cumulative impacts from pile driving. The effects that noise may have on eggs and larvae have been little studied. Research is also lacking on the impacts on fish at larger distances from the source, where they are unlikely to be killed but may suffer from other physiological effects such as damage to the swim bladder or internal bleeding (Hastings and Popper 2005).

9. The noise created during the construction and decommissioning processes may cause some fish species to leave the area. This could cause a disruption in feeding, breeding, or other essential activities, and may have significant impacts if fish are removed from a spawning area. Less mobile species are likely to be more susceptible (Gill and Kimber 2005). The effect on fish populations would be greater if they are dispersed during the times of year when they would be naturally congregating for spawning or other purposes

(Gill and Kimber 2005). Thus, effects will be determined in part by the timing of the project, such as the time of year when the noise disturbance occurs and for how long it occurs. Some studies have found that fish displaced from an area by noise during construction processes are likely to return following construction activity (Hvidt et al. 2006 referenced in MMS 2007a). This may be dependent upon duration of the construction project; if construction occurs over a prolonged period, some fish species may not return. The length of time will in turn be dictated by a number of factors including the number of turbines, the availability of vessels, and access to the site as a result of weather conditions. The cumulative effects are likely to be more significant for a larger wind farm where more turbines would be constructed and the period of construction is longer. Miller et al. (2010) predicted that pile driving activity within the Ocean SAMP area could have observable behavioral effects on fish within 4000 m (2.5 miles) of the pile driving activity. As described in Section 850.5.1, this analysis was calculated for a 1.7 m [5.5 foot] diameter pile (similar to those used in lattice jacket structures) driven into the bottom with an impact hammer. If explosives were used in the decommissioning process, the noise produced could have a serious impact on any marine life within 500 m (0.3 miles) of the activity (Miller et al. 2010) (see Section 850.5 for more information).

10. Fish of different species produce a variety of sounds, many of which may be used for mating or other communication purposes. The sounds produced by wind turbines, particularly in the construction phase, may mask some of these sounds produced by fish, as the frequencies of pile driving and fish signals overlap. For example, cod, which are found in the Ocean SAMP area, produce a number of grunting sounds that are used in defensive and aggressive behaviors, and in courting mates. Masking these sounds with construction noise could have implications for mating and other behaviors. Because the transmission of the sounds could be audible by some species over great distances, the masking effects may also occur over great distances (Thomsen et al. 2006). The effect may depend on the signals produced by the fish; in species where only a single sound makes up a communication signal the effect may be negligible, because the duration of the pile driving sound is very short. However, some fish produce sequences of sounds that might be disrupted by pile driving pulses. Where a large number of turbines are being installed and the length of construction is longer, the masking effect may be appreciable (Thomsen et al. 2006). The noise produced in construction and operation could also mask the sounds of approaching predators or prey. Detecting those sounds may be crucial for survival (Wahlberg and Westerberg 2005). However, because neither the hearing capabilities of most fish nor the function of sounds produced by the fish is well understood, the effects of masking cannot yet be determined (Thomsen et al. 2006).

11. One potential effect on fish from noise could be stress; while this is difficult to quantify, some studies have shown that exposure to stressors can result in opportunistic infections, or may make fish more susceptible to predation or other environmental effects. Some studies on fish exposed to noise found no significant change in stress levels, but these results cannot necessarily be extrapolated to predicting the overall effects of exposure to noise on fish stress levels (Popper and Hastings 2009).

12. If the effects of noise on fish are poorly understood, the effects on invertebrates are even less well understood. One study found that shrimp demonstrated decreases in growth and reproductive rates when exposed to noise for an extended period (Popper and Hastings 2009).

13. Research on existing offshore wind farms in the Baltic Sea has found that the operation of the turbines adds to the existing array of underwater sound, and that the acoustic disturbance caused by the turbines is most likely a function of the number of turbines and their operation procedure (studies reviewed by Gill 2005). As noted above, operational noise produced by wind turbines is significantly less than the levels of noise produced during the construction phase. Even within ten meters of the turbine, the noise created is not likely to be sufficient to cause temporary or permanent hearing loss in any species of fish (Wahlberg and Westerberg 2005). One study found that the noise created by a 1.5 MW turbine was merged with ambient noise within one kilometer from the source (Thomsen et al. 2006). Miller et al. (2010) predicted that within the Ocean SAMP area where eight wind turbines are proposed south of Block Island, the operational noise of the turbines would contribute 424 pW/m^2 or 88 dB re 1 mPa of additional noise, significantly less than the noise produced by shipping, wind, and rain in the area. This level would be greater than ambient noise within one kilometer (0.6 miles) of the source, and would be below ambient noise levels at a distance of ten kilometers (6 miles) from the source (Miller et al. 2010). Underwater noise created by offshore wind turbines in Europe has been measured at 118 dB re 1 mPa^2 for a 1/3 octave band at a range of 100 meters during full power production (Betke et al. 2004).

14. Thomsen et al. (2006) predicted the noise generated by wind turbine operation might be heard up to four or five kilometers from the source by fish with exceptional hearing such as cod and herring, and maybe less than one kilometer by fish with less specialized hearing capabilities such as dab and salmon. Any behavioral or physiological effects on fish for levels of noise created by turbine operation would likely be restricted to very short ranges (Thomsen et al. 2006). However, it is important to note that most of these studies have been for 1.5 MW turbines, while those proposed for the Ocean SAMP area would likely be 3.6 or 5.0 MW. Additional studies are needed on the noise levels generated by these larger turbines.

15. As noted above, another source of sound from wind turbine projects is ship traffic, from ships carrying parts and maintenance equipment during the construction, operation, and decommissioning processes. The noise levels of sound created by vessels will not cause physical harm to fish, but may cause avoidance of the area (MMS 2007a). The duration of avoidance may be determined by the duration of construction activity and the accompanying period of increased vessel traffic.

850.7.2. Electromagnetic Fields

1. Producing electricity with a wind turbine requires it to be moved over long distances by means of a submarine cable. The transmission is either via high voltage Direct Current (DC) or Alternating Current (AC) cables, with AC being the favored for short distances

and DC for longer distances between the project and shore. These cables will necessarily produce magnetic fields around the cables. The intensity of the magnetic field increases with the electric current, and decreases with distance from the cable. The design of industry standard AC cables prevent electric field emissions, but do not prevent magnetic field emissions. These magnetic emissions induce localized electric fields in the marine environment as sea water moves through them. Furthermore, in AC cables the magnetic fields oscillate, and thereby also create an induced electric field in the environment around the cables, regardless of whether the cable is buried. Thus the term electromagnetic field, or EMF, refers to both of these created fields (Petersen and Malm 2006).

2. Exposure to magnetic fields is not unique to undersea cables; the earth has its own geomagnetic field, which many organisms utilize for orientation. Little is understood about the orientation of animals in response to the geomagnetic field, but evidence of geomagnetic orientation has been observed in a number of marine species, including fish, mollusks, and other crustaceans. In laboratory experiments conducted on a number of different marine animals in response to static magnetic fields generated by electrical current, most demonstrated no short-term change in behavior when the magnetic field was introduced. In one experiment by Bochert and Zettler (2004) where several organisms were exposed to EMF generated by a DC power source, of four crustacean species, blue mussels, and flounder studied, only one crustacean species, an isopod, demonstrated any avoidance of the magnetic field. In other experiments by the same authors on the long-term effects of magnetic fields on crustaceans and flounder, no significant effects were demonstrated. The authors conclude that the static magnetic fields of submarine cables produced by DC currents have no clear influence on the orientation, physiology, or movement of the benthic animals they tested (Bochert and Zettler 2004).

3. However, some evidence exists supporting the argument that EMF may have detrimental effects. Other studies have shown that some species of sharks, rays, and bony fishes detect electromagnetic fields and have demonstrated sensitivity to these EMFs (Gill et al. 2005). The induced electrical fields created by the magnetic fields from the cables are within the range of electrical transmissions detectable by sharks and rays (Gill and Kimber 2005). Exposure to certain magnetic fields was found to delay the development of embryos in fish and sea urchins (Cameron et al. 1985; Cameron et al. 1993; Zimmerman et al. 1990). Barnacle larvae exposed to high frequency AC EMF were found to retract their antennae, which would interfere with settlement (Leya et al. 1999). In another study, brown shrimp (*Crangon crangon*) were found to be attracted to magnetic fields of the magnitude that would be expected to be present around wind farms (ICES 2003). Little is known about the effects of EMF on lobsters. However, because effects have been demonstrated on brown shrimp and other crustaceans, an effect on lobsters can be anticipated.

4. Species using the Earth's magnetic field for navigation or orientation may be affected by the EMF, possibly becoming confused, but this effect will likely be short-lived as the animal moves through the area. Species that are magnetosensitive may either be attracted

to or avoid the area (Gill 2005). If elasmobranchs (sharks, rays or skates) and other fish are sensitive to the electromagnetic fields and avoid passing over the cables, this could prevent movement from one location to another, trapping fish either within our outside of the cables (BMT Cordah Limited 2003). It is generally thought that the magnetic fields created by the cables will be much lower than the earth's geomagnetic field and will therefore cause no significant response (Gill and Kimber 2005). One study on the European eel (*Anguilla anguilla*) found that eels significantly decrease their swimming speed when passing over an AC cable (Westerberg and Lagenfelt 2008). A study of cables at Danish wind farms found some effects on fish behavior from the presence of the cables, but the effects included both avoidance and attraction, and could not be correlated with the strength of the EMFs (DONG Energy et al. 2006). Catch studies on some species of fish (Baltic herring, common eel, Atlantic cod and flounder) at the Nysted wind farm in Denmark found the catches of these species were reduced in the vicinity of the cables, indicating the migration of fish across the cables may be reduced, but not blocked. In a separate study, they also found cod accumulating close to the cables however this was not when the cables were energized so there may be some other stimuli that the fish were responding to such as the physical presence of the cable trench (DONG Energy and Vattenfall 2006).

5. If the electric fields being emitted by the cables approximate the bioelectric fields of some species, there is a possibility that certain electro-sensitive species, particularly elasmobranchs (sharks, skates, and rays) and sturgeon species, will be attracted to the cables, thinking them to be prey. The same species may be repelled by stronger electric fields closer to the cables, depending on the power sent through the cable and the characteristics of the cable itself. Because the cables will be buried in sediment or laid along the bottom, benthic species are most likely to encounter them (Gill and Kimber 2005). There is one report of sharks biting an unburied cable on the seafloor that was emitting induced AC electric fields (Marra 1989); however, there is little other data on interactions between sharks or other species and cables.

6. Miller et al. (2010) predict the electromagnetic fields that would be produced by the 26 kVA power cables likely to be used for the wind turbines proposed south of Block Island could have behavioral effects on marine life within 20 m (66 feet) of the cables.

7. There is no conclusive evidence at present on whether EMFs may have an impact on marine species (Johnson et al. 2008). However, because the effects of electromagnetic fields on fish and other species are poorly understood, more research is needed in this field. The effects of EMFs on species present within the Ocean SAMP area should not be assumed until further research is completed. It is not known whether resident species will be able to habituate to EMF, but this could be important for helping to determine appropriate mitigation measures.

850.7.3. Habitat disturbance

1. Disturbance to existing habitat is likely to result through the construction of offshore renewable energy infrastructure. Here, habitat disturbance is used broadly to refer to

sediment disturbance and settling; increased turbidity of the waters in the construction area; and the installation of infrastructure including piles, anti-scour devices, and other structures (MMS 2007a). The period of time and the extent of the disturbance, and thus its severity, will depend on the size of the wind farm and the amount of time necessary to construct it. For the proposed large-scale project in the Ocean SAMP area, this is likely to be a year or two. The total area of the seafloor affected will be only a small percentage of the entire Ocean SAMP area; however, the overall effect will depend in part upon the relative prevalence or scarcity of the habitat type(s) affected, and the availability of similar habitat in the adjacent area. For more on the effects of offshore renewable energy on habitat and the benthic ecology of the Ocean SAMP area, see Section 850.3.1.

2. The construction of wind turbines is likely to have both short- and long-term effects on habitat. Habitat conversion and loss can result because of physical occupation of the substrate, and includes both changes to existing habitat and the creation of new habitat. Scour protection around the structures, which is made up of rock or concrete mattresses, increases the loss or conversion of habitat (Johnson et al. 2008). Direct effects to the seabed are likely to be limited to within one or two hundred meters of the structure, and there are likely to be areas between turbines which remain undisturbed (OSPAR 2006). For more on the creation of new habitat, see Section 850.7.7 (Reef Effects and Fisheries), and 850.3.2 (Reef Effects and Benthic Ecology).

3. Construction of the wind turbine foundations and the installation of cables can result in increased turbidity in the water column as well. This may in turn affect primary production of phytoplankton and the food chain, which could lead to an increased likelihood of eutrophic conditions. However, these effects are likely to be short-term and localized, and the overall impact on fish resources would be negligible (MMS 2007a). Removal of sediments may result in habitat loss (Gill 2005). These are generally short-term impacts which will subside once construction has been completed (Johnson et al. 2008). Any sediments resuspended in the construction or decommissioning processes are likely to be transported by water movement, and may smother the neighboring habitats of sedimentary species. These sediments may also carry contaminants with them if the area has a history of industrial processes emitting into the adjacent waters (Gill 2005).

4. The interference in water flow caused by the wind turbine substructures may accelerate local tidal currents and wave action around the structures, forming scour holes in the sea bed adjacent to the pilings. These holes may be attractive habitat to species such as crab and lobster, and to some fish species (Rodmell and Johnson 2005).

5. Additional impacts from wind turbines would come from the eventual decommissioning and removal of the undersea structures, immediately reducing habitat heterogeneity and removing a large component of the benthic community that has established since the wind farm has been in operation (Gill 2005).

6. The installation and burial of submarine cables causes temporary habitat destruction through plowing and from barge anchor damage, and can cause permanent habitat alteration if the top layers of sediment are replaced with new material during the cable-

laying process, or if the cables are not sufficiently buried within the substrate. Likewise, cable repair or decommissioning can impact benthic habitats. The effect of the cables will depend on the grain size of sediments, hydrodynamics and turbidity of the area, and on the species and habitats present where the cable is being laid (OSPAR 2008). Undersea cables can also cause damage if allowed to "sweep" along the bottom while being placed in the correct location. The most serious threats are to submerged aquatic vegetation, which serves as an important habitat for a wide variety of marine species. Shellfish beds and hard-bottom habitats are also especially at risk (Johnson et al. 2008).

7. The placement of wind turbines, especially in large arrays, may affect flow regimes by altering tidal current patterns around the structures, which may affect the distribution of eggs and larvae (Johnson et al. 2008). Because the structures are likely to affect currents, the settlement of new recruits may be locally affected. These effects on habitat will be most harmful if they affect the spawning or nursery areas of species whose populations are depleted, especially if the spawning or nursery areas used by these species are limited and the species have long maturation periods, such as sharks and skates (Gill 2005). A study of turbines in Danish waters found little to no impact on native benthic communities and sediment structure from a change in hydrodynamic regimes (DONG Energy et al. 2006). For more on the effects of wind turbines on coastal processes, see Section 850.2.

850.7.4. Water Quality Impacts

1. Offshore renewable energy facilities would result in increased vessel traffic through the pre-construction site characterization, construction, operation, and decommissioning phases. The PEIS indicates that such an increase in traffic could increase the likelihood of fuel spills as a result of vessel accidents or mechanical problems, though it indicates that the likelihood of such spills is relatively small because of the small amount of vessel traffic that would be associated with the project (MMS 2007a). The risk of fuel spills could also increase because of the increased likelihood of vessel collisions with the wind turbine structures.

2. Wastewater, trash, and other debris can be generated at offshore energy sites by human activities associated with the facility (in construction and maintenance processes). The platforms may hold hazardous materials such as fuel, oils, greases, and coolants. The discharge of these contaminants into the water column could affect the water quality around the facility. Large-scale offshore renewable energy projects are likely to have one or more transformers, which will contain dielectric fluid, such as mineral oil, which could pose a threat to water quality through leakage or in the event of a collision (MMS 2009a). Vessels traveling to and from the platforms may dump gray water or sewage, or may release plastics and other debris (Johnson et al. 2008).

3. Water quality may also be impacted during the construction process by re-suspending bottom sediments, increasing the sedimentation within the water column. This may impact the abundance of planktonic species, and could lead to eutrophication.

850.7.5. Changes in Community Composition

1. Wind energy and other offshore renewable energy projects could have indirect ecological effects that could affect the composition of fish species within the area. During the construction and decommissioning phases of a project, highly mobile fauna, including fish and large crustaceans, are likely to be displaced from the area, and there may be changes to some habitats, either through habitat loss or through enhancement. These factors may affect the composition of species found in the area. For more on the effects of changes in community composition, see Section 850.3.3.

2. During the construction and decommissioning phases of a project, the eggs and larvae of many species of fish may be vulnerable to being buried or removed. Some species, such as herring and sand eels, lay their eggs in the substrate; if wind farm construction took place within the spawning grounds of these species, it would likely impact the species (BMT Cordah Limited 2003). Other benthic organisms may also be buried in the process, which could affect finfish and shellfish that rely on these organisms for food. Individual fish are likely to move out of the area during construction because of the disturbance and because of the loss of food (MMS 2007a). After the activity has ceased, recolonization may take months or years (Gill 2005).

3. No detailed, long-term analyses have yet been conducted on entire fish assemblages around either decommissioned oil platforms (a suitable comparable development of the coastal environment) or wind energy projects (Ehrich et al. 2006). Ehrich et al. (2006) hypothesize that any effects on fish densities and diversity resulting from newly installed wind turbines will be restricted to the immediate vicinity of the structures, and will not have wide-reaching effects, unless rare species are directly affected, which could have effects at the population level. The authors also note that in cases where wind turbines are constructed in areas with a sandy bottom, there may be localized removal of species dependent on soft-bottom habitat, favoring species which prefer hard bottoms, as the hard structures serve as habitat for these species. As most wind farms thus far have been constructed in areas of sandy bottom, there is little data on changes to other types of benthic habitats. They suggest that the wind farms will also favor large predators, particularly if fishing pressure among the turbines is reduced (Ehrich et al. 2006).

4. There may also be changes in predator-prey relationships, in which some predators move out of the area temporarily or have their numbers temporarily reduced during the construction phase. This can result in the process of competitive release, in which species preyed upon by these predators become available to other predators. Often it is smaller species with faster rates of reproduction that will replace existing species. This could have secondary effects elsewhere, if the numbers of predators increase outside of the area of development (Gill and Kimber 2005).

5. The decommissioning of wind turbines would also have significant ecological effects, as the new habitat and accompanying species are removed. Habitat heterogeneity and the abundance of species would be reduced.

850.7.6. Structures

1. Organisms may either collide with or avoid the wind turbine structures underwater. While little information is available regarding this topic, the greatest impacts are likely to be within enclosed waters or where the devices form a barrier to movement (Gill 2005); thus collision and avoidance are not likely to be major impacts of the proposed wind turbines in the Ocean SAMP area.

850.7.7. Reef Effect

1. As noted above in Section 850.3.2, wind turbine structures may serve as both artificial reefs, in providing surfaces for non-mobile species to grow on and shelter for small fish, and as fish aggregating devices, which are used to enhance catches by attracting fish (Wilhelmsson et al. 2006).

2. After the wind turbines are in place, a change in the type and abundance of benthic species can be expected, which will change food availability for higher trophic levels. Because the placement of wind turbines may increase habitat for benthic species, the structures may have the effect of increasing local food availability, which may bring some species into the area. This may increase use of the area by immigrant fauna. More adaptable species will probably dominate the area under these new ecological conditions. The change in prey size, type, and abundance in the vicinity of the structures may also affect predators. Predators moving into the area may result in prey depletion (Gill 2005).

3. Oil and gas platforms have been found to harbor large numbers of larval and juvenile fish, and wind turbine support structure can be expected to have a similar effect. Because the structures extend throughout the water column, juvenile or larval fish are more likely to encounter them than other habitat types found only on the bottom, and may be more likely to settle there. There may also be less predation on small fish in midwater habitats, so they can safely hide in the structure at a variety of depths (Love et al. 2003). Fish can take advantage of the shelter provided by the structures while being exposed to stronger currents created by the structures, which generate more plankton for plankton-eating fish (Wilhelmsson et al. 2006). While colonization of the new structures will begin shortly after construction, it will usually take several years for the colonization to be completed, because not all species will colonize the area at once (DONG Energy et al. 2006) and there will be a succession of species and a likely increase in species using the newly formed community hence increasing diversity.

4. Wind turbines may also provide refuge from predation for juveniles of a number of mobile species, which is critical in promoting growth and survival until they reach maturity. Similarly, the structures may also provide refuge for both large and small fish and other species from fishing pressure. In the UK, where fishing is currently not permitted around the structures, they are being promoted as protected areas, and may

eventually contribute to stock replenishment for some species. These structures have not yet been in the water long enough to see these effects; however, many of the juvenile fish found around the turbines are small *Gadoid* species such as cod. Additionally, if there is an absence of trawling and dredging between the wind farms, it may result in increases in benthic fauna (DONG Energy et al. 2006; Kaiser et al. 2000). Even if fishing is permitted, most fishermen are unlikely to fish immediately next to the turbines because of the possibility of having gear tangled in the structures (see Section 850.8). In oil and gas platforms, fish that remain within the jacketed structures may be less vulnerable to fishing pressure than others (Love et al. 2003). In addition to fish, these structures may also provide important habitat for lobsters and crabs. Young, newly-settled individuals of these species typically seek out refuge to avoid predation, including hiding among stones and cobbles, or burying in sediments. Wind turbines and scour protection may provide suitable hiding places for these individuals, and may enhance the lobster fishery in cases where habitat is a limiting factor (Linley et al. 2007).

5. A number of studies of decommissioned oil platforms have indicated fish are attracted by the structures (Ehrich et al. 2006). A study conducted on oil and gas platforms off the Californian coast found that the platforms tended to have higher abundances of large, commercially targeted fish than did natural reefs. This result may have been because of low fishing activity around the platforms, creating de facto marine protected areas. Generally, the platforms also had higher numbers of young-of-the-year rockfish than other areas, including natural reefs (Love and Schroeder 2006). One study noted the tendency of large, recreationally targeted species such as tunas and mackerel to associate with fish aggregating devices, and predicted wind turbines might have the same effect (Fayram and de Risi 2007). A study of decommissioned oil rigs in the North Sea off Norway found aggregations of cod, mackerel, and other species around the structures (Soldal et al. 2002).

6. The observed effect of other wind turbines has found some species are attracted to wind farms. A study of wind farms in Danish waters found the increased habitat heterogeneity from turbine foundations resulted in an increase of species from adjacent hard surfaces, leading to a local increase in biomass of 50 to 150 times, most of which served as available food for fish and seabirds (DONG Energy et al. 2006). Monitoring of the Horns Rev wind farm in Denmark found a 300% increase in the number of sand eels around the wind turbines between 2002 and 2004, and an eight-fold increase in the availability of food for fish in the area, but not a statistically significant difference in the number of fish (DONG Energy and Vattenfall 2006). Another study found an increased number of cod in the area surrounding wind turbines at the Vindeby Offshore Wind Farm in Denmark (Bioconsult A/S 2002). Some studies have not found an increase in fish around structures; this may be because the studies were conducted during the early stages of colonization (DONG Energy et al. 2006).

7. One question to be determined about wind turbines is whether they actually increase fish populations by providing habitat, or simply attract fish from elsewhere, concentrating them in the area of the structure. If individual fish are being attracted to the site, but populations are not increasing, this may have impacts on adjacent habitats where the fish

would ordinarily be found (Gill 2005). If the structures serve only to aggregate fish and not to produce additional biomass, there is a risk of harvesting pressure around the structures leading to overexploitation of certain stocks by concentrating the fish and leaving them more vulnerable to harvesting (Whitmarsh et al. 2008).

8. Love and Schroeder (2006) found that in some instances, the fish found at the platforms were producing significant amounts of larvae that may have been increasing populations around the platforms and elsewhere. They also found that while some of the fish present around oil and gas platforms were adults of species that had likely migrated from elsewhere, the majority of individuals for many species were small juveniles that had likely been brought to the platforms as plankton and settled there (Love et al. 2003). Love and Schroeder (2006) also found that juvenile fish living around oil and gas platforms had lower predation rates than fish living on natural reefs, because of a low density of predators in the mid- and upper waters around the platforms, and that there appeared to be no difference in growth rates between fish living on platforms or on natural reefs.

850.7.8. Decommissioning Effects

1. As discussed above, wind turbine structures may serve as artificial reefs, providing habitat for a number of invertebrate and fish species, especially juvenile fish. As such, the eventual decommissioning of the turbines could have negative environmental impacts by reducing or removing this habitat. While this issue has not yet been dealt with for offshore wind energy projects, the debate over how to best decommission oil and gas platforms has been ongoing in California and the Gulf of Mexico. For oil and gas platforms, it is estimated that the life of a decommissioned platform left in place will be from 100 to more than 300 years (Love et al. 2003). A large-scale wind farm will occupy more seabed space than individual oil and gas rigs, and thus the area of the ocean floor affected by both construction and decommissioning will be larger than for oil and gas rigs. The decommissioning of the wind turbines and the resulting effects on fish and fisheries should be considered.

Section 850.8. Commercial and Recreational Fishing

1. Offshore renewable energy may affect commercial and recreational fisheries activity in many different ways. Some of the potential effects on fishermen from the placement of a wind farm in the Ocean SAMP area may include changing the distribution and/or abundance of fish populations, increasing stocks of certain fish through reef effects; limiting fishermen's access to traditional fishing grounds; gear or vessel damage; and other changes to fishing activities. These general types of effects are discussed below, though specific effects are dependent on site-specific conditions such as location, type and scale of project, and other factors. The potential site-specific effects of an offshore renewable energy project in the Ocean SAMP area will undergo in-depth evaluation as part of the permitting process (see Section 820.4 and Chapter 10, Existing Statutes, Regulations and Policies).

850.8.1. Effects on Fish Populations

1. Some fish species, especially rare or overfished species, could be negatively affected by the presence of wind farms if the wind farms result in a localized concentration of fishing effort and an increased harvest if the species are attracted to the structures. Alternatively, the increased habitat for some species created by the structures may result in increased populations of commercially important species (see Section 850.7.7), leading to economic gains for commercial fishermen targeting these species (BMT Cordah Limited 2003), and increased opportunities for recreational anglers, who are likely to focus their efforts around the wind turbines.

2. There is also the potential for secondary effects on fish populations if fishermen are displaced from the wind farm area, and as a result concentrate their efforts elsewhere on vulnerable populations or habitats (BMT Cordah Limited 2003). Likewise, if the wind turbines serve as fish aggregating devices, attracting and concentrating fish from elsewhere in the Ocean SAMP area, and attracting more commercial and recreational fishing activity to the area to take advantage of the aggregation, it could have the undesired outcome of leaving fish species more vulnerable to overharvesting from more concentrated fishing effort (Whitmarsh et al. 2008).

3. Fish populations could be affected by some or a combination of the factors listed in Section 850.7, such as noise or electromagnetic fields, which could potentially have effects at the population levels if activities such as spawning or feeding are affected. Some fish populations could also be affected by a change in benthic habitat as some areas of the seafloor are converted to hard structures. The cumulative effects of the factors mentioned above may also need to be considered. For more on the ways in which wind farms may affect fish, see Section 850.7.

850.8.2. Effects on Fish Catch

1. Negative impacts to fish catches may be greatest during the construction phase, when the noise generated by construction activities may drive some mobile species out of the immediate area.

2. Engås et al. (1996) found the average catch rates for cod to decrease by about 50% both in the immediate vicinity of and at a distance from air gun activity. Haddock catches also decreased by similar percentages. Five days after the air gun was used, fish catches had not increased. However, as noted above, air guns are unlikely to be used in the pre-construction siting process.

3. Positive impacts to fish catch may occur during the operational phase as a result of reef effects if there is a resulting increase in or aggregation of biomass around the turbine structures. If there is an increase in fish in the vicinity of the turbines, this could benefit fishermen, particularly recreational and commercial rod and reel fishermen, who may be most easily able to target these fish.

4. Westerberg (1994, 2000, as reported in Thomsen et al. 2006) found that catches of cod decreased within 100m [328 ft] of a wind turbine while it was operating, likely because of the noise generated by the turbine itself. The study also found higher catches within 100m [328 ft] of the turbines than in the surrounding areas when the turbines were stopped, likely because of the reef effect (for more on the reef effect and fisheries, see Section 850.7.7). However, in a separate study, Wahlberg and Westerberg (2005) estimated that the levels of noise produced by operating turbines (1.5 MW) were only likely to cause avoidance responses by fish closer than 4 m [13 ft] to the turbines and only at high wind speeds (13 m/s [29.1 mph]). They also noted that fish may habituate to the noise created by the wind turbines and disregard the sound. The potential effect of operational noise on fish may vary between projects, as operational noise will varies depending on the turbine size, model, foundation type and speed of rotation (see Section 850.5.1).

5. In a study by Vella et al. (2001), the catch per unit effort (CPUE) of cod (*Gadus morhua*) and shorthorn sculpin (*Myoxocephalus scorpius*) was greater within 200 m [656 ft] of a wind turbine than between 200 – 400 m [656-1,312 ft] of a turbine, regardless of whether the turbine was operational or not. The study did find that CPUE was lower in the vicinity of the turbine while the turbine was operational, but still higher than in the area 200 – 400 m from the turbine. This indicates that the turbine may be increasing catch because it is acting as a fish aggregating device (Rodmell and Johnson 2005).

850.8.3. Access to Fishing Grounds

1. Offshore renewable energy facilities may have an adverse impact on commercial and recreational fishermen's access to traditional fishing grounds. The degree of impact varies significantly by facility design, stage of the development process, location in the offshore environment, and type of fishing activity, and may be either temporary or long-term. Fishermen may be displaced from traditional fishing grounds by the structures

themselves, regulatory decisions that limit access around the structures or through the facility, or other factors.

2. Fishing access around existing offshore renewable energy facilities in Belgium, Germany, the Netherlands, and the United Kingdom is subject to restrictions imposed by those countries' respective governments. In Belgium, Germany, and the Netherlands, a 500-meter Safety Zone is established around the entire wind farm, and fishing is prohibited within this area. In the United Kingdom, a 500-meter [0.3 mi] Safety Zone is established around each individual turbine only during the construction period. During operation, a 50-meter [164 ft] Safety Zone is established around each individual turbine. These restrictions are primarily instituted for safety reasons and are similar to those applied to offshore oil and gas rigs in these same countries (except for Belgium, where there are no rigs).[62]

3. In the Ocean SAMP area and other U.S. waters, access around individual turbines or through wind farms is the jurisdiction of the U.S. Coast Guard, in partnership with the U.S. Army Corps of Engineers (in state waters) and the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (in federal waters). At the time of this writing, there is no formal policy in place that would universally limit fishing or navigational access around and through offshore wind farms in U.S. waters. In addition, as a point of reference, it should be noted that safety zones are not universally established at Gulf of Mexico offshore oil and gas platforms. Those few platform specific safety zones that are in place are designed to address site- and activity-specific safety issues and typically allow recreational activities, including recreational fishing (LeBlanc, pers. comm.).

4. Fishing activity will be affected differently through different stages of the development process. Fishing vessels may be required or may choose to avoid the area during the construction process to avoid conflict with construction activities and vessels. During the operation phase, fishermen may be required or may choose to avoid the turbines because of the potential risk to their vessels or fishing gear from collision with a turbine, snagging gear, or other safety concerns.

5. The potential impacts of offshore renewable energy on fisheries activity varies by gear type. The PEIS (MMS 2007a) indicates that bottom trawling has the greatest potential for conflict with offshore facilities because of the potential for snagging bottom gear on cables and debris. It further indicates that surface longlining may encounter water-sheet use conflicts with renewable energy facility construction and service vessels.

6. If certain gear or vessel types are restricted from the wind farms, either for safety and navigational reasons, or because those fishermen choose to fish elsewhere because of the difficulty of navigating amongst the turbines, this may actually benefit competing gear types fishing for the same species within the wind farms. The presence of a wind farm

[62] Findings confirmed through responses to informal questionnaires completed by the Center for Environment, Fisheries, and Aquaculture Science in the UK; the German Maritime and Hydrographic Agency; and the Belgian and Dutch delegations to the OSPAR and London Convention Scientific Group, March 12, 2010.

may significantly alter the patterns of fishing within the area (North Western and North Wales Sea Fisheries Committee n.d.).

7. A loss of fishing grounds from the placement of a wind farm could cause vessels to have to travel further to fishing grounds (BMT Cordah Limited 2003), increasing fuel costs and potentially risks to safety. This could have a disproportionate impact on smaller fishing vessels, to which the risks of venturing further to sea will be greater.

8. Some fishermen have expressed the concern that marine insurance companies might increase their insurance premiums or prohibit insured fishing vessels from operating within the vicinity of offshore wind farms (e.g. Ichthys Marine 2009). However, it should be noted that at the time of this writing, Sunderland Marine does not currently impose restrictions or higher premiums on their members, nor have they heard of other insurance companies issuing such demands (McBurnie, pers. comm.). Sunderland Marine is the world's largest insurer of fishing vessels, and insures The Point Club, a fishing vessel insurance and safety club that insures many of the fishing vessels operating out of Point Judith and Newport (Nixon, pers. comm.).

850.8.4. Gear/Vessel Damage

1. Wind farms may present a navigational hazard for fishing and other vessels, and there is some risk of collision with turbines, or with service vessels. Power cables and bottom fishing gear present mutual possibilities for damage, and may endanger the safety of fishing vessels. Burying cables between the turbines, as well as from the wind farm to shore, will mitigate some of this problem. However, even if cables are buried, there is a potential for them to become uncovered through sea bed movement, putting a trawled net and perhaps the fishing vessel in danger of hang ups (Rodmell and Johnson 2005). Rodmell and Johnson (2005) note that single vessel trawling within and around the wind turbines may be possible if cables are sufficiently buried or protected, but that pair trawling may not be practical, and scallop dredging may not be compatible with wind farms.

2. Long lining and gill nets may be feasible in the vicinity of wind turbines, although their lengths may need to be limited depending on the spacing of the turbines. Purse seining within the wind farms is likely to be difficult, although may be possible on a small scale. The use of lobster and fish pots in the vicinity of the wind turbines should be mostly undisturbed. Even if fishing activity is permitted within the wind farms, fishing vessels may prefer to avoid navigating within and through wind farms (Rodmell and Johnson 2005).

850.8.5. Changes to Fishing Activity

1. The presence of wind farms may impede access to fishing grounds for some fishermen; even if fishing within the turbines is not restricted, some fishermen may choose to avoid the wind farms for safety or insurance reasons, and may have to travel further to fish, making it harder or more costly to retain the same level of catch. The greatest impacts

may be to smaller vessels, which may be more limited in their ability to fish elsewhere. This may also result in increased competition for space in other areas (Rodmell and Johnson 2005). Those vessels most likely to have to avoid the wind farm areas will be those with towed or static nets (Mackinson et al. 2006), which in the Ocean SAMP waters includes primarily trawlers and scallop dredges. As many trawlers are targeting groundfish, already a vulnerable fishery due to declining catches and increasing regulations, groundfishing vessels may be the most vulnerable to possible increased costs or reduced earnings from displacement.

2. Fishermen interviewed in the UK were concerned that if they were displaced from their usual fishing grounds, they would have to spend time searching for new fishing grounds, and that if there were insufficient resources in the new fishing grounds to support them, they would inevitably suffer from a reduction in catch. If the fishermen are displaced, they may also suffer a reduction in catch because of the time required to search for and develop the specialized local knowledge of their new fishing grounds they have held at their previous grounds. Fishermen relocated to another area may suffer reduced earnings because they are competing with vessels already fishing in the area, or, in the case that a larger vessel is displaced and seeks out new fishing grounds, it may in turn displace smaller vessels fishing already fishing in the new area (Mackinson et al. 2006).

3. Fishermen in the UK were concerned about impacts on the availability and cost of insurance for fishing vessels navigating around wind farms, even if fishing within wind farms is legal (Mackinson et al. 2006).

4. If the wind turbine support structures serve as artificial reefs or fish aggregating devices, they could have positive economic benefits for some commercial fishermen through increased catch rates. A study of artificial reefs off Portugal found that fishing around the artificial reefs resulted in substantially higher revenues, and that the value per unit of effort was also greater, because the fish were more concentrated (Whitmarsh et al. 2008). These benefits would likely only accrue to fishermen able to fish in the vicinity of the structures, although if the reef effects of the turbine support structures serve to increase fish biomass overall, this could benefit all fishermen in terms of spillover to adjacent habitats and thereby increased catches. There is also a danger that the economic benefits from fish aggregation and the resulting increase in catch efficiency around the turbines could lead to overexploitation of stocks and decrease catches elsewhere, negating any positive benefits to be had (Whitmarsh et al. 2008).

5. Any reef effect would also have positive benefits for recreational anglers, who would likely be drawn to the area and may have more opportunities for fishing. This could have secondary economic effects by increasing recreational fishing activity and thus expenditures in the Ocean SAMP area.

6. Fishing incomes may be supplemented or enhanced by offshore aquaculture activities that may be based around the wind turbines. For more on this potential future use, see Chapter 9, Other Future Uses.

Section 850.9. Cultural and Historic Resources

1. The potential effects of offshore renewable energy on cultural and historic resources may include physical impacts on existing offshore submerged archaeological resources such as shipwrecks or pre-contact settlements on the ocean floor, as well as visual impacts when the development is proposed within the viewshed of onshore land-based sites designated as historically significant.

2. Research and documentation of the effects of offshore renewable energy on cultural and historic resources have been compiled for projects in Europe, and during review for the Cape Wind project proposal in the United States (MMS 2010). In anticipation of future offshore renewable energy development within the U.S., BOEMRE has identified potential impacts and enhancements of such development on cultural and visual resources in the PEIS (MMS 2007a). From Europe, the Collaborative Offshore Wind Research Into the Environment (COWRIE) released, "*Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy*", that identifies both synergistic and cumulative impacts on cultural and historic resources (COWRIE 2007).

3. The term "Area of Potential Effect" (APE) is defined under the federal National Historic Preservation Act (36 CFR § 800.1-800.16) as the areas within which a project may directly or indirectly alter the character or use of historic properties. For offshore development proposals, BOEMRE defines an APE for direct impacts to include both offshore submerged areas and onshore land-based sites where physical disturbance would be required for construction, operation, maintenance, and decommissioning. The APE for submerged areas includes footprints of proposed structures to be secured on the ocean floor and related work area as well as all related bottom-disturbing activities, including, but not limited to, barges, anchorages, appurtenances, and cable routes where ocean sediments and sub-bottom may be disturbed. (MMS 2010). For onshore sites, the APE would include any soil disturbance required for cables or connections to onshore electric transmission cable systems, or visual impacts specifically related to National Historic Landmarks, and other properties listed or eligible for listing on the National Register of Historic Places, including Traditional Cultural Properties (MMS 2010).

4. The construction of offshore renewable energy facilities may result in direct disturbance of offshore submerged archaeological resources, including shipwreck sites and potential settlements that may have existed on what is now the ocean floor. The maps presented in Section 420.4 illustrate a paleo-geographic landscape reconstruction that suggests much of the area that is now Block Island and Rhode Island Sound was dry land over 12,500 years Before Present (yBP), and that human settlement in these areas was possible. Any disturbance of the bottom could potentially affect any cultural resources present, including early settlement sites; the level of impact may depend on the number and importance of cultural resources in that location, and any seabed disturbance that has occurred previously in the location (MMS 2007a). BOEMRE requires if any unanticipated cultural resources are encountered during a project, all activities within the area must be stopped and BOEMRE be consulted (MMS 2007a).

5. For offshore development proposals, an Area of Potential Effect (APE) for indirect impacts is defined to include the area within which the final project as well as the various phases of construction will be notably visible. Visual impacts to the setting, character and other aspects of onshore land-based sites may result from the final project as well as the various phases of construction in an offshore renewable energy project. If turbines were visible from shore, this would represent a change in the viewshed and an alteration of the aesthetics of the visual setting of areas where the structures were visible. For onshore land-based sites, the overall perception of visual impacts of offshore developments is subjective and opinions vary about whether visual impacts for a given project are positive, negative, or neutral (MMS 2007a). In advance of the construction phase, a meteorological tower will likely be installed in the project area to collect data to assess the wind resources. The visual impact of the tower will depend on its distance and thus visibility from shore. During the construction, operation and decommissioning phases, there will be increased vessel traffic in the project area, which will alter the visual characteristics of this area in that many of the construction and maintenance vessels, including a variety of ships and crane/jack-up barges, may be larger in size than other vessels traditionally in use within the project area (MMS 2009a). The FAA will likely require aircraft warning lights on the turbines for air safety purposes; these will be single red lights that flash at night on the nacelles of the peripheral turbines. Whether these lights are visible from land, and thus have an effect on land-based viewing, will depend on whether the turbines themselves are visible from land (MMS 2009a).

6. Section 106 of the National Historic Preservation Act, however, requires that a given project's visual effect on historic resources be evaluated for National Historic Landmarks and other properties listed or eligible for listing on the National Register of Historic Places, including Traditional Cultural Properties (MMS 2010). If there is a potential visual effect, it must be evaluated to determine what effect, if any, it would have on significant historic resources. A project may be found to have: no effect; no adverse effect if the visual impact is limited and insignificant; or an adverse effect. Adverse effects are defined by the Criteria of Adverse Effect in the Section 106 procedures of the National Historic Preservation Act [36 CFR 800.5(a)(1)], which state, *"An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association."* Examples of adverse effects relevant to the development of offshore renewable energy are listed as including, but not limited to, the following [36 CFR 800.5(a)(2)]: *"Alteration of a property…; Change of the character of the property's use or of physical features within the property's setting that contribute to its historic significance…; Introduction of visual, atmospheric or audible elements that diminish the integrity of the property's significant historic features."* Adverse effects from visual impacts may be further evaluated in the case of National Historic Landmarks to determine if they are indirect impacts or direct impacts, which diminish the core significance of the National Historic Landmark (Advisory Council on Historic Preservation, 2010).

7. The magnitude of the visual impacts will depend on site- and project-specific factors, including: distance of the proposed wind facility from shore; size of the facility (i.e., number of wind turbines); size (particularly height) of the wind turbines; surface treatment (primarily color) of wind turbines and electrical service platforms (ESPs); number and type of viewers (e.g., residents, tourists, workers); viewer location (onshore vs. offshore); viewer attitudes toward alternative energy and wind power; visual quality and sensitivity of the landscape/seascape; existing level of development and activities in the wind facility area and nearby onshore areas (i.e., scenic integrity and visual absorption capability); presence of sensitive visual and cultural resources; weather conditions; lighting conditions; and presence and arrangements of aviation and navigation lights on the wind turbines (MMS 2007a).

8. Factors that influence the perception an evaluation of visual impacts include: viewer distance; view duration; visibility factors; seasonal and lighting conditions; landscape/seascape setting; number of viewers; and viewer activity, sensitivity, and cultural factors (MMS 2007a).

Section 850.10. Recreation and Tourism

1. The potential effects of offshore renewable energy on recreational and tourism activities are not well understood given the relatively recent occurrence of offshore renewable energy. The PEIS indicated that offshore renewable energy installations might have visual impacts on marine recreational users and coastal tourists, though this depends on the location and visibility of the structures, as well as the preferences of the individual (MMS 2007a). Visual impacts may be caused by the offshore structures themselves, as well as the sights of support vessels, construction equipment, and helicopters traveling to and from offshore facilities, which may impact cruise ship tourists, coastal tourists, beach users, and recreational boaters. Such impacts could result in the reduction of tourism or recreational activity within sight of the project area (Lilley et al. 2009). BOEMRE cites no evidence of such impacts in other locations with offshore renewable facilities and indicates that such impacts, if any, are expected to be minor (MMS 2007a).

2. Alternatively, the PEIS also indicates that offshore renewable energy structures may enhance marine recreational and tourism activities by becoming an attraction that recreational boaters, charter boat clients, cruise ship passengers, and other visitors may want to visit (MMS 2007a). A 2007 University of Delaware study found that 65.8% of surveyed out-of-state tourists were likely to visit a beach in order to see a wind farm offshore, and 44.5% were likely to pay to take a boat tour of an offshore wind facility (Lilley et al. 2009). Anecdotal data provided by a 2006 British Wind Energy Association study indicates several instances in which tourism increased at UK destinations adjacent to offshore wind farms, or where surveyed tourists indicated that the wind farm had no effect on their likelihood to visit the site (British Wind Energy Association 2006). Visitor centers have been developed at some of these sites to facilitate tourists' experience (British Wind Energy Association 2006).

3. Noise associated with on-site marine construction, or traffic noise from support vessels and helicopters traveling to and from the offshore facility, may have a potential impact on coastal tourists and marine recreational users. Such impacts could result in the reduction of tourism or recreational activity within the affected area. In the PEIS, BOEMRE cites no evidence of such impacts in other locations with offshore renewable facilities and indicates that such impacts, if any, are expected to be minor (MMS 2007a).

4. The construction and operation of offshore renewable energy facilities may result in short- or long-term displacement of marine recreational users, particularly recreational boaters. The construction phase may result in temporary closures of the offshore project area and/or adjacent shoreline areas during activities such as driving piles or installing transmission cables. Though less likely, the operation phase may also result in the long-term displacement of recreational users from all or part of the project area. Such temporary or long-term closures could alter recreational activities and use patterns within the Ocean SAMP area by lengthening transit times between destinations, displacing fishing activities conducted by income-generating charter boat operations, or displacing large-scale sailboat races that rely on the use of the project area. Such a displacement could also cause individual users or entire events to relocate, resulting in increased

recreational activity in other in-state or out-of-state locations (MMS 2007a; Royal Yachting Association and the Cruising Association 2004). In the PEIS, BOEMRE indicates that such impacts, if any, are expected to be minor (MMS 2007a). It should also be noted that enforcing access restrictions around an offshore renewable energy facility may be very difficult given the offshore location.

5. The construction and operation of offshore renewable energy facilities may impact navigation and marine safety for recreational boaters in and around the project area. Alternatively, offshore facilities may provide enhancements to navigation and marine safety by providing mariners access to offshore weather data. Such impacts, enhancements, and mitigation measures are discussed at length in the Section 850.11 which deals with potential affects to marine transportation, navigation, and infrastructure.

6. Some of the recreational uses discussed in Chapter 6, Recreation and Tourism rely on the presence and visibility of marine and avian species including fish, whales, sharks, and birds. Offshore renewable energy facilities may have some impacts on these species and/or the habitats on which they rely. Alternatively, offshore renewable energy support structures may add to habitat complexity and increase biodiversity within the immediate area, attracting more fish, birds, whales and sharks, thereby improving recreational activities that rely on these species. See Sections 850.3, 850.4, 850.5 and 850.7 for more information on the potential affects offshore renewable energy development may pose to these resources.

7. If offshore renewable energy development results in a reduction in marine recreation and tourism in the Ocean SAMP area, Rhode Island-based businesses that serve these industries may lose some business. Alternatively, marine trades and coastal tourism businesses may benefit from offshore renewable energy in response to the potential growth of marine and coastal tourism activities such as wind farm boat trips (OSPAR 2004) (see above). In addition the construction and operation of an offshore facility may require additional shore-based infrastructure or services that may boost the marine trades sector.

Section 850.11. Marine Transportation, Navigation and Infrastructure

1. Offshore renewable energy may have some effects on marine transportation, navigation activities and other infrastructure in the Ocean SAMP area. The degree to which offshore renewable energy structures may affect marine transportation, navigation and infrastructure varies in large part on the specific siting of a project. Careful consideration when planning the location of an offshore renewable energy facility, as well as the use of appropriate mitigation strategies, can minimize any potential negative impacts (MMS 2007a).

2. In addition to the potential effects identified in European research, the PEIS and the Cape Wind FEIS, the U.S. Coast Guard has issued a Navigation and Vessel Inspection Circular (U.S. Coast Guard NAVIC 02-07) to provide guidance on the information and factors the Coast Guard will consider, which include navigational safety and security, when reviewing a permit application for an offshore renewable energy installation in the navigable waters of the United States (U.S. Coast Guard 2007).

3. Offshore renewable energy facilities may affect navigational safety in a project area by increasing the risk of collision, limiting visibility, or limiting a vessel's ability to maneuver (MMS 2007a; U.S. Coast Guard 2007; BWEA 2007; U.K. Maritime and Coast Guard Agency 2008). However, collision risk was found to be low, especially when facilities are sited appropriately (e.g. MMS 2007a). Risks that have been identified include vessels colliding with offshore renewable structures themselves; with other vessels; or with ice that has formed on or around the structures during winter months. Moreover, visibility may be impaired surrounding an offshore renewable energy facility, as structures may block or hinder a mariner's view of other vessels, nearby land masses, or other navigational features (U.S. Coast Guard 2007; United Kingdom Maritime and Coast Guard Agency 2008). Obstructed visibility could potentially put a vessel at risk of collision or running aground. However, mitigation measures have been identified that can lower this potential risk to acceptable levels. For instance, mariners have been advised to follow required standard operating procedures, where applicable, as outlined in the International Regulations for Preventing Collisions at Sea (COLREGS) for limited visibility conditions. Adherence with these standard regulations can mitigate hazards to navigation caused by impaired visibility within an offshore renewable energy facility (U.S. Coast Guard 2009; U.K. Maritime and Coast Guard Agency 2008). Offshore renewable energy structures may also limit the ability of some larger vessels to maneuver to avoid collision, as these vessels usually require greater stopping distances and have wider turning radii (U.S. Coast Guard 2007; U.S. Coast Guard 2009). The PEIS notes that such impacts can be mitigated to acceptable levels by siting offshore renewable energy facilities so that they do not interfere with designated fairways or shipping lanes, and using appropriate signage and/or lighting to warn passing vessels (MMS 2007a; U.S. Coast Guard 2009). In addition, the U.S. Coast Guard considers all of these navigational safety issues when evaluating a permit application for an offshore renewable energy structure (U.S. Coast Guard 2007).

4. Whereas offshore renewable energy facilities may potentially displace marine transportation, military, or navigation uses, appropriate siting away from shipping lanes, military usage areas, or other intensively-used areas can minimize or eliminate any potential displacement of these uses (MMS 2007a). Vessels that cannot safely operate or navigate within an offshore renewable energy facility may be excluded from areas that were previously used, and therefore would need to alter travel routes in the vicinity of such projects (United Kingdom Maritime and Coastguard Agency 2008; U.S. Coast Guard 2007). Route alterations may potentially extend vessel travel times. The PEIS (MMS 2007a) notes that such impacts can be mitigated to acceptable levels by siting offshore renewable energy facilities away from designated fairways or shipping lanes. In addition, BOEMRE (MMS 2007a) expects that the military impacts of offshore wind farms will be negligible provided that development is coordinated with the U.S. Department of Defense and all appropriate military agencies.

5. Offshore renewable energy structures may affect the physical characteristics of a waterway, which include localized currents and sediment deposition and erosion (United Kingdom Maritime and Coastguard Agency 2008) though can be minimized to acceptable levels through proper siting and mitigation methods (U.S. Coast Guard 2007; MMS 2007a). Currents that are altered in direction and/or speed within or around an offshore renewable energy facility, may affect how vessels navigate through an area. In addition, structures that attach to the seafloor or extend through the water column may affect the surrounding water depth by altering sediment movement or deposition (MMS 2007a; U.S. Coast Guard 2007; United Kingdom Maritime and Coastguard Agency 2008). Consequently, if shoaling occurs, vessel navigation may be impacted within or around an offshore renewable energy facility. These effects may be most pronounced in predominantly shallow areas, or areas composed of highly mobile substrate (i.e. sands) with strong waves or currents. Mitigation measures may include installing scour-protection devices and monitoring sediment transport processes (United Kingdom Maritime and Coastguard Agency 2008; U.S. Coast Guard 2007; MMS 2007a). For more information on scour and the potential affects to coastal processes and physical oceanography see Section 850.2.

6. Due to the large size of some offshore renewable structures, offshore renewable energy installations may interfere with the use of radar by ships or shore-based facilities within the area. However, interference may be negligible to minor when properly mitigated (MMS 2007a; U.S. Coast Guard 2007; Technology Service Corporation 2008; Howard and Brown 2004; U.S. Department of Defense 2006). Studies have shown that ship and land-based radar systems may have some difficulty in detecting marine targets within an offshore renewable energy facility as the result of the distortion or degradation of radar signals by the installed structures (U.S. Coast Guard 2009; Technology Service Corporation 2008; MMS 2007a; U.S. Department of Defense 2006, BWEA 2007). Research conducted to assess the potential radar impacts of the proposed Cape Wind project in Nantucket Sound found that the facility would only pose adverse impacts in accurately detecting targets within and immediately behind the wind farm, as the installed structures may produce false targets or mask real targets (U.S. Coast Guard 2009; Technology Service Corporation 2008; United Kingdom Maritime and Coastguard

Agency 2008). In other words, vessels navigating near but outside a wind farm may not be able to clearly identify, by radar, another vessel operating within the wind farm due to radar clutter. However, radar impacts observed within the wind farm can be mitigated to acceptable levels through greater attention by radar operators in distinguishing between real and false targets (U.S. Coast Guard 2009). No adverse impacts were found to occur between vessels operating completely outside, but within the vicinity of, the wind farm (U.S. Coast Guard 2009; Technology Service Corporation 2008). Because the severity of impacts to radar varies widely depending on site-specific characterizations, the U.S. Coast Guard considers impacts on navigation radar when reviewing a permit application (U.S. Coast Guard 2007).

7. Weather radar located near offshore renewable energy installations may also be adversely impacted by offshore renewable energy structures; impacts may include misidentification of thunderstorm features, false radar estimates of precipitation accumulation, and incorrect storm cell identification and tracking (MMS 2007a).

8. The installation of offshore renewable energy facilities may cause either minimal impacts or possible enhancements to navigation and communication tools and systems, including global positioning systems, magnetic compasses, cellular phone communications, very-high frequency (VHF) communications, ultra-high frequency (UHF) and other microwave systems, and automatic identification systems (AIS) (MMS 2007a, United Kingdom Maritime and Coastguard Agency 2008). The PEIS (MMS 2007a) indicates that any impacts are likely to be negligible to minor, and cites a number of studies in which no negative impacts were found. For example, Brown and Howard (2004) found no impact of wind farms on GPS accuracy and also noted that magnetic compasses, AIS, and VHF communications (ship-to-ship and ship-to-shore) were not affected within the wind farm installation. The U.S. Coast Guard requires permit applicants to conduct research on the potential impacts of an offshore renewable energy installation on navigation and communication systems prior to construction (U.S. Coast Guard 2007).

9. Search and rescue operations by agencies such as the U.S. Coast Guard, may be positively and/or negatively affected by offshore renewable energy installations (U.S. Coast Guard 2007; LeBlanc 2009). For example, installations may prolong the response time of search and rescue missions in cases where longer routes around the facility are required. Alternatively, offshore renewable energy structures may provide refuge to distressed mariners stranded or disabled within the vicinity of the facility (U.S. Coast Guard 2007). When evaluating an offshore renewable energy permit, the U.S. Coast Guard will examine if an offshore renewable energy facility will prolong an agency's response time during a rescue mission (LeBlanc 2009). Previous research conducted to analyze the effects of offshore wind farms on search and rescue operations, involving helicopters, showed that radio communications and VHF homing systems worked satisfactorily, as did thermal imaging of vessels, turbines, and personnel within the wind facility (Brown 2005).

10. Operational offshore renewable energy facilities may provide enhancements to navigation and marine safety by providing mariners with access to in-situ offshore

weather, wave and current data. This information may increase navigational safety by informing mariners of current offshore conditions, or providing a recent history of offshore conditions to aid in search and rescue operations within the area.

11. During the construction of an offshore renewable energy facility, vessel traffic may temporarily increase in a project area (MMS 2007a). Transits and operations of vessels involved in the transport of equipment and materials, facility construction, or the laying of submarine cables may temporarily increase (MMS 2007a). As a result, port facilities may also experience increased activity (MMS 2007a). Increased vessel activity may continue, albeit to a lesser extent, through the operation of the offshore renewable energy facility, as maintenance vessels will be required to service the installed structures. The presence of these vessels may increase the demand for port services, and enhance the economic activity associated with port facilities and marine industries.

12. Siting of offshore renewable energy facilities near pre-existing submarine cables may impact the security and accessibility of these cables. Such impacts can be mitigated to acceptable levels by considering pre-existing cables when siting offshore renewable energy facilities. Cable ships require a minimum distance from an offshore structure in order to safely access a submarine cable for repair or replacement (International Cable Protection Committee 2007). Offshore renewable energy installations whose location does not allow for safe access to existing submarine cables by the appropriate vessels may negatively impact the operation, performance, and longevity of this infrastructure (International Cable Protection Committee 2007). In addition, laying new submarine cables associated with an offshore renewable energy facility may require crossing existing cables in the area.

Section 850.12. Cumulative Impacts

1. Table 8.20 summarizes of all the potential effects of offshore renewable energy development on existing resources and uses identified in this section. The range and severity of effects will vary depending on the project. Project specific effects will be thoroughly examined as part of a project's NEPA review. In order to assess what the net effect might be from any of these effects related to offshore renewable energy, numerous factors will need to be taken into account, including the duration, frequency, and/or intensity of the effect. Furthermore, most effects are still not fully understood and will require further monitoring (see Section 860 for monitoring requirements for offshore renewable energy in the Ocean SAMP area).

2. In addition to the effects caused by any one renewable energy project within the Ocean SAMP area, the cumulative impact of past, present, and future uses on the Ocean SAMP area must be considered. The Ocean SAMP area is not pristine – activities in the offshore waters have been taking place for hundreds of years – but neither is it heavily industrialized. The ecosystem and its resources, as well as those who use the Ocean SAMP area, are currently being directly or indirectly affected by activities taking place inside of and beyond the Ocean SAMP area. When considering the effects of a wind energy project on the marine environment, the cumulative effects of existing activities such as fishing, marine transportation, and recreation will need to be considered alongside the proposed project, as should the effects of multiple renewable energy or other development projects on this area. Particularly important will be the cumulative effects of global climate change along with other current and future activities. The total cumulative effects cannot be fully understood and cannot be predicted with certainty, but nonetheless the potential for cumulative effects should be taken into account. A cumulative impact analysis of a proposed project would be required under 40 CFR Section 1508.7 of NEPA regulations.

3. While not all offshore renewable energy projects will have the same affects on the natural resources or existing uses of the Ocean SAMP area, identifying all potential effects aids in determining the most appropriate siting for any future projects. Through the Ocean SAMP process existing uses and resources have been identified and described, adding to the current understanding of the area. Moreover, the policies and standards outlined in the Ocean SAMP document provide protection and consideration to important areas, resources and uses of the area. In the end, the findings and policies of the Ocean SAMP will help to manage and address cumulative impacts of potential offshore renewable energy development, or any future development within the waters of the Ocean SAMP boundary.

Table 8.20. Summary of potential effects of offshore renewable energy development during each stage of development.

Area	Pre-construction Siting	Construction	Operation	Decommissioning
Alteration of waves and currents	N/A	N/A	Changes in current velocity and direction; changes in wave heights; Changes in larval distribution; Scour (local and global)	N/A
Water Column Density Stratification	N/A	N/A	Reduced spatial extent of stratification; Shorter seasonal duration of stratification	N/A
Alteration of Benthic Habitat	N/A	Redistribution of sediments; Smothering of benthic organisms; smothering of eggs and larvae; damage to benthic habitat from cable sweep; Loss of habitat; disturbance to shellfish beds or hard bottom habitats from cable laying	Introduction of hard substrate; Loss of seabed area	Loss of habitat; Redistribution of sediments; Smothering of benthic organisms; smothering of eggs and larvae;
Water quality	Accidental spillage of contaminants or debris	Accidental spillage of contaminants or debris	Accidental release of contaminants	Accidental spillage of contaminants or debris
Turbidity	N/A	Affect primary production; secondary effects on prey species; potential smothering of eggs and larvae	N/A	Affect primary production; secondary effects on prey species; potential smothering of eggs and larvae
Noise effects – marine mammals	Avoidance; sound masking; stress	Masking of sounds; displacement; temporary/permanent hearing threshold shifts; stress; injury; mortality	Avoidance; sound masking; stress	Avoidance; sound masking; stress

Noise effects - fish	Avoidance; sound masking; stress.	Masking of sounds; displacement; temporary/permanent hearing threshold shifts; stress; injury; mortality; decreased catch rates.	Avoidance; sound masking; stress.	Avoidance; sound masking; stress.
Noise effects – sea turtles	Avoidance	Avoidance	Probably none	Avoidance
EMF	N/A	N/A	Avoidance or attraction by sensitive species, resulting in changes to feeding or migratory behavior.	N/A
Reef effects	N/A	N/A	Increased colonization for invertebrates; increased fish habitat; shelter for juvenile species; increased predators; possibility of invasive species; increased fish catch; attraction for sea turtles.	Loss of reef effects.
Vessel traffic	Increased risk of collision with marine mammals; Increased noise causing avoidance by fish and marine mammals.	Increased risk of collision with marine mammals; Increased noise causing avoidance by fish and marine mammals; Increased risk of collision with sea turtles.	Increased risk of collision with marine mammals; Increased noise causing avoidance by fish and marine mammals.	Increased risk of collision with marine mammals; Increased noise causing avoidance by fish and marine mammals.
Effects to birds	N/A	Displacement; disturbance.	Displacement; disturbance; avoidance; collision with turbines.	Displacement; disturbance.
Visual effects	Increased vessel traffic.	Increased vessel traffic, including heavy construction equipment.	Presence of wind turbines.	Increased vessel traffic, including heavy construction equipment.

Section 860. General Policies and Regulatory Standards

860.1. General Policies

1. The Council supports offshore development in the Ocean SAMP area that is consistent with the Ocean SAMP goals which are to:
    i. Foster a properly functioning ecosystem that can be both ecologically effective and economically beneficial;
    ii. Promote and enhance existing uses; and
    iii. Encourage marine-based economic development that considers the aspirations of local communities and is consistent and complementary to the state's overall economic development needs and goals.

2. The Council supports the policy of increasing renewable energy production in Rhode Island. The Coucil also recognizes:
    i. Offshore wind energy currently represents the greatest potential for utility-scale renewable energy generation in Rhode Island;
    ii. Offshore renewable energy development is a means of mitigating the potential effects of global climate change;
    iii. Offshore renewable energy development will diversify Rhode Island's energy portfolio;
    iv. Offshore renewable energy development will aid in meeting the goals set forth in Rhode Island's Renewable Energy Standard;
    v. Marine renewable energy has the potential to assist in the redevelopment of urban waterfronts and ports.

    The Council's support of offshore renewable energy development shall not be construed to endorse or justify any particular developer or particular offshore renewable energy proposal.

3. The policies and standards contained herein supersede Sections 300.3 and 300.8 of the Rhode Island Coastal Resources Management Program (RICRMP) only for the jurisdictional area of the Ocean SAMP. Dredging and dredge disposal activities remain governed by Section 300.9 of the RICRMP.

4. The Council may require the applicant to fund a program to mitigate the potential impacts of a proposed Offshore Development to natural resources and existing human uses. The mitigation program may be used to support restoration projects, additional monitoring, preservation, or research activities on the impacted resource or site.

5. To the greatest extent possible, Offshore Development structures and projects shall be made available to researchers for the investigation into the effects of large-scale installations on the marine environment, and to the extent practicable, educators for the purposes of educating the public.

6. The Council shall work in coordination with the U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement to develop a seamless process for review and design approval of offshore wind energy facilities that is consistent across state and federal waters.

7. The Council shall work together with the U.S. Coast Guard, the U.S. Navy, the U.S. Army Corps of Engineers, NOAA, fishermen's organizations, marine pilots, recreational boating organizations, and other marine safety organizations to promote safe navigation, fishing, and recreational boating activity around and through offshore structures and developments, and along cable routes, during the construction, operation and decommissioning phases of such projects. The Council will promote and support the education of all mariners regarding safe navigation around offshore structures and developments, and along cable routes.

8. Discussions with the U.S. Coast Guard, the U.S. Department of Interior Bureau of Ocean Energy Management, Regulation, and Enforcement, and the U.S. Army Corps of Engineers have indicated that no vessel access restrictions are planned for the waters around and through offshore structures and developments, or along cable routes, except for those necessary for navigational safety. Commercial and recreational fishing and boating access around and through offshore structures and developments and along cable routes is a critical means of mitigating the potential adverse impacts of offshore structures on commercial and recreational fisheries and recreational boating. The Council endorses this approach and shall work to ensure that the waters surrounding offshore structures, developments, and cable routes remain open to commercial and recreational fishing, marine transportation, and recreational boating, except for navigational safety restrictions. The Council requests that federal agencies notify the Council as soon as is practicable of any federal action that may affect vessel access around and through offshore structures and developments and along cable routes. The Council will continue to monitor changes to navigational activities around and through offshore developments and along cable routes. Any changes affecting existing navigational activities may be subject to CZMA Federal Consistency review if the federal agency determines its activity will have reasonably foreseeable effects on the uses or resources of Rhode Island's coastal zone.

9. To coordinate the review process for offshore wind energy developments, the Council shall adopt consistent information requirements similar to the requirements of the U.S. Department of the Interior's Bureau of Ocean Energy Management, Regulation and Enforcement for offshore wind energy. All documentation required at the time of application shall be similar with the requirements followed by the U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement when issuing renewable energy leases on the Outer Continental Shelf. For further details on these regulations see 30 CFR §§285 *et seq*. The Council shall continue to monitor the federal review process and information requirements for any changes and will make adjustments to the Ocean SAMP policies accordingly.

10. To the maximum extent practicable, the Council shall coordinate with the appropriate federal and state agencies to establish project specific requirements that shall be followed by the applicant during the pre-construction, construction, operation and decommissioning phases of an Offshore Development. To the maximum extent practicable, the Council shall work in coordination with a Joint Agency Working Group when establishing pre-construction survey and data requirements, monitoring requirements, protocols and mitigation measures for a proposed Offshore Development. State members of the Joint Agency Working Group shall coordinate with the Habitat Advisory Board and the Fishermen's Advisory Board and shall seek input from these Boards before establishing project specific requirements that shall be followed by the applicant for an Offshore Development. And, to the maximum extent practical, and consistent with the federal agency and tribal members' authorities, federal members of the Joint Agency Working Group, are strongly encouraged to coordinate with the Habitat Advisory Board and the Fishermen's Advisory Board. The Joint Agency Working Group shall comprise those state and federal agencies that have a regulatory responsibility related to the proposed project, as well as the Narragansett Indian Tribal Historic Preservation Office. The agency composition of this working group may differ depending on the proposed project, but will generally include the lead federal agency with primary jurisdiction over the proposed project and the CRMC. The pre-construction survey requirements outlined in Section 860.2.5.1(i) may be reduced for small- scale offshore developments as specified by the Joint Agency Working Group.

11. The following are industry goals that projects should strive for. These are not required standards at this time but are targets project proponents should try to meet where possible to alleviate potential adverse impacts:

    i. A goal for the wind farm applicant and operator is to have operational noise from wind turbines average less than or equal to 100 dB re 1 μPa_2 in any 1/3 octave band at a range of 100 meters at full power production.
    ii. The applicant and manufacturer should endeavor to minimize the radiated airborne noise from the wind turbines.
    iii. A monitoring system including acoustical, optical and other sensors should be established near these facilities to quantify the effects.

860.2 Regulatory Standards

1. The federal offshore renewable energy leasing process, and subsequent regulation of renewable energy projects located in federal waters, will remain under the jurisdiction of BOEMRE, in consultation and coordination with relevant federal agencies and affected state, local, and tribal officials, as per BOEMRE's statutory authority at 43 USC 1337(p) and the regulations found at 30 CFR 285.

860.2.1 Overall Regulatory Standards

1. All Offshore Developments regardless of size, including energy projects, which are proposed for or located within state waters of the Ocean SAMP area, are subject to the policies and standards outlined in Sections 1150 and 1160 (except, as noted above, Section 1150 policies shall not be used for CRMC concurrence or objection for CZMA Federal Consistency reviews). For the purposes of the Ocean SAMP, Offshore Developments are defined as:
    i. Large-scale projects, such as:
        a. offshore wind facilities (5 or more turbines within 2 km of each other, or 18 MW power generation);
        b. wave generation devices (2 or more devices, or 18 MW power generation);
        c. instream tidal or ocean current devices (2 or more devices, or 18 MW power generation); and
        d. offshore LNG platforms (1 or more); and
        e. Artificial reefs (1/2 acre footprint and at least 4 feet high), except for projects of a public nature whose primary purpose is habitat enhancement.
    ii. Small-scale projects, defined as any projects that are smaller than the above thresholds;
    iii. Underwater cables;
    iv. Mining and extraction of minerals, including sand and gravel;
    v. Aquaculture projects of any size, as defined in RICRMP Section 300.11 and subject to the regulations of RICRMP Section 300.11;
    vi. Dredging, as defined in RICRMP Section 300.9 and subject to the regulations of RICRMP Section 300.9; or
    vii. Other development (as defined in the RICRMP)[63] which is located in tidal waters from the mouth of Narragansett Bay seaward, between 500 feet offshore and the 3-nautical mile, state water boundary.

2. In assessing the natural resources and existing human uses present in state waters of the Ocean SAMP area, the Council finds that the most suitable area for offshore renewable energy development in the state waters of the Ocean SAMP area is the Renewable Energy Zone depicted in Figure 8.47. The Council designates this area as Type 4E waters. In the Rhode Island Coastal Resources Management Program these waters were

[63] "Development" is defined in the RICRMP Glossary.

previously designated as Type 4 (or multipurpose) but are hereby modified to show that this is the preferred site for large scale renewable energy projects in state waters. The Council may approve offshore renewable energy development elsewhere in the Ocean SAMP area, within state waters, where it is determined to have no significant adverse impact on the natural resources or human uses of the Ocean SAMP area. Large-scale Offshore Developments shall avoid areas designated as Areas of Particular Concern constistent with Section 860.2.2. No large-scale offshore renewable energy development shall be allowed in Areas Designated for Preservation consistent with Section 860.2.3.

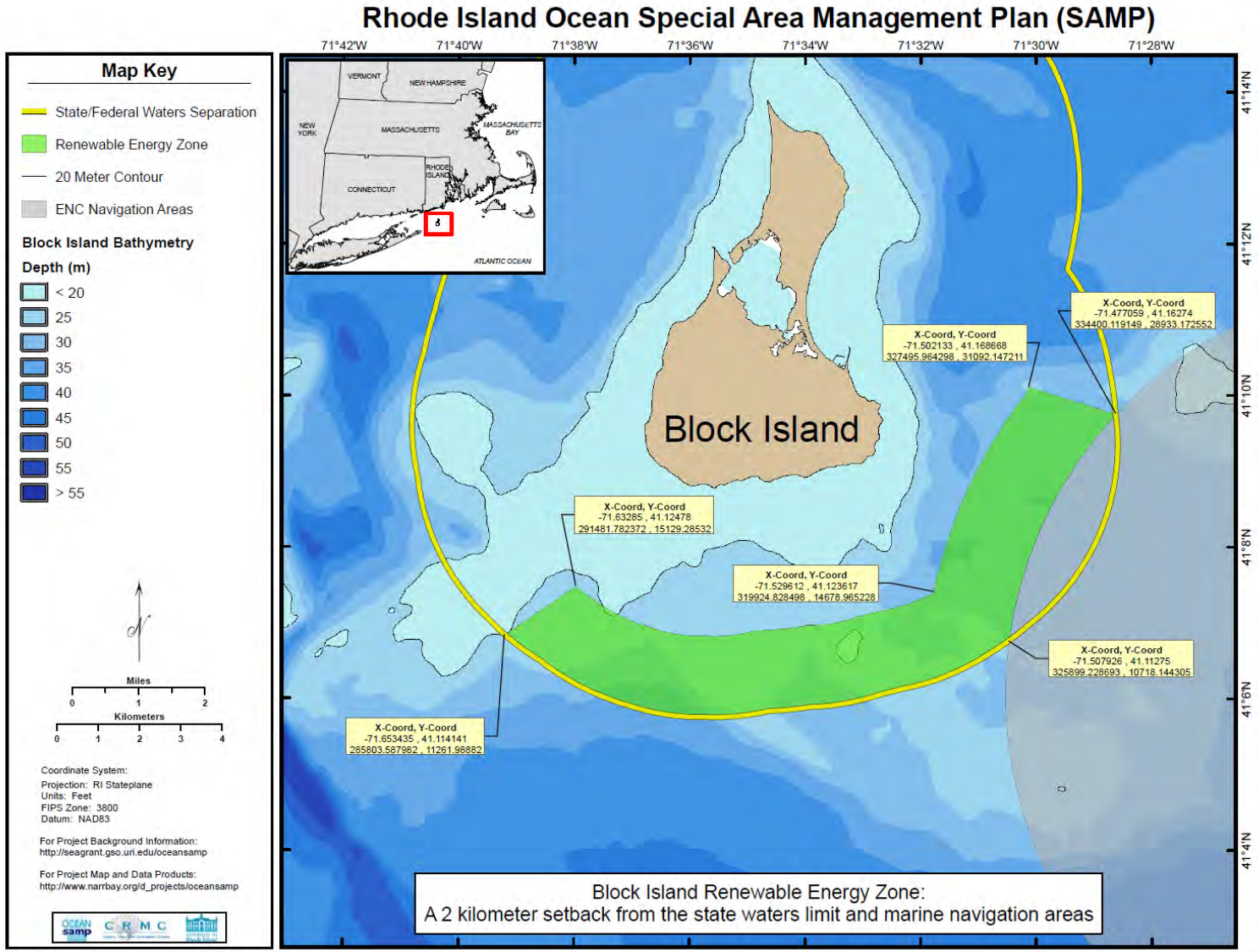


Figure 8.47. Renewable Energy Zone.

3. Offshore Developments shall not have a significant adverse impact on the natural resources or existing human uses of the Rhode Island coastal zone, as described in the Ocean SAMP. Where the Council determines that impacts on the natural resources or human uses of the Rhode Island coastal zone through the pre-construction, construction, operation, or decommissioning phases of a project constitute significant adverse impacts, the Council shall, through its permitting and enforcement authorities in state waters and through any subsequent CZMA federal consistency reviews, require that the applicant modify the proposal to avoid and/or mitigate the impacts or the Council shall deny the proposal.

4. Any assent holder of an approved Offshore Development shall:
    i. Design the project and conduct all activities in a manner that ensures safety and shall not cause undue harm or damage to natural resources, including their physical, chemical, and biological components to the extent practicable; and take measures to prevent unauthorized discharge of pollutants including marine trash and debris into the offshore environment.
    ii. Submit requests, applications, plans, notices, modifications, and supplemental information to the Council as required;
    iii. Follow up, in writing, any oral request or notification made by the Council, within 3 business days;
    iv. Comply with the terms, conditions, and provisions of all reports and notices submitted to the Council, and of all plans, revisions, and other Council approvals, as provided in Sections 860.2.5;
    v. Make all applicable payments on time;
    vi. Conduct all activities authorized by the permit in a manner consistent with the provisions of this document, the Rhode Island Coastal Resources Management Program, and all relevant federal and state statutes, regulations and policies;
    vii. Compile, retain, and make available to the Council within the time specified by the Council any information related to the site assessment, design, and operations of a project; and
    viii. Respond to requests from the Council in a a timeframe specified by the Council.

5. Any Large-Scale Offshore Development, as defined in section 1160.1.1, shall require a meeting between the Fisherman's Advisory Board (FAB), the applicant, and the Council staff to discuss potential fishery-related impacts, such as, but not limited to, project location, construction schedules, alternative locations, project minimization and identification of high fishing activity or habitat edges. For any state permit process for a Large-Scale Offshore Development this meeting shall occur prior to submission of the state permit application. The Council cannot require a pre-application meeting for federal permit applications, but the Council strongly encourages applicants for any Large-Scale Offshore Development, as defined in Section 1160.1.1, in federal waters to meet with the HAB and the Council staff prior to the submission of a federal application, lease, license, or authorization. However, for federal permit applicants, a meeting with the HAB shall be

necessary data and information required for federal consistency reviews for purposes of starting the CZMA 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930, subpart E, pursuant to 15 C.F.R. § 930.58(a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project .

6. The Council shall prohibit any other uses or activities that would result in significant long-term negative impacts Rhode Island's commercial or recreational fisheries. Long-term impacts are defined as those that affect more than one or two seasons.

7. The Council shall require that the potential adverse impacts of Offshore Developments and other uses on commercial or recreational fisheries be evaluated, considered, and mitigated as described in 860.1.1.9.

8. For the purposes of Sections 560.1-560.2, mitigation is defined as a process to make whole those fisheries user groups that are adversely affected by proposals to be undertaken, or undertaken projects, in the Ocean SAMP area. Mitigation measures shall be consistent with the purposes of duly adopted fisheries management plans, programs, strategies and regulations of the agencies and regulatory bodies with jurisdiction over fisheries in the SAMP area, including but not limited to those set forth in 560.1.2. Mitigation shall not be designed or implemented in a manner that substantially diminishes the effectiveness of duly adopted fisheries management programs. Mitigation measures may include, but are not limited to, compensation, effort reduction, habitat preservation, restoration and construction, marketing, and infrastructure improvements. Where there are potential impacts associated with proposed projects, the need for mitigation shall be presumed. Negotiation of mitigation agreements shall be a necessary condition of any approval or permit of a project by the Council. Mitigation shall be negotiated between the Council staff, the FAB, the project developer, and approved by the Council. The reasonable costs associated with the negotiation, which may include data collection and analysis, technical and financial analysis, and legal costs, shall be borne by the applicant. The applicant shall establish and maintain either an escrow account to cover said costs of this negotiation or such other mechanism as set forth in the permit or approval condition pertaining to mitigation. This policy shall apply to all Large-Scale Offshore Developments, underwater cables, and other projects as determined by the Council.

9. The Council recognizes that moraine edges, as illustrated in Figure 8.49, are important to commercial and recreational fishermen. In addition to these mapped areas, the FAB may identify other edge areas that are important to fisheries within a proposed project location. The Council shall consider the potential adverse impacts of future activities or projects on these areas to Rhode Island's commercial and recreational fisheries. Where it is determined that there is a significant adverse impact, the Council will modify or deny activities that would impact these areas. In addition, the Council will require assent holders for Offshore Developments to employ micro-siting techniques in order to minimize the potential impacts of such projects on these edge areas.

10. The finfish, shellfish, and crustacean species that are targeted by commercial and recreational fishermen rely on appropriate habitat at all stages of their life cycles. While all fish habitat is important, spawning and nursery areas are especially important in providing shelter for these species during the most vulnerable stages of their life cycles. The Council shall protect sensitive habitat areas where they have been identified through the Site Assessment Plan or Construction and Operation Plan review processes for Offshore Developments as described in Section 860.2.5.

11. Any Large-Scale Offshore Development, as defined in section 860.2.1.1, shall require a meeting between the HAB, the applicant, and the Council staff to discuss potential marine resource and habitat-related issues such as, but not limited to, impacts to marine resource and habitats during construction and operation, project location, construction schedules, alternative locations, project minimization, measures to mitigate the potential impacts of proposed projects on habitats and marine resources, and the identification of important marine resource and habitat areas. For any state permit process for a Large-Scale Offshore Development, this meeting shall occur prior to submission of the state permit application. The Council cannot require a pre-application meeting for federal permit applications, but the Council strongly encourages applicants for any Large-Scale Offshore Development, as defined in Section 1160.1.1, in federal waters to meet with the HAB and the Council staff prior to the submission of a federal application, lease, license, or authorization. However, for federal permit applicants, a meeting with the HAB shall be necessary data and information required for federal consistency reviews for purposes of starting the CZMA 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930, subpart E, pursuant to 15 C.F.R. § 930.58 (a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project..

12. The potential impacts of a proposed project on cultural and historic resources will be evaluated in accordance with the National Historic Preservation Act and Antiquities Act, and the Rhode Island Historical Preservation Act and Antiquities Act as applicable. Depending on the project and the lead federal agency, the projects that may impact marine historical or archaeological resources identified through the joint agency review process shall require a Marine Archaeology Assessment that documents actual or potential impacts the completed project will have on submerged cultural and historic resources.

13. Guidelines for Marine Archaeology Assessment in the Ocean SAMP Area can be obtained through the RIHPHC in their document, "Performance Standards and Guidelines for Archaeological Projects: Standards for Archaeological Survey" (RIHPHC 2007), or the lead federal agency responsible for reviewing the proposed development.

14. The potential non-physical impacts of a proposed project on cultural and historic resources shall be evaluated in accordance with 36 CFR 800.5, *Assessment of Adverse Effects, (v) Introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features.* Depending on the project and the lead federal agency, the Ocean SAMP Interagency Working Group may require that a

project undergo a Visual Impact Assessment that evaluates the visual impact a completed project will have on onshore cultural and historic resources.

15. A Visual Impact Assessment may require the development of detailed visual simulations illustrating the completed project's visual relationship to onshore properties that are designated National Historic Landmarks, listed on the National Register of Historic Places, or determined to be eligible for listing on the National Register of Historic Places. Assessment of impacts to specific views from selected properties of interest may be required by relevant state and federal agencies to properly evaluate the impacts and determination of adverse effect of the project on onshore cultural or historical resources.

16. A Visual Impact Assessment may require description and images illustrating the potential impacts of the proposed project.

17. Guidelines for Landscape and Visual Impact Assessment in the Ocean SAMP Area can be obtained through the lead federal agency responsible for reviewing the proposed development.

860.2.2 Areas of Particular Concern

1. Areas of Particular Concern (APCs) have been designated in state waters through the Ocean SAMP process with the goal of protecting areas that have high conservation value, cultural and historic value, or human use value from Large-Scale Offshore Development.[64] These areas may be limited in their use by a particular regulatory agency (e.g. shipping lanes), or have inherent risk associated with them (e.g. unexploded ordnance locations), or have inherent natural value or value assigned by human interest (e.g. glacial moraines, historic shipwreck sites). Areas of Particular Concern have been designated by reviewing habitat data, cultural and historic features data, and human use data that has been developed and analyzed through the Ocean SAMP process. Currently designated Areas of Particular Concern are based on current knowledge and available datasets; additional Areas of Particular Concern may be identified by the Council in the future as new datasets are made available. Areas of Particular Concern may be elevated to Areas Designated for Preservation in the future if future studies show that Areas of Particular Concern cannot risk even low levels of Large-Scale Offshore Development within these areas. Areas of Particular Concern include:

    i. Areas with unique or fragile physical features, or important natural habitats;
    ii. Areas of high natural productivity;
    iii. Areas with features of historical significance or cultural value;
    iv. Areas of substantial recreational value;
    v. Areas important for navigation, transportation, military and other human uses; and
    vi. Areas of high fishing activity.

[64] Areas of Particular Concern are identified in the federal Coastal Zone Management Act and associated CFRs; see 15 CFR 923.21

2. The Council has designated the areas listed below in section 860.2.2.3 in state waters as Areas of Particular Concern.All Large-scale, Small-scale, or other offshore development, or any portion of a proposed project, shall be presumptively excluded from APCs. This exclusion is rebuttable if the applicant can demonstrate by clear and convincing evidence that there are no practicable alternatives that are less damaging in areas outside of the APC, or that the proposed project will not result in a significant alteration to the values and resources of the APC. When evaluating a project proposal, the Council shall not consider cost as a factor when determining whether practicable alternatives exist. Applicants which successfully demonstrate that the presumptive exclusion does not apply to a proposed project because there are no practicable alternatives that are less damaging in areas outside of the APC must also demonstrate that all feasible efforts have been made to avoid damage to APC resources and values and that there will be no significant alteration of the APC resources or values. Applicants successfully demonstrating that the presumptive exclusion does not apply because the proposed project will not result in a significant alteration to the values and resources of the APC must also demonstrate that all feasible efforts have been made to avoid damage to the APC resources and values. The Council may require a successful applicant to provide a mitigation plan that protects the ecosystem. The Council will permit underwater cables, only in certain categories of Areas of Particular Concern, as determined by the Council in coordination with the Joint Agency Working Group. The maps listed below in section 860.2.2.3 depicting Areas of Particular Concern may be superseded by more detailed, site-specific maps created with finer resolution data.

3. Areas of particular concern that have been identified in the Ocean SAMP area in state waters are described as follows.

    i. Historic shipwrecks, archeological or historical sites and their buffers as described in Chapter 4, Cultural and Historic Resources, section 440.1.1 through 440.1.4, are Areas of Particular Concern. For the latest list of these sites and their locations please refer to the Rhode Island State Historic Preservation and Heritage Commission.

    ii. Offshore dive sites within the Ocean SAMP area, as shown in Figure 8.48 are designated Areas of Particular Concern. The Council recognizes that offshore dive sites, most of which are shipwrecks, are valuable recreational and cultural ocean assets and are important to sustaining Rhode Island's recreation and tourism economy.

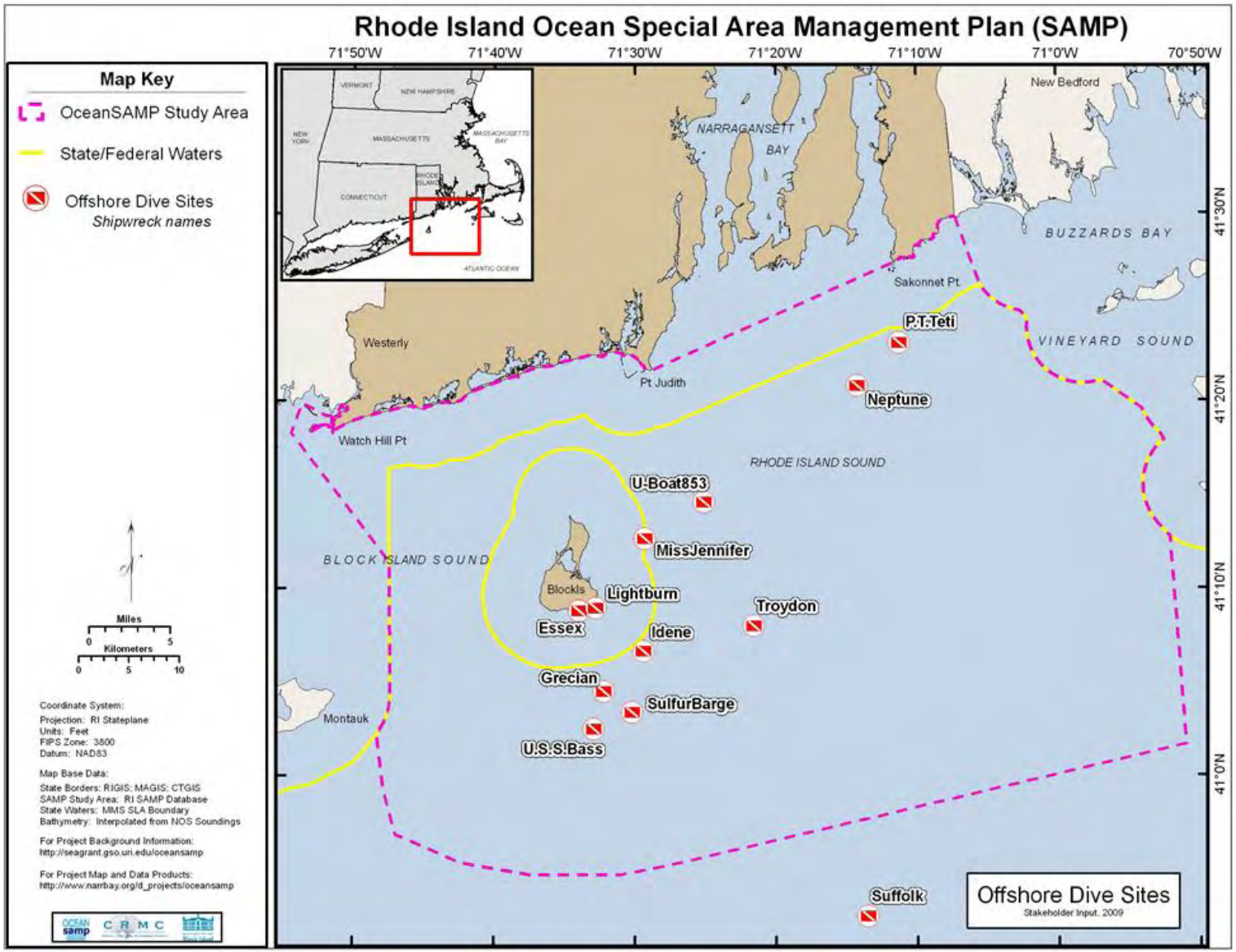


Figure 8.48. Offshore dive sites designated as Areas of Particular Concern in state waters.

iii. Glacial moraines are important habitat areas for a diversity of fish and other marine plants and animals because of their relative structural permanence and structural complexity. Glacial moraines create a unique bottom topography that allows for habitat diversity and complexity, which allows for species diversity in these areas and creates environments that exhibit some of the highest biodiversity within the entire Ocean SAMP area. The Council also recognizes that because glacial moraines contain valuable habitats for fish and other marine life, they are also important to commercial and recreational fishermen. Accordingly, the Council shall designate glacial moraines as identified in Figure 8.49 and Figure 8.50 as Areas of Particular Concern.

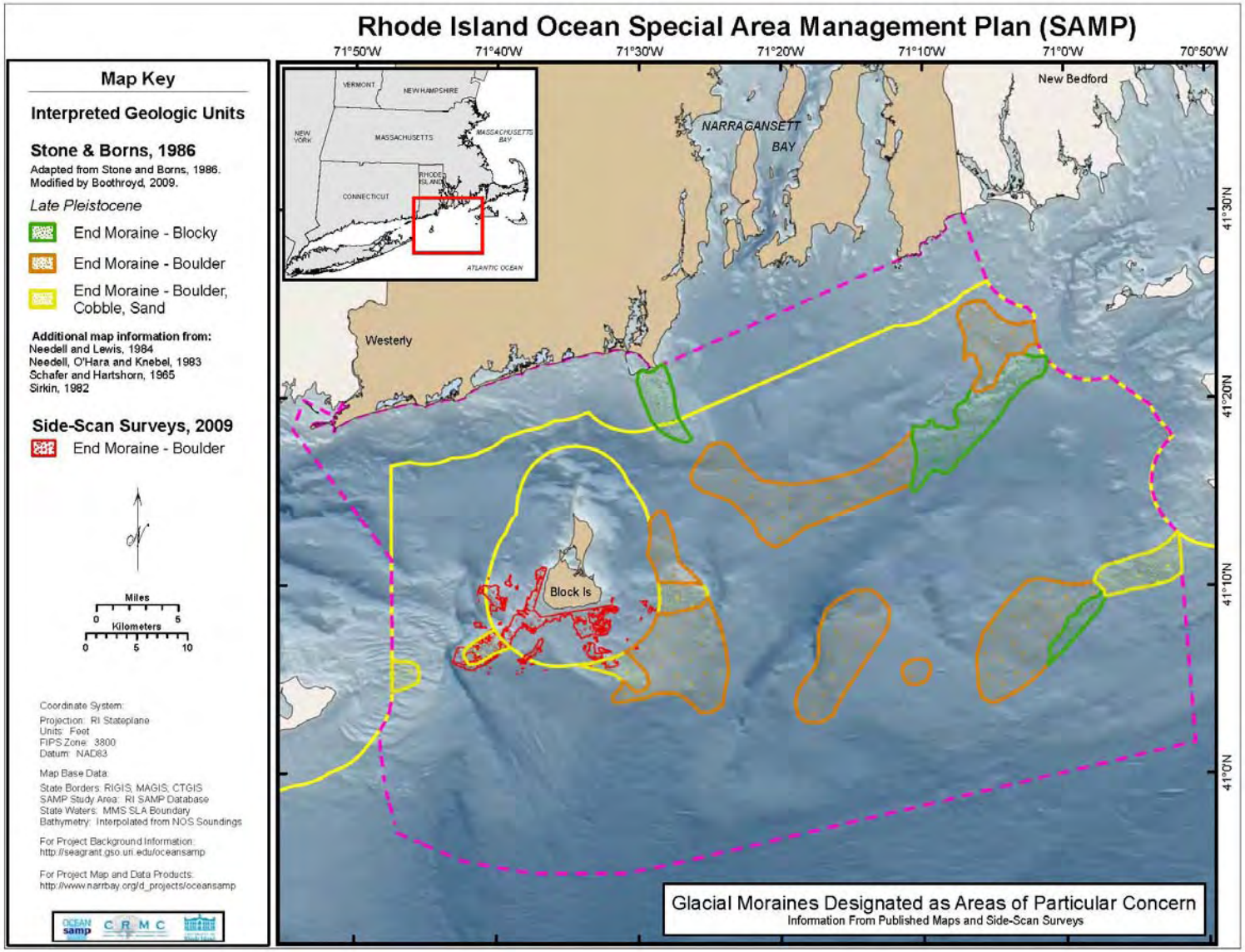


Figure 8.49. Glacial moraines designated as Areas of Particular Concern in state waters.

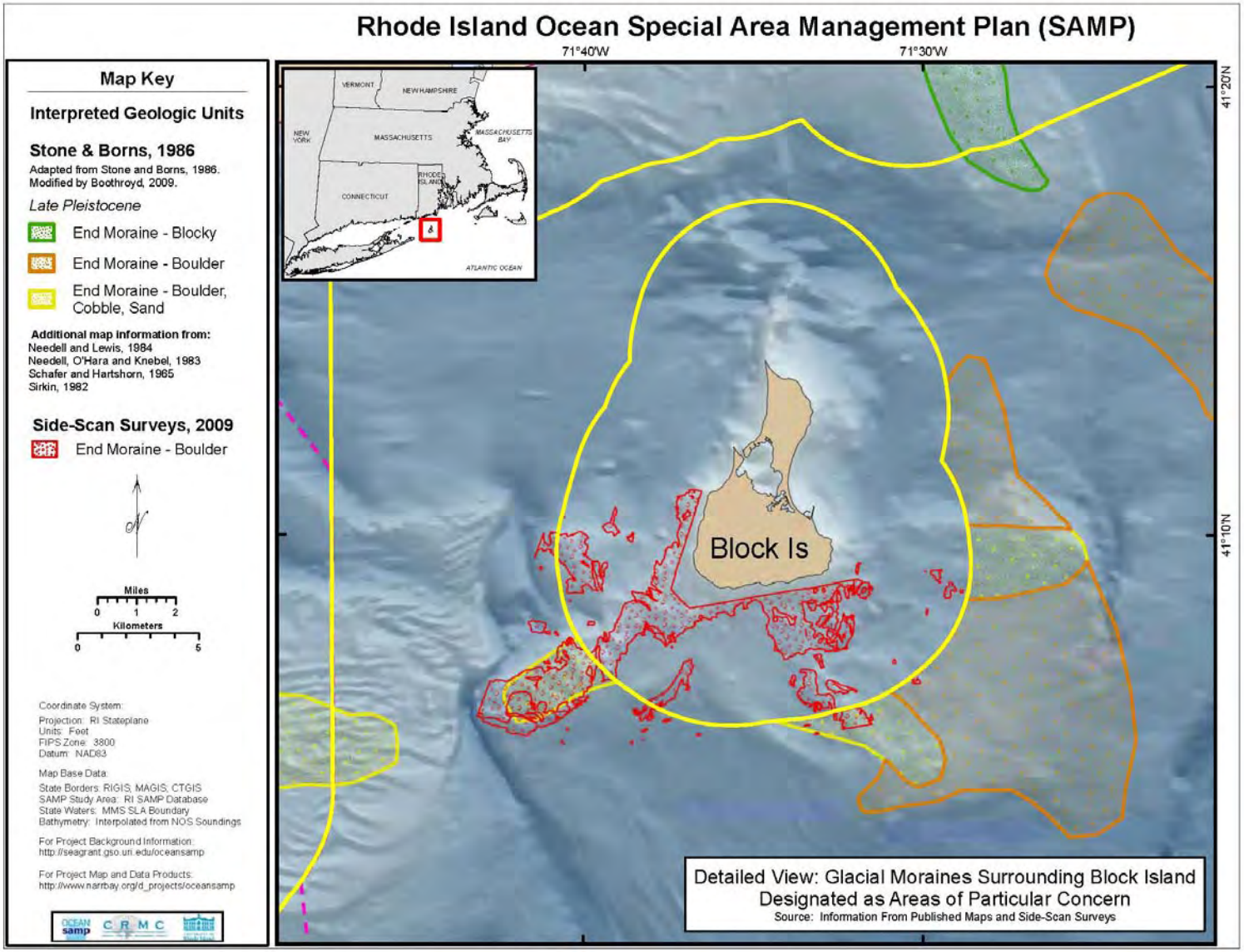


Figure 8.50. Detailed view: Glacial moraines surrounding Block Island designated as Areas of Particular Concern in state waters.

iv. Navigation, Military, and Infrastructure areas including: designated shipping lanes, precautionary areas, recommended vessel routes, ferry routes, dredge disposal sites, military testing areas, unexploded ordnance, pilot boarding areas, anchorages, and a coastal buffer of 1 km as depicted in Figure 8.51 are designated as Areas of Particular Concern. The Council recognizes the importance of these areas to marine transportation, navigation and other activities in the Ocean SAMP area.

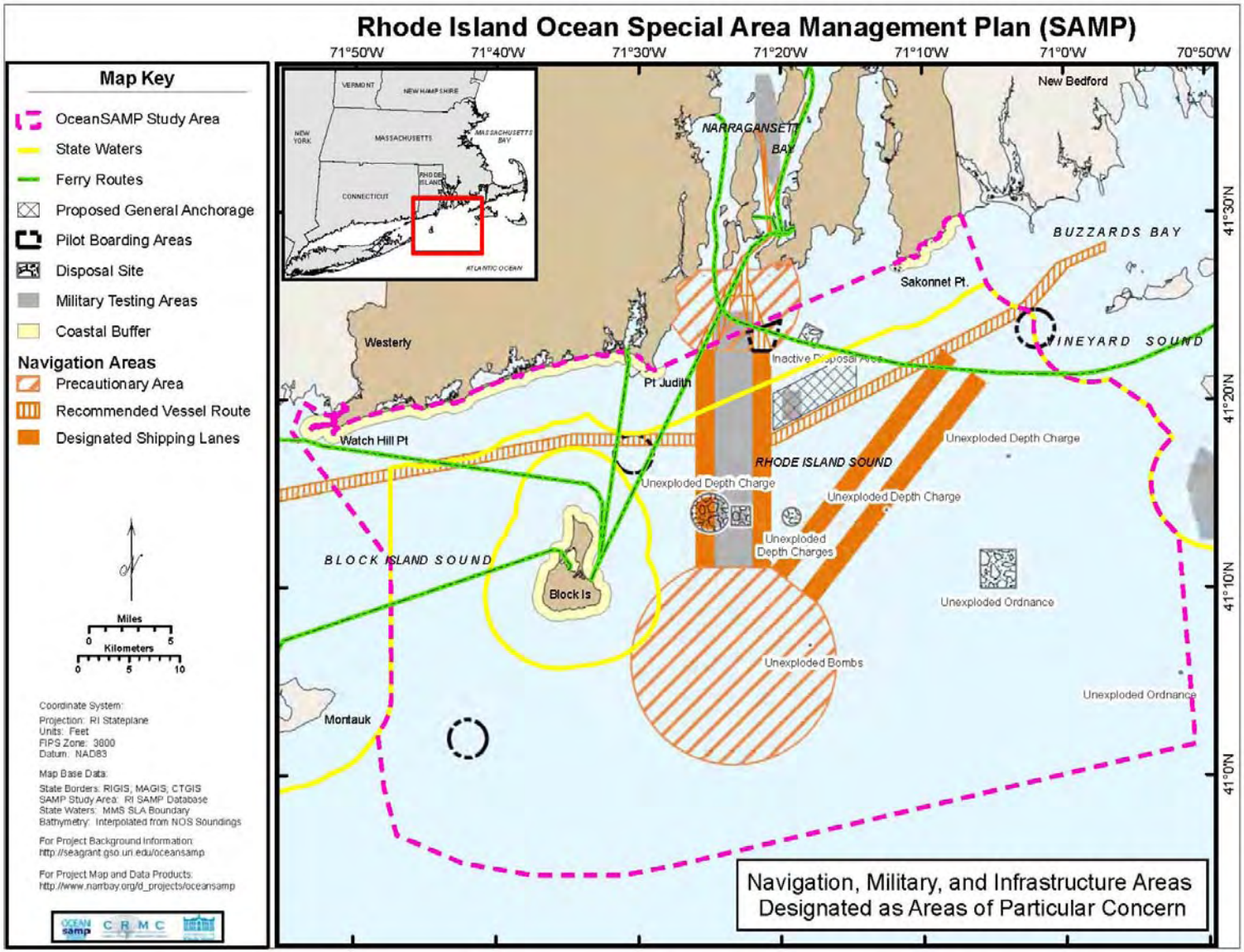


Figure 8.51. Navigation, military, and infrastructure areas designated as Areas of Particular Concern in state waters.

v. Areas of high fishing activity as identified during the pre-application process by the Fishermen's Advisory Board, as defined in section 860.2.1.6, may be designated by the Council as Areas of Particular Concern.

vi. Several heavily-used recreational boating and sailboat racing areas, as shown in Figure 8.52, are designated as Areas of Particular Concern. The Council recognizes that organized recreational boating and sailboat racing activities are concentrated in these particular areas, which are therefore important to sustaining Rhode Island's recreation and tourism economy.

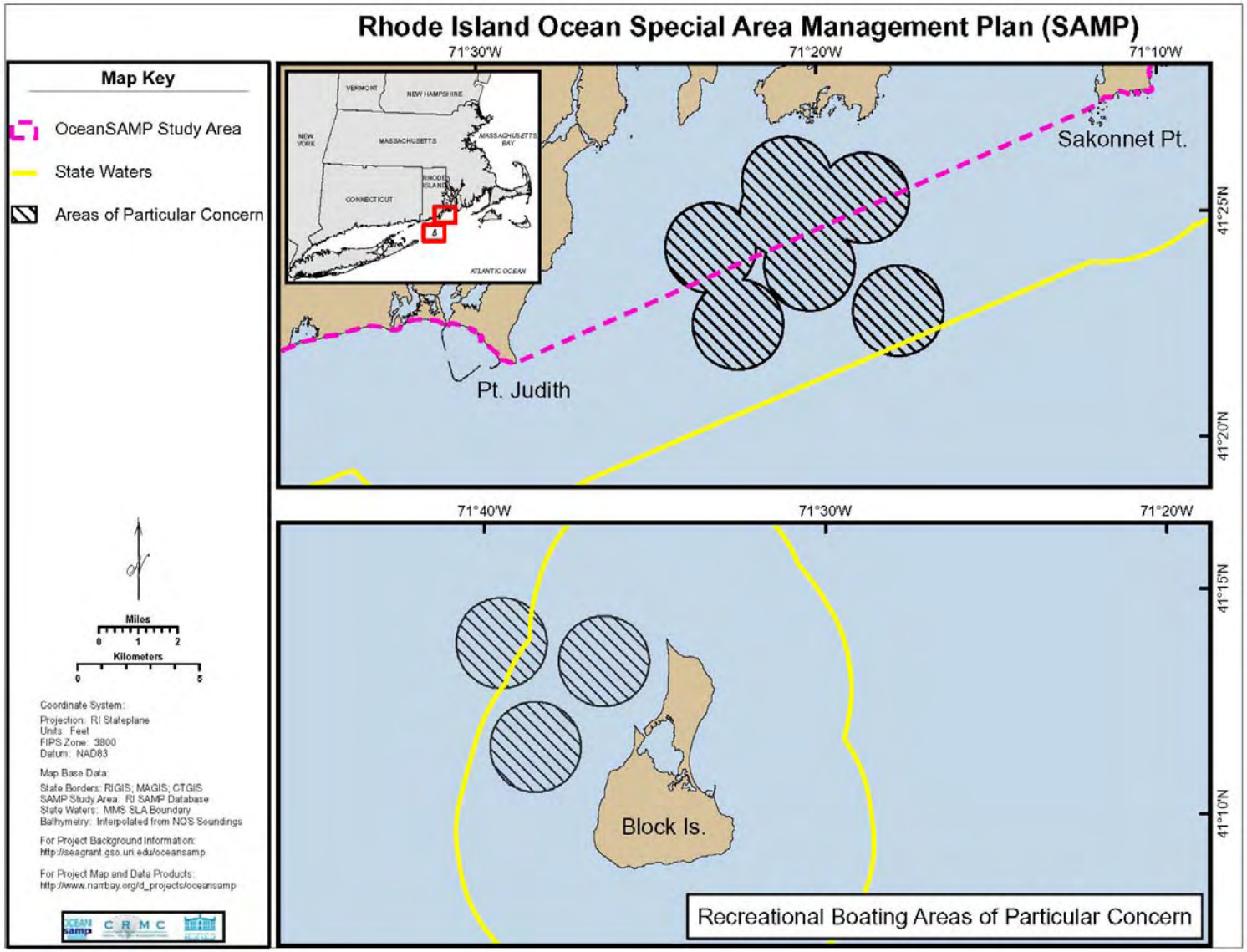


Figure 8.52. Recreational boating areas designated as Areas of Particular Concern in state waters.

vii. Naval Fleet Submarine Transit Lane, as described in Chapter 7, Marine Transportation, Navigation, and Infrastructure section 720.7, are designated as Areas of Particular Concern.
viii. Other Areas of Particular Concern may be identified during the pre-application review by state and federal agencies as areas of importance.

4. Developers proposing projects for within the Renewable Energy Zone as described in section 860.2.2 shall adhere to the requirements outlined in 860.2.2.2 regarding Areas of Particular Concern in state waters, including any Areas of Particular Concern that overlap the Renewable Energy Zone (see Figure 8.53).

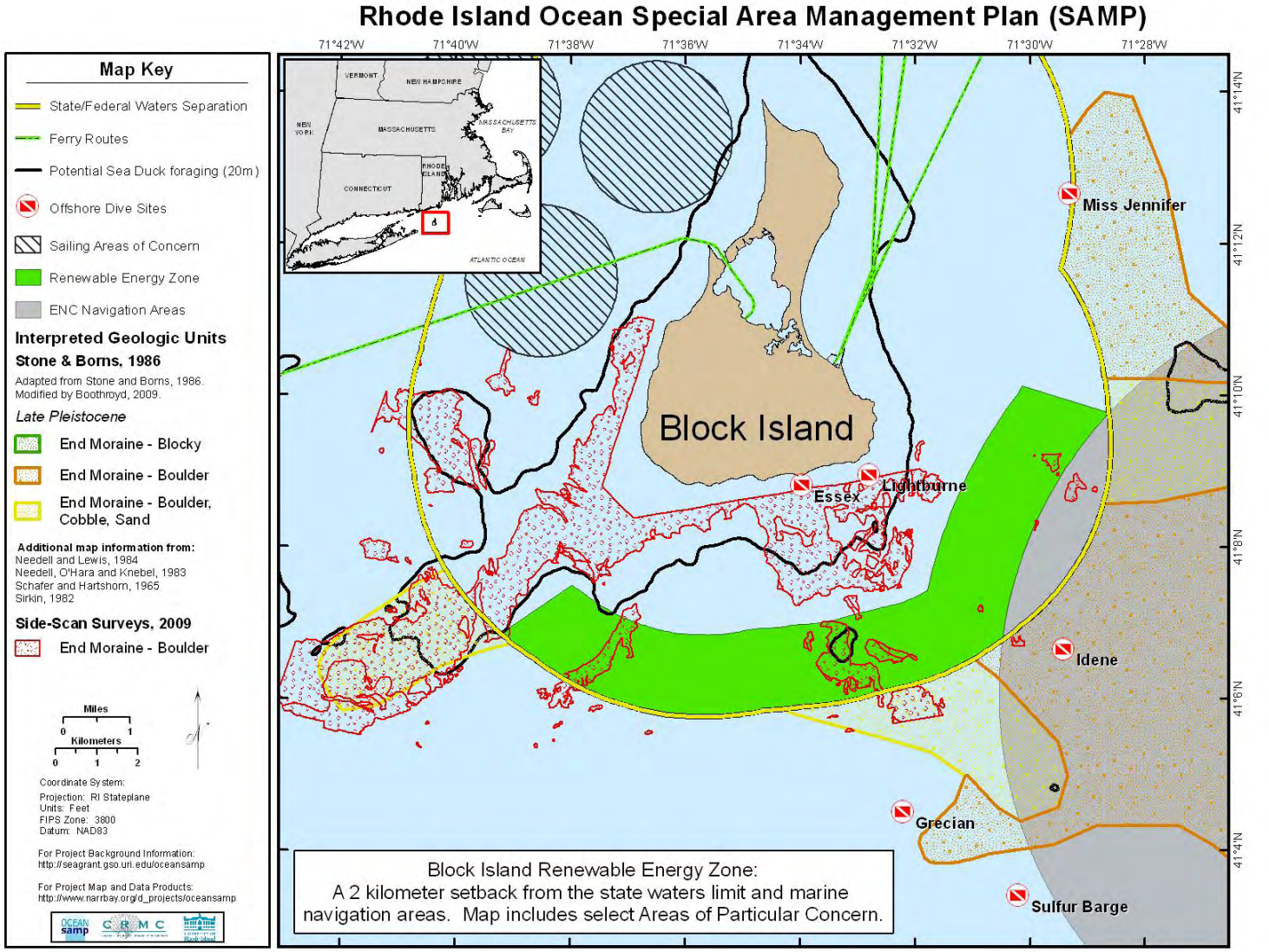


Figure 8.53. Areas of Particular Concern overlapping the Renewable Energy Zone in state waters.

860.2.3 Prohibitions and Areas Designated for Preservation

1. Areas Designated for Preservation are designated in the Ocean SAMP area in state waters for the purpose of preserving them for their ecological value.[65] Areas Designated for Preservation were identified by reviewing habitat and other ecological data and findings that have resulted from the Ocean SAMP process. Areas Designated for Preservation are afforded additional protection than Areas of Particular Concern (see section 860.2.2) because of scientific evidence indicating that Large-Scale Offshore Development in these areas may result in significant habitat loss. The areas listed in Section 860.2.3.1 are designated as Areas Designated for Preservation. The Council shall prohibit any Large-Scale Offshore Development, mining and extraction of minerals, or other development that has been found to be in conflict with the intent and purpose of an Area Designated for Preservation. Underwater cables are exempt from this prohibition. Areas designated for preservation include:

    i. Ocean SAMP sea duck foraging habitat in water depths less than or equal to 20 meters [65.6 feet] (as shown in Figure 8.54) is designated as an Area Designated for Preservation due to their ecological value and the significant role these foraging habitats play to avian species, and existing evidence suggesting the potential for permanent habitat loss as a result of offshore wind energy development.The current research regarding sea duck foraging areas indicates that this habitat is depth limited and generally contained within the 20 meter depth contour. It is likely there are discreet areas within this region that are prime feeding areas, however at present there is no long-term data set that would allow this determination. Thus, the entire area within the 20 meter contour is being protected as an Area Designated for Preservation until further research allows the Council and other agencies to make a more refined determination.

[65] Areas Designated for Preservation are identified in the federal Coastal Zone Management Act and associated CFRs; see 15 CFR 923.22.

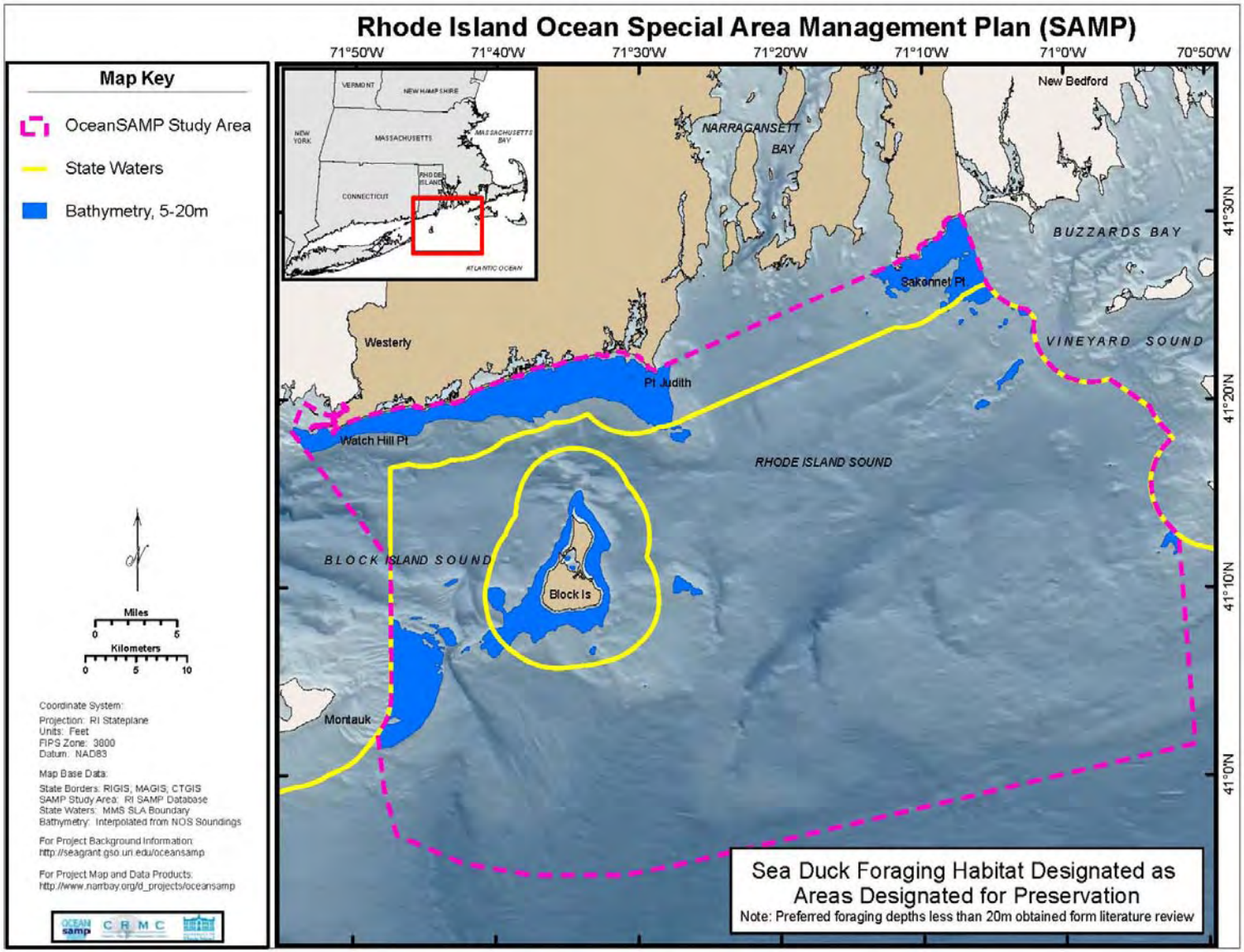


Figure 8.54. Sea duck foraging habitat designated as Areas Designated for Preservation in state waters.

2. The mining and extraction of minerals, including sand and gravel, from tidal waters and salt ponds is prohibited. This prohibition does not apply to dredging for navigation purposes, channel maintenance, habitat restoration, or beach replenishment for public purposes.

3. The Council shall prohibit any Offshore Development in areas identified as Critical Habitat under the Endangered Species Act.

4. Dredged material disposal, as defined in RICRMP Section 300.9 and subject to the regulations of RICRMP Section 300.9, is further limited in the Ocean SAMP area by the prohibition of dredged material disposal in the following Areas of Particular Concern as defined in section 860.2.2: historic shipwrecks, archaeological, or historic sites; offshore dive sites; navigation, military, and infrastructure areas; and moraines. Beneficial reuse may be allowed in Areas Designated for Preservation, whereas all other dredged material disposal is prohibited in those areas. All disposal of dredged material will be conducted in accordance with the U.S. EPA and U.S. Army Corps of Engineers' manual, *Evaluation of Dredged Material Proposed for Ocean Disposal*.

860.2.4 Other Areas

1. Large-scale projects or other development which is found to be a hazard to commercial navigation shall avoid areas of high intensity commercial marine traffic in state waters. Avoidance shall be the primary goal of these areas. Areas of High Intensity Commercial Marine Traffic are defined as having 50 or more vessel counts within a 1 km by 1 km grid, as in Figure 8.55.

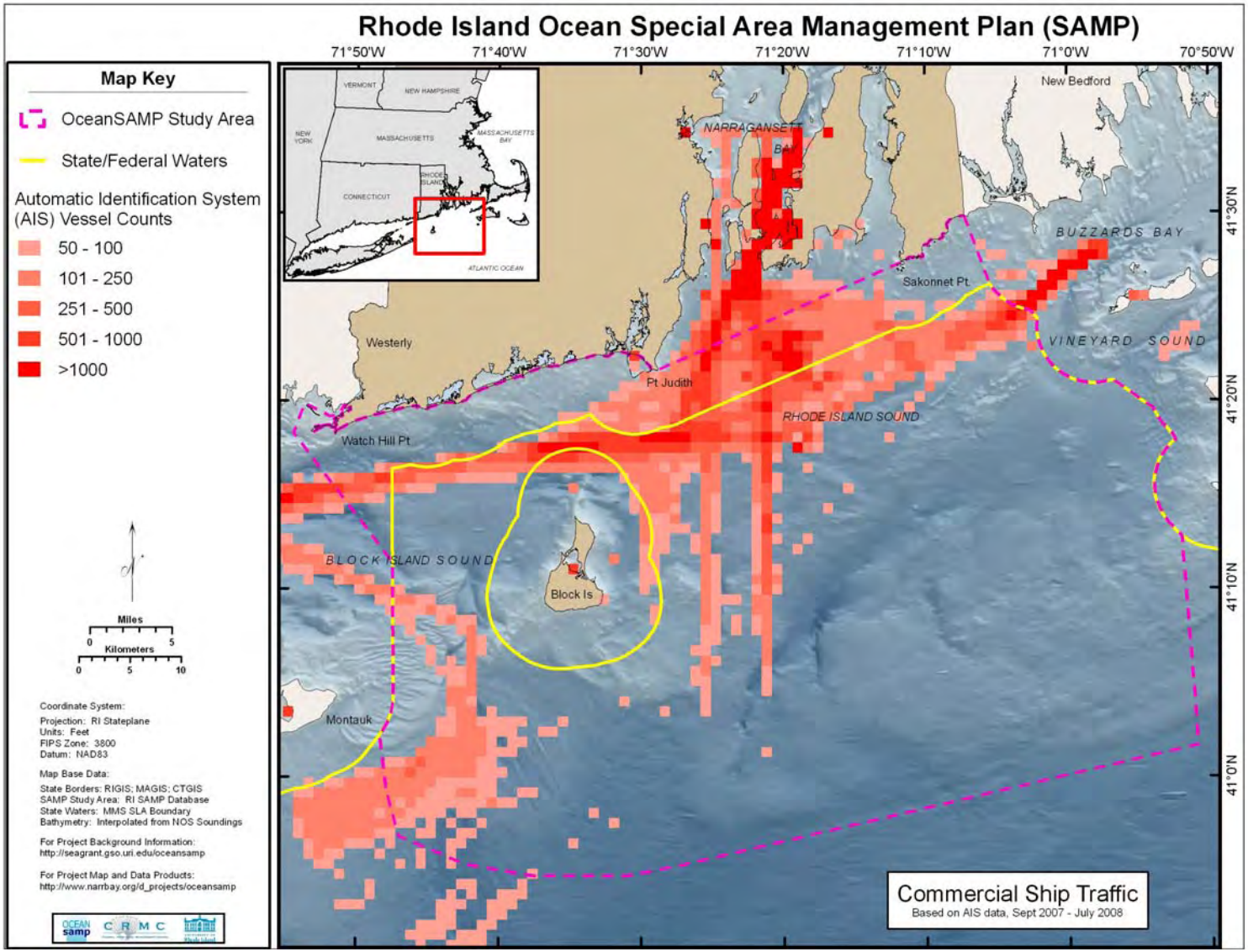


Figure 8.55. Areas of high intensity commercial ship traffic in state waters.

860.2.5 Application Requirements

1. For the purposes of this document, the phrase "'necessary data and information'" shall refer to the necessary data and information required for federal consistency reviews for purposes of starting the Coastal Zone Management Act (CZMA) 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930, subpart E, pursuant to 15 C.F.R. § 930.58(a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project. It should be noted that other federal and state agencies may require other types of data or information as part of their review processes.

2. For the purposes of this document, the following terms shall be defined as:

   i. A **Site Assessment Plan** (SAP**)** is defined as a pre-application plan that describes the activities and studies the applicant plans to perform for the characterization of the project site**.**
   ii. A **Construction and Operations Plan** (COP) is defined as a plan that describes the applicant's construction, operations, and conceptual decommissioning plans for a proposed facility, including the applicant's project easement area.
   iii. A **Certified Verification Agent** (CVA) is defined as an independent third-party agent that shall use good engineering judgment and practices in conducting an independent assessment of the design, fabrication and installation of the facility. The CVA shall have licensed and qualified Professional Engineers on staff.

3. Prior to construction, the following sections shall be considered necessary data and information and shall be required by the Council:

   i. Site Assessment Plan – A SAP is a pre-application plan that describes the activities and studies (e.g. installation of meteorological towers, meteorological buoys) the applicant plans to perform for the characterization of the project site**. Within the Renewable Energy Zone, if an applicant applies within 2 years of CRMC's adoption of the Ocean Special Area Management Plan they may elect to combine the SAP and Construction and Operation Plan (COP) phase, but only within the renewable energy zone and only for 2 years after the adoption date. If an applicant elects to combine these two phases all requirements shall still be met.** The SAP shall describe how the applicant shall conduct the resource assessment (e.g., meteorological and oceanographic data collection) or technology testing activities. The applicant shall receive the approval of the SAP by the Council. For projects within Type 4E waters (depicted in Figure 8.47), pre-construction data requirements may incorporate data generated by the Ocean SAMP provided the data was collected within 2 years of the date of application, or where the Ocean SAMP data is determined to be current enough to meet the requirements of the Council in coordination with the Joint Agency Working

Group. The applicant shall reference information and data discussed in the Ocean SAMP (including appendices and technical reports) in their SAP.

a. The applicant's SAP shall include data from:
    1. Physical characterization surveys (e.g., geological and geophysical surveys or hazards surveys); and
    2. Baseline environmental surveys (e.g., biological or archaeological surveys).
b. The SAP shall demonstrate that the applicant has planned and is prepared to conduct the proposed site assessment activities in a manner that conforms to the applicant's responsibilities listed above in §860.2.1.5 and:
    1. Conforms to all applicable laws, regulations;
    2. Is safe;
    3. Does not unreasonably interfere with other existing uses of the state waters,
    4. Does not cause undue harm or damage to natural resources; life (including human and wildlife);the marine, coastal, or human environment; or sites, structures, or direct harm to objects of historical or archaeological significance;
    5. Uses best available and safest technology;
    6. Uses best management practices; and
    7. Uses properly trained personnel.
c. The applicant shall also demonstrate that the site assessment activities shall collect the necessary data and information required for the applicant's COP, as described below in Section 860.2.5.3(ii).
d. The applicant's SAP shall include the information described in Table 8.21, as applicable.

Table 8.21. Contents of a Site Assessment Plan.

Project information:	**Including:**
(1) Contact information	The name, address, e-mail address, and phone number of an authorized representative.
(2) The site assessment or technology testing concept.	A discussion of the objectives; description of the proposed activities, including the technology to be used; and proposed schedule from start to completion.
(4) Stipulations and compliance.	A description of the measures the applicant took, or shall take, to satisfy the conditions of any permit stipulations related to the applicant's proposed activities.
(5) A location.	The surface location and water depth for all proposed and existing structures, facilities, and appurtenances located both offshore and onshore.
(6) General structural and project design, fabrication, and installation.	Information for each type of facility associated with the applicant's project.
(7) Deployment activities.	A description of the safety, prevention, and environmental protection features or measures that the

	applicant will use.
(8) The applicant's proposed measures for avoiding, minimizing, reducing, eliminating, and monitoring environmental impacts.	A description of the measures the applicant shall take to avoid or minimize adverse effects and any potential incidental take, before the applicant conducts activities on the project site, and how the applicant shall mitigate environmental impacts from proposed activities, including a description of the measures to be used.
(9) Reference information.	Any document or published source that the applicant cites as part of the plan. The applicant shall reference information and data discussed in the Ocean SAMP (including appendices and technical reports), other plans referenced in the Ocean SAMP, other plans previously submitted by the applicant or that are otherwise readily available to the Council.
(10) Decommissioning and site clearance procedures.	A discussion of methodologies.
(11) Air quality information.	Information required for the Clean Air Act (42 U.S.C. 7409) and implementing regulations
(12) A listing of all Federal, State, and local authorizations or approvals required to conduct site assessment activities on the project site.	A statement indicating whether such authorization or approval has been applied for or obtained.
(13) A list of agencies or persons with whom the applicant has communicated, or will communicate, regarding potential impacts associated with the proposed activities.	Contact information and issues discussed.
(14) Financial assurance information.	Statements attesting that the activities and facilities proposed in the applicant's SAP are or shall be covered by an appropriate performance bond or other Council approved security.
(15) Other information.	Additional information as requested by the Council in coordination with the Joint Agency Working Group.

e. The applicant's SAP shall provide the results of geophysical and geological surveys, hazards surveys, archaeological surveys (as required by the Council in coordination with the Joint Agency Working Group), and biological surveys outlined in Table 8.22 (with the supporting data) in the applicant's SAP:

Table 8.22. Necessary data and information to be provided in the Site Assessment Plan.

Information.	**Report contents.**	**Including.**
(1) Geotechnical.	Reports from the geotechnical survey with supporting data.	A description of all relevant seabed and engineering information to allow for the design of the foundation of that facility. The applicant shall provide

		information to depths below which the underlying conditions shall not influence the integrity or performance of the structure. This could include a series of sampling locations (borings and *in situ* tests) as well as laboratory testing of soil samples.
(2) Shallow hazards.	The results from the shallow hazards survey with supporting data, if required.	A description of information sufficient to determine the presence of the following features and their likely effects on the proposed facility, including: (i) Shallow faults; (ii) Gas seeps or shallow gas; (iii) Slump blocks or slump sediments; (iv) Hydrates; and (v) Ice scour of seabed sediments.
(3) Archaeological resources.	The results from the archaeological survey with supporting data, if required.	(i) A description of the results and data from the archaeological survey; (ii) A description of the historic and prehistoric archaeological resources, as required by the National Historic Preservation Act and Antiquities Act (16 U.S.C. 470 et. seq.), as amended, the Rhode Island Historical Preservation Act and Antiquities Act and Sections 220 and 330 of the RICRMP, as applicable; (iii) For more information on the archeological surveys and assessments required see Section 440.
(4) Geological survey.	The results from the geological survey with supporting data.	A report that describes the results of a geological survey that includes descriptions of: (i) Seismic activity at the proposed site; (ii) Fault zones; (iii) The possibility and effects of seabed subsidence; and (iv) The extent and geometry of faulting attenuation effects of geologic conditions near the site.
(5) Biological survey.	The results from the biological survey with supporting data.	A description of the results of a biological survey, including descriptions of the presence of live bottoms; hard bottoms; topographic features; and surveys of other marine resources such as fish populations (including migratory populations) not

		targeted by commercial or recreational fishing, marine mammals, sea turtles, and sea birds.
(6) Fish and Fisheries Survey	The results from the fish and fisheries survey with supporting data.	A report that describes the results of: (i) A biological assessment of commercially and recreationally targeted species. This assessment shall assess the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site. (ii) An assessment of commercial and recreational fisheries effort, landings, and landings value. Assessment shall focus on the proposed project area and alternatives across all four seasons of the year must. Assessment may use existing fisheries monitoring data but shall be supplemented by interviews with commercial and recreational fishermen. (iii) For more information on these assessments see Section 860.2.9.

f. The applicant shall submit a SAP that describes those resources, conditions, and activities listed in Table 8.23 that could be affected by the applicant's proposed activities, or that could affect the activities proposed in the applicant's SAP, including but not limited to:

Table 8.23. Resource data and uses that shall be described in the Site Assessment Plan.

Type of information	**Including:**
(1) Hazard information.	Meteorology, oceanography, sediment transport, geology, and shallow geological or manmade hazards.
(2) Water quality.	Turbidity and total suspended solids from construction.

(3) Biological resources.	Benthic communities, marine mammals, sea turtles, coastal and marine birds, fish and shellfish (not targeted by commercial or recreational fishing), plankton, seagrasses, and plant life.
(4) Threatened or endangered species.	As required by the Endangered Species Act (ESA) of 1973 (16. U.S.C. 1531 et. seq.).
(5) Sensitive biological resources or habitats.	Essential fish habitat, refuges, preserves, Areas of Particular Concern, Areas Designated for Preservation, sanctuaries, rookeries, hard bottom habitat, and calving grounds; barrier islands, beaches, dunes, and wetlands.
(6) Archaeological and visual resources.	As required by the National Historic Preservation Act and Antiquities Act (16 U.S.C. 470 et. seq.), as amended, the Rhode Island Historical Preservation Act and Antiquities Act and Sections 220 and 330 of the RICRMP, as applicable.
(7) Social and economic resources.	Employment, existing offshore and coastal infrastructure (including major sources of supplies, services, energy, and water), land use, subsistence resources and harvest practices, recreation, minority and lower income groups, and viewshed.
(8) Fisheries Resources and Uses	Commercially and recreationally targeted species, recreational and commercial fishing (including fishing seasons, location, and type), commercial and recreational fishing activities, effort, landings, and landings value.
(8) Coastal and marine uses.	Military activities, vessel traffic, and energy and non-energy mineral exploration or development.

g. The Council shall review the applicant's SAP in conjunction with the Joint Agency Working Group to determine if it contains the information necessary to conduct technical and environmental reviews and shall notify the applicant if the SAP lacks any necessary information.
h. As appropriate, the Council shall coordinate and consult with relevant Federal and State agencies, and affected Indian tribes.
i. Any Large-Scale Offshore Development, as defined above in section 860.2.1.1, shall require a pre-application meeting between the FAB, the applicant, and the Council staff to discuss potential fishery-related impacts, such as, but not limited to, project location, construction schedules, alternative locations, and project minimization. During the pre-application meeting for a Large-Scale Offshore Development, the FAB can also identify areas of high

fishing activity or habitat edges to be considered during the review process.

j. During the review process, the Council may request additional information if it is determined that the information provided is not sufficient to complete the review and approval process.

k. Once the SAP is approved by the the Council the applicant may begin conducting the activities approved in the SAP.

l. Reporting requirements of the applicant under an approved SAP:
    1. Following the approval of a SAP, the applicant shall notify the Council in writing within 30 days of completing installation activities of any temporary measuring devices approved by the Council.
    2. The applicant shall prepare and submit to the Council a report semi-annually. The first report shall be due 6 months after work on the SAP begins; subsequent reports shall be submitted every 6 month thereafter until the SAP period is complete. The report shall summarize the applicant's site assessment activities and the results of those activities.
    3. The Council reserves the right to require additional environmental and technical studies, if it is found there is a critical area lacking or missing information.

m. The applicant shall seek the Council's approval before conducting any activities not described in the approved SAP, describing in detail the type of activities the applicant proposes to conduct and the rationale for these activities. The Council shall determine whether the activities proposed are authorized by the applicant's existing SAP or require a revision to the applicant's SAP. The Council may request additional information from the applicant, if necessary, to make this determination.

n. The Council shall periodically review the activities conducted under an approved SAP. The frequency and extent of the review shall be based on the significance of any changes in available information and on onshore or offshore conditions affecting, or affected by, the activities conducted under the applicant's SAP. If the review indicates that the SAP should be revised to meet the requirements of this part, the Council shall require the applicant to submit the needed revisions.

o. The applicant may keep approved facilities (such as meteorological towers) installed during the SAP period in place during the time that the Council reviews the applicant's COP for approval. Note: Structures in state waters shall require separate authorizations outside the SAP process.

p. The applicant is not required to initiate the decommissioning process for facilities that are authorized to remain in place under the applicant's approved COP. If, following the technical and

environmental review of the applicant's submitted COP, the Council determines that such facilities may not remain in place the applicant shall initiate the decommissioning process.

ii. Construction and Operations Plan (COP) - The COP describes the applicant's construction, operations, and conceptual decommissioning plans for the proposed facility, including the applicant's project easement area.

a. The applicant's COP shall describe all planned facilities that the applicant shall construct and use for the applicant's project, including onshore and support facilities and all anticipated project easements.
b. The applicant's COP shall describe all proposed activities including the applicant's proposed construction activities, commercial operations, and conceptual decommissioning plans for all planned facilities, including onshore and support facilities.
c. The applicant shall receive the Council's approval of the COP before the applicant can begin any of the approved activities on the applicant's project site, lease or easement.
d. The COP shall demonstrate that the applicant has planned and is prepared to conduct the proposed activities in a manner that:
    1. Conforms to all applicable laws, implementing regulations.
    2. Is safe;
    3. Does not unreasonably interfere with other uses of state waters;
    4. Does not cause undue harm or damage to natural resources; life (including human and wildlife); the marine, coastal, or human environment; or direct impact to sites, structures, or objects of historical or archaeological significance;
    5. Uses best available and safest technology;
    6. Uses best management practices; and
    7. Uses properly trained personnel.

e. The applicant's COP shall include the following project-specific information, as applicable.

Table 8.24. Contents of the Construction and Operations Plan.

Project information:	**Including:**
(1) Contact information	The name, address, e-mail address, and phone number of an authorized representative.
(2) Designation of operator, if applicable.	
(3) The construction and operation concept	A discussion of the objectives, description of the proposed activities, tentative schedule from start to completion, and plans for phased development.
(5) A location.	The surface location and water depth for all proposed and existing structures, facilities, and appurtenances located both

	offshore and onshore, including all anchor/mooring data.
(6) General structural and project design, fabrication, and installation.	Information for each type of structure associated with the project and, unless the Council provides otherwise, how the applicant shall use a CVA to review and verify each stage of the project.
(7) All cables and pipelines, including cables on project easements.	Location, design and installation methods, testing, maintenance, repair, safety devices, exterior corrosion protection, inspections, and decommissioning. The applicant shall prior to construction also include location of all cable crossings and appropriate clearance from the owners of existing cables.
(8) A description of the deployment activities.	Safety, prevention, and environmental protection features or measures that the applicant shall use.
(9) A list of solid and liquid wastes generated.	Disposal methods and locations.
(10) A list of chemical products used (if stored volume exceeds Environmental Protection Agency (EPA) Reportable Quantities).	A list of chemical products used; the volume stored on location; their treatment, discharge, or disposal methods used; and the name and location of the onshore waste receiving, treatment, and/or disposal facility. A description of how these products would be brought onsite, the number of transfers that may take place, and the quantity that shall be transferred each time.
(12) Decommissioning and site clearance procedures.	A discussion of general concepts and methodologies.
(13) A list of all Federal, State, and local authorizations, approvals, or permits that are required to conduct the proposed activities, including commercial operations.	A list of all Federal, State, and local authorizations, approvals, or permits that are required to conduct the proposed activities, including commercial operations. In addition, a statement indicating whether the applicant hass applied for or obtained such authorizations, approvals, or permits.
(14) The applicant's proposed measures for avoiding, minimizing, reducing, eliminating, and monitoring environmental impacts.	A description of the measures the applicant shall take to avoid or minimize adverse effects and any potential incidental take before conducting activities on the project site, and how the applicant shall minimize environmental impacts from proposed activities, including a description of the measures.
(15) Information the applicant incorporates by reference.	A list of the documents referenced and the actual document if requested.
(16) A list of agencies and persons with whom the applicant has communicated, or with whom the applicant shall communicate, regarding potential impacts associated with the proposed activities.	Contact information, issues discussed and the actual document if requested
(17) Reference.	Contact information.
(18) Financial assurance.	Statements attesting that the activities and facilities proposed in the applicant's COP are or shall be covered by an appropriate bond or security, as required by Section 860.2.7.2.

(19) CVA nominations	CVA nominations for reports required.
(20) Construction schedule.	A reasonable schedule of construction activity showing significant milestones leading to the commencement of commercial operations.
(21) Air quality information.	Information required for the Clean Air Act (42 U.S.C. 7409) and implementing regulations.
(22) Other information.	Additional information as required by the Council.

f. The applicant's COP shall include the following information and surveys for the proposed site(s) of the applicant's facility or facilities:

Table 8.25. Necessary data and information to be provided in the Construction and Operations Plan.

Information:	**Report contents:**	**Including:**
(1) Shallow hazards.	The results of the shallow hazards survey with supporting data, if required.	Information sufficient to determine the presence of the following features and their likely effects on the proposed facility, including: (i) Shallow faults; (ii) Gas seeps or shallow gas; (iii) Slump blocks or slump sediments; (iv) Hydrates; or (v) Ice scour of seabed sediments.
(2) Geological survey relevant to the siting and design of the facility.	The results of the geological survey with supporting data.	Assessment of: (i) Seismic activity at the proposed site; (ii) Fault zones; (iii) The possibility and effects of seabed subsidence; and (iv) The extent and geometry of faulting attenuation effects of geologic conditions near the site.
(3) Biological Survey	The results of the biological survey with supporting data.	A description of the results of biological surveys used to determine the presence of live bottoms, hard bottoms, and topographic features, and surveys of other marine resources such as fish populations (including migratory populations) not targeted by commercial or recreational fishing, marine mammals, sea turtles, and sea birds.
(4) Fish and Fisheries Survey	The results from the fish and fisheries survey with supporting data.	A report that describes the results of: (i) A biological assessment of commercially and recreationally targeted species. This assessment shall assess the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site. (ii) An assessment of commercial and

		recreational fisheries effort, landings, and landings value. Assessment shall focus on the proposed project area and alternatives across all four seasons of the year must. Assessment may use existing fisheries monitoring data but shall be supplemented by interviews with commercial and recreational fishermen. (iii) For more information on these assessments see Section 860.2.9.
(5) Geotechnical survey.	The results of any sediment testing program with supporting data, the various field and laboratory tests employed, and the applicability of these methods as they pertain to the quality of the samples, the type of sediment, and the anticipated design application. The applicant shall explain how the engineering properties of each sediment stratum affect the design of the facility. In the explanation, the applicant shall describe the uncertainties inherent in the overall testing program, and the reliability and applicability of each method.	(i) The results of a testing program used to investigate the stratigraphic and engineering properties of the sediment that may affect the foundations or anchoring systems of the proposed facility. (ii) The results of adequate *in situ* testing, boring, and sampling at each foundation location, to examine all important sediment and rock strata to determine its strength classification, deformation properties, and dynamic characteristics. A minimum of one boring shall be taken per turbine planned, and the boring shall be taken within 50 feet of the final location of the turbine. (iii) The results of a minimum of one deep boring (with soil sampling and testing) at each edge of the project area and within the project area as needed to determine the vertical and lateral variation in seabed conditions and to provide the relevant geotechnical data required for design.
(6) Archaeological and Visual resources, if required.	The results of the archaeological resource survey with supporting data.	A description of the historic and prehistoric archaeological resources, as required by the National Historic Preservation Act and Antiquities Act (16 U.S.C. 470 et. seq.), as amended, the Rhode Island Historical Preservation Act and Antiquities Act and Sections 220 and 330 of the RICRMP, as applicable.
(7) Overall site investigation.	An overall site investigation report for the proposed facility that integrates the findings of the shallow hazards surveys and	An analysis of the potential for: (i) Scouring of the seabed; (ii) Hydraulic instability; (iii) The occurrence of sand waves;

	geologic surveys, and, if required, the subsurface surveys with supporting data.	(iv) Instability of slopes at the facility location; (v) Liquefaction, or possible reduction of sediment strength due to increased pore pressures; (vi) Cyclic loading; (vii) Lateral loading; (viii) Dynamic loading; (ix) Settlements and displacements; (x) Plastic deformation and formation collapse mechanisms; and (xi) Sediment reactions on the facility foundations or anchoring systems.

g. The applicant's COP shall describe those resources, conditions, and activities listed in Table 8.26 that could be affected by the applicant's proposed activities, or that could affect the activities proposed in the applicant's COP, including:

Table 8.26. Resources, conditions and activities that shall be described in the Construction and Operations Plan.

Type of Information:	**Including:**
(1) Hazard information and sea level rise.	Meteorology, oceanography, sediment transport, geology, and shallow geological or manmade hazards. Provide an analysis of historic and project (medium and high) rates of sea level rise and shall at minimum assess the risks for each alternative on public safety and environmental impacts resulting from the project (see Section 350.2 for more information).
(2) Water qualityand circulation	Turbidity and total suspended solids from construction. Modeling of circulation and stratification to ensure that water flow patterns and velocities are not altered in ways that would lead to major ecosystem change.
(3) Biological resources.	Benthic communities, marine mammals, sea turtles, coastal and marine birds, fish and shellfish not targeted by commercial or recreational fishing, plankton, seagrasses, and plant life.
(4) Threatened or endangered species.	As defined by the ESA (16 U.S.C. 1531 et. seq.)
(5) Sensitive biological resources or habitats.	Essential fish habitat, refuges, preserves, Areas of Particular Concern, sanctuaries, rookeries, hard bottom habitat, barrier islands, beaches, dunes, and wetlands.

(6) Fisheries Resources and Uses	Commercially and recreationally targeted species, recreational and commercial fishing (including fishing seasons, location, and type), commercial and recreational fishing activities, effort, landings, and landings value.
(6) Archaeological resources.	As required by the NHPA (16 U.S.C. 470 et. seq.), as amended.
(7) Social and economic resources.	As determined by the Council in coordination with the Joint Agency Working Group.
(8) Coastal and marine uses.	Military activities, vessel traffic, and energy and non-energy mineral exploration or development.

h. The applicant shall submit an oil spill response plan per the Oil Pollution Act of 1990, 33 USC 2701 *et seq*.
i. The applicant shall submit the applicant's Safety Management System, the contents of which are described below:
    1. How the applicant plans to ensure the safety of personnel or anyone on or near the facility;
    2. Remote monitoring, control and shut down capabilities;
    3. Emergency response procedures;
    4. Fire suppression equipment (if needed);
    5. How and when the safety management system shall be implemented and tested; and
    6. How the applicant shall ensure personnel who operate the facility are properly trained.
j. The Council shall review the applicant's COP and the information provided to determine if it contains all the required information necessary to conduct the project's technical and environmental reviews. The Council shall notify the applicant if the applicant's COP lacks any necessary information.
k. As appropriate, the Council shall coordinate and consult with relevant Federal, State, and local agencies, the FAB and affected Indian tribes.
l. During the review process, the Council may request additional information if it is determined that the information provided is not sufficient to complete the review and approval process. If the applicant fails to provide the requested information, the Council may disapprove the applicant's COP.
m. Upon completion of the technical and environmental reviews and other reviews required, the Council may approve, disapprove, or approve with modifications the applicant's COP.
n. In the applicant's COP, the applicant may request development of the project area in phases. In support of the applicant's request, the applicant shall provide details as to what portions of the site shall be initially developed for commercial operations and what portions of the site shall be reserved for subsequent phased development.

o. If the application and COP is approved, prior to construction the applicant shall submit to the Council for approval the documents listed below:

1. **Facility Design Report**- The applicant's Facility Design Report provides specific details of the design of any facilities, including cables and pipelines, that are outlined in the applicant's approved SAP or COP. The applicant's Facility Design Report shall demonstrate that the applicant's design conforms to the applicant's responsibilities listed in Section 860.2.1.5. The applicant shall include the following items in the applicant's Facility Design Report:

Table 8.27. Contents of the Facility Design Report.

Required documents:	**Required contents:**	**Other requirements:**
(1) Cover letter.	(i) Proposed facility designations; (ii)The type of facility	The applicant shall submit 4 paper copies and 1 electronic copy.
(2) Location.	(i) Latitude and longitude coordinates, Universal Mercator grid-system coordinates, state plane coordinates in the Lambert or Transverse Mercator Projection System; (ii) These coordinates shall be based on the NAD (North American Datum) 83 datum plane coordinate system; and (iii) The location of any proposed project easement.	The applicant's plat shall be drawn to a scale of 1 inch equals 100 feet and include the coordinates of the project site, and boundary lines. The applicant shall submit 4 paper copy and 1 electronic copy.
(3) Front, Side, and Plan View drawings.	(i) Facility dimensions and orientation; (ii) Elevations relative to Mean Lower Low Water; and (iii) Pile sizes and penetration.	The applicant's drawing sizes shall not exceed 11" x 17". The applicant shall submit 4 paper copies and 1 electronic copy.
(4) Complete set of structural drawings.	The approved for construction fabrication drawings should be submitted, including, e.g., (i) Cathodic protection systems; (ii) Jacket design; (iii) Pile foundations; (iv) Mooring and tethering systems; (v) Foundations and anchoring systems; and (vi) Associated cable and pipeline designs.	The applicant's drawing sizes shall not exceed 11" x 17". The applicant shall submit 4 paper copies and 1 electronic copy.
(5) Summary of environmental data used for design.	A summary of the environmental data used in the design or analysis of the facility. Examples of relevant data	The applicant shall submit 4 paper copies and 1 electronic copy. If the applicant submitted

	include information on: (i) Extreme weather; (ii) Seafloor conditions; and (iii) Waves, wind, currents, tides, temperature, sea level rise projections, snow and ice effects, marine growth, and water depth.	these data as part of the SAP or COP, the applicant may reference the plan.
(6) Summary of the engineering design data.	(i) Loading information (e.g., live, dead, environmental); (ii) Structural information (e.g., design-life; material types; cathode protection systems; design criteria; fatigue life; jacket design; deck design; production component design; foundation pilings and templates, and mooring or tethering systems; fabrication or installation guidelines); (iii) Location of foundation boreholes and foundation piles; and (iv) Foundation information (e.g., soil stability, design criteria).	The applicant shall submit 4 paper copies and 1 electronic copy.
(7) A complete set of design calculations.	Self-explanatory.	The applicant shall submit 4 paper copies and 1 electronic copy.
(8) Project-specific studies used in the facility design or installation.	All studies pertinent to facility design or installation, (e.g., oceanographic and soil reports)	The applicant shall submit 4 paper copies and 1 electronic copy.
(9) Description of the loads imposed on the facility.	(i) Loads imposed by jacket; (ii) Turbines; (iii) Transition pieces; (iv) Foundations, foundation pilings and templates, and anchoring systems; and (v) Mooring or tethering systems.	The applicant shall submit 4 paper copies and 1 electronic copy.
(10) Geotechnical report.	A list of all data from borings and recommended design parameters.	The applicant shall submit 4 paper copies and 1 electronic copy.

a. For any floating facility, the applicant's design shall meet the requirements of the U.S. Coast Guard for structural integrity and stability (e.g., verification of center of gravity). The design shall also consider:
    i. Foundations, foundation pilings and templates, and anchoring systems; and
    ii. Mooring or tethering systems.

b. The applicant is required to use a Certified Verified Agent (CVA). The Facility Design Report shall include two paper copies of the following certification

statement: ‘‘The design of this structure has been certified by a Council approved CVA to be in accordance with accepted engineering practices and the approved SAP, or COP as appropriate. The certified design and as-built plans and specifications shall be on file at (given location).’’

2. **Fabrication and Installation Report**- The applicant’s Fabrication and Installation Report shall describe how the applicant’s facilities shall be fabricated and installed in accordance with the design criteria identified in the Facility Design Report; the applicant’s approved SAP or COP; and generally accepted industry standards and practices. The applicant’s Fabrication and Installation Report shall demonstrate how the applicant’s facilities shall be fabricated and installed in a manner that conforms to the applicant’s responsibilities listed in Section 860.2.1.5. The applicant shall include the following items in the applicant’s Fabrication and Installation Report:

Table 8.28. Contents of the Fabrication and Installation Report.

Required documents:	**Required contents:**	**Other requirements:**
(1) Cover letter.	(i) Proposed facility designation,; (ii) Area, name, and block number; and (iii) The type of facility	The applicant shall submit 4 paper copies and 1 electronic copy.
(2) Schedule.	Fabrication and installation.	The applicant shall submit 4 paper copies and 1 electronic copy.
(3) Fabrication information.	The industry standards the applicant shall use to ensure the facilities are fabricated to the design criteria identified in the Facility Design Report.	The applicant shall submit 4 paper copies and 1 electronic copy.
(4) Installation process information.	Details associated with the deployment activities, equipment, and materials, including offshore and onshore equipment and support, and anchoring and mooring permits.	The applicant shall submit 4 paper copies and 1 electronic copy.
(5) Federal, State, and local permits (e.g., EPA, Army Corps of Engineers).	Either 1 copy of the permit or information on the status of the application.	The applicant shall submit 4 paper copies and 1 electronic copy.
(6) Environmental information.	(i) Water discharge; (ii) Waste disposal;	The applicant shall submit 4 paper copies and 1 electronic

	(iii) Vessel information; and (iv) Onshore waste receiving treatment or disposal facilities.	copy. If the applicant submitted these data as part of the SAP or COP, the applicant may reference the plan.
(7) Project easement.	Design of any cables, pipelines, or facilities. Information on burial methods and vessels.	The applicant shall submit 4 paper copies and 1 electronic copy.

a. A CVA report shall include the following: a Fabrication and Installation Report which shall include four paper copies of the following certification statement: ‘‘The fabrication and installation of this structure has been certified by a Council approved CVA to be in accordance with accepted engineering practices and the approved SAP or COP as appropriate.”

p. Based on the Council’s environmental and technical reviews, if approved, the Council may specify terms and conditions to be incorporated into any approval the Council may issue. The applicant shall submit a certification of compliance annually (or another frequency as determined by the Council) with certain terms and conditions which may include:
   1. Summary reports that show compliance with the terms and conditions which require certification; and
   2. A statement identifying and describing any mitigation measures and monitoring methods, and their effectiveness. If the applicant identified measures that were not effective, then the applicant shall make recommendations for new mitigation measures or monitoring methods.

q. After the applicant’s COP, Facility Design Report, and Fabrication and Installation Report is approved, and the Council has issued a permit and lease for the project site, construction shall begin by the date given in the construction schedule included as a part of the approved COP, unless the Council approves a deviation from the applicant’s schedule.

r. The applicant shall seek approval from the Council in writing before conducting any activities not described in the applicant’s approved COP. The application shall describe in detail the type of activities the applicant proposes to conduct. The Council shall determine whether the activities the applicant proposes are authorized by the applicant’s existing COP or require a revision to the applicant’s COP. The Council may request additional information from the applicant, if necessary, to make this determination.

s. The Council shall periodically review the activities conducted under an approved COP. The frequency and extent of the review shall be

based on the significance of any changes in available information, and on onshore or offshore conditions affecting, or affected by, the activities conducted under the applicant's COP. If the review indicates that the COP should be revised, the Council may require the applicant to submit the needed revisions.

t. The applicant shall notify the Council, within 5 business days, any time the applicant ceases commercial operations, without an approved suspension, under the applicant's approved COP. If the applicant ceases commercial operations for an indefinite period which extends longer than 6 months, the Council may cancel the applicant's lease, and the applicant shall initiate the decommissioning process.

u. The applicant shall notify the Council in writing of the following events, within the time periods provided:
    1. No later than 10 days after commencing activities associated with the placement of facilities on the lease area under a Fabrication and Installation Report.
    2. No later than 10 days after completion of construction and installation activities under a Fabrication and Installation Report.
    3. At least 7 days before commencing commercial operations.

v. The applicant may commence commercial operations within 30 days after the CVA has submitted to the Council the final Fabrication and Installation Report.

w. The applicant shall submit a Project Modification and Repair Report to the Council, demonstrating that all major repairs and modifications to a project conform to accepted engineering practices.
    1. A major repair is a corrective action involving structural members affecting the structural integrity of a portion of or all the facility.
    2. A major modification is an alteration involving structural members affecting the structural integrity of a portion of or all the facility.
    3. The report must also identify the location of all records pertaining to the major repairs or major modifications.
    4. The Council may require the applicant to use a CVA for project modifications and repairs.

860.2.6 Design, Fabrication and Installation Standards

1. **Certified Verification Agent**- The Certified Verification Agent (CVA) shall use good engineering judgment and practices in conducting an independent assessment of the design, fabrication and installation of the facility. The CVA shall certify in the Facility Design Report to the Council that the facility is designed to withstand the environmental and functional load conditions appropriate for the intended service life at the proposed location. The CVA is paid for by the applicant, but is approved and reports to the Council.
    i. The applicant shall use a CVA to review and certify the Facility Design Report, the Fabrication and Installation Report, and the Project Modifications and Repairs Report. The applicant shall use a CVA to:
        a. Ensure that the applicant's facilities are designed, fabricated, and installed in conformance with accepted engineering practices and the Facility Design Report and Fabrication and Installation Report;
        b. Ensure that repairs and major modifications are completed in conformance with accepted engineering practices; and
        c. Provide the Council immediate reports of all incidents that affect the design, fabrication, and installation of the project and its components.
    ii. **Nominating a CVA for Council approval**- The applicant shall nominate a CVA for the Council approval. The applicant shall specify whether the nomination is for the Facility Design Report, Fabrication and Installation Report, Modification and Repair Report, or for any combination of these.
        a. For each CVA that the applicant nominates, the applicant shall submit to the Council a list of documents they shall forward to the CVA and a qualification statement that includes the following:
            1. Previous experience in third-party verification or experience in the design, fabrication, installation, or major modification of offshore energy facilities;
            2. Technical capabilities of the individual or the primary staff for the specific project;
            3. Size and type of organization or corporation;
            4. In-house availability of, or access to, appropriate technology (including computer programs, hardware, and testing materials and equipment);
            5. Ability to perform the CVA functions for the specific project considering current commitments;
            6. Previous experience with the Council requirements and procedures, if any; and
            7. The level of work to be performed by the CVA.

iii. Individuals or organizations acting as CVAs shall not function in any capacity that shall create a conflict of interest, or the appearance of a conflict of interest.
iv. The verification shall be conducted by or under the direct supervision of registered professional engineers.
v. The Council shall approve or disapprove the applicant's CVA prior to construction.
vi. The applicant shall nominate a new CVA for the Council approval if the previously approved CVA:
    a. Is no longer able to serve in a CVA capacity for the project; or
    b. No longer meets the requirements for a CVA set forth in this subpart.
vii. The CVA shall conduct an independent assessment of all proposed:
    a. Planning criteria;
    b. Operational requirements;
    c. Environmental loading data;
    d. Load determinations;
    e. Stress analyses;
    f. Material designations;
    g. Soil and foundation conditions;
    h. Safety factors; and
    i. Other pertinent parameters of the proposed design.
viii. For any floating facility, the CVA shall ensure that any requirements of the U.S. Coast Guard for structural integrity and stability (e.g., verification of center of gravity), have been met. The CVA shall also consider:
    a. Foundations;
    b. Foundation pilings and templates, and
    c. Anchoring systems.
ix. The CVA shall do all of the following:
    a. Use good engineering judgment and practice in conducting an independent assessment of the fabrication and installation activities;
    b. Monitor the fabrication and installation of the facility;
    c. Make periodic onsite inspections while fabrication is in progress and verify the items required by Section 860.2.6.1(xi);
    d. Make periodic onsite inspections while installation is in progress and satisfy the requirements of Section 860.2.6.1(xii); and
    e. Certify in a report that project components are fabricated and installed in accordance with accepted engineering practices; the applicant's approved COP or SAP; and the Fabrication and Installation Report.
        1. The report shall also identify the location of all records pertaining to fabrication and installation.

2. The applicant may commence commercial operations or other approved activities 30 days after the Council receives that certification report, unless the Council notifies the applicant within that time period of its objections to the certification report.

x. The CVA shall monitor the fabrication and installation of the facility to ensure that it has been built and installed according to the Facility Design Report and Fabrication and Installation Report.
    a. If the CVA finds that fabrication and installation procedures have been changed or design specifications have been modified, the CVA shall inform the applicant and the Council.

xi. The CVA shall make periodic onsite inspections while fabrication is in progress and shall verify the following items, as appropriate:
    a. Quality control by lessee (or grant holder) and builder;
    b. Fabrication site facilities;
    c. Material quality and identification methods;
    d. Fabrication procedures specified in the Fabrication and Installation Report, and adherence to such procedures;
    e. Welder and welding procedure qualification and identification;
    f. Adherence to structural tolerances specified;
    g. Nondestructive examination requirements and evaluation results of the specified examinations;
    h. Destructive testing requirements and results;
    i. Repair procedures;
    j. Installation of corrosion protection systems and splash-zone protection;
    k. Erection procedures to ensure that overstressing of structural members does not occur;
    l. Alignment procedures;
    m. Dimensional check of the overall structure, including any turrets, turret and- hull interfaces, any mooring line and chain and riser tensioning line segments; and
    n. Status of quality-control records at various stages of fabrication.

xii. The CVA shall make periodic onsite inspections while installation is in progress and shall, as appropriate, verify, witness, survey, or check, the installation items required by this section. The CVA shall verify, as appropriate, all of the following:
    a. Load out and initial flotation procedures;
    b. Towing operation procedures to the specified location, and review the towing records;
    c. Launching and uprighting activities;
    d. Submergence activities;
    e. Pile or anchor installations;
    f. Installation of mooring and tethering systems;

g. Transition pieces, support structures, and component installations; and
h. Installation at the approved location according to the Facility Design Report and the Fabrication and Installation Report.

xiii. For a fixed or floating facility, the CVA shall verify that proper procedures were used during the following:
a. The loadout of the transition pieces and support structures, piles, or structures from each fabrication site; and
b. The actual installation of the facility or major modification and the related installation activities.

xiv. For a floating facility, the CVA shall verify that proper procedures were used during the following:
a. The loadout of the facility;
b. The installation of foundation pilings and templates, and anchoring systems.

xv. The CVA shall conduct an onsite survey of the facility after transportation to the approved location.

xvi. The CVA shall spot-check the equipment, procedures, and recordkeeping as necessary to determine compliance with the applicable documents incorporated by reference and the regulations under this part.

xvii. The CVA shall prepare and submit to the applicant and the Council all reports required by this subpart. The CVA shall also submit interim reports to the applicant and the Council, as requested by the Council. The CVA shall submit one electronic copy and four paper copies of each final report to the Council. In each report, the CVA shall:
a. Give details of how, by whom, and when the CVA activities were conducted;
b. Describe the CVA's activities during the verification process;
c. Summarize the CVA's findings; and
d. Provide any additional comments that the CVAdeems necessary.

xviii. Until the Council releases the applicant's financial assurance under § 860.5.1, the applicant shall compile, retain, and make available to the Council representatives, all of the following:
a. The as-built drawings;
b. The design assumptions and analyses;
c. A summary of the fabrication and installation examination records;
d. Results from the required inspections and assessments;
e. Records of repairs not covered in the inspection report submitted.

xix. The applicant shall record and retain the original material test results of all primary structural materials during all stages of construction until the Council releases the applicant's financial assurance under § 860.2.7.2. Primary material is material that, should it fail, would lead to a significant reduction in facility safety, structural reliability, or operating capabilities. Items such as steel brackets, deck stiffeners and secondary braces or beams

would not generally be considered primary structural members (or materials).

xx. The applicant shall provide the Council with the location of these records in the certification statement.

xxi. The Council may hire its own CVA agent to review the work of the applicants CVA. The applicant shall be responsible for the cost of the Council's CVA. The Council's CVA shall perform those duties as assigned by the Council.

860.2.7 Pre-Construction Standards

1. The Council may issue a permit for a period of up to 50 years to construct and operate an Offshore Development. A lease shall be issued at the start of the construction phase and payment shall commence at the end of the construction phase. Lease payments shall be due when the project becomes operational. Lease renewal shall be submitted 5 years before the end of the lease term. Council approval shall be required for any assignment or transfer of the permit or lease. This provision shall not apply to aquaculture permitting. Aquaculture permitting and leasing are governed by the provisions of Title 20 Chapter 10 of the General Laws of Rhode Island and Section 300.11 of the RICRMP.

2. Prior to construction, the assent holder shall post a Performance Bond sufficient to ensure removal of all structures at the end of the lease and restore the site. The Council shall review the bond amount initially and every 3 years thereafter to ensure the amount is sufficient.

3. Prior to construction, the assent holder shall show compliance with all federal and state agency requirements, which may include but are not limited to the requirements of the following agencies: the Rhode Island Coastal Resources Management Council, the Rhode Island Department of Environmental Management, the Rhode Island Energy Facilities Siting Board, the Rhode Island Historical Preservation and Heritage Commission, U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement, Army Corps of Engineers, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency.

4. The Council shall consult with the U.S. Coast Guard, the U.S. Navy, marine pilots, the Fishermen's Advisory Board as defined in section 860.2.1.6, fishermen's organizations, and recreational boating organizations when scheduling offshore marine construction or dredging activities. Where it is determined that there is a significant conflict with season-limited commercial or recreational fishing activities, recreational boating activities or scheduled events, or other navigation uses, the Council shall modify or deny activities to minimize conflict with these uses.

5. The Council shall require the assent holder to provide for communication with commercial and recreational fishermen, mariners, and recreational boaters regarding offshore marine construction or dredging activities. Communication shall be facilitated through a project website and shall complement standard U.S. Coast Guard procedures such as Notices to Mariners for notifying mariners of obstructions to navigation.

6. For all Large-Scale Offshore Developments, underwater cables, and other development projects as determined by the Council, the assent holder shall designate and fund a third-party fisheries liaison. The fisheries liaison must be knowledgeable

about fisheries and shall facilitate direct communication between commercial and recreational fishermen and the project developer. Commercial and recreational fishermen shall have regular contact with and direct access to the fisheries liaison throughout all stages of an offshore development (pre-construction; construction; operation; and decommissioning).

7. Where possible, Offshore Developments should be designed in a configuration to minimize adverse impacts on other user groups, which include but are not limited to: recreational boaters and fishermen, commercial fishermen, commercial ship operators, or other vessel operators in the project area. Configurations which may minimize adverse impacts on vessel traffic include, but are not limited to, the incorporation of a traffic lane through a development to facilitate safe and direct navigation through, rather than around, an Offshore Development.

8. Any assent holder of an approved Offshore Development shall work with the Council when designing the proposed facility to incorporate where possible mooring mechanisms to allow safe public use of the areas surrounding the installed turbine or other structure.

9. The facility shall be designed in a manner that minimizes adverse impacts to navigation. As part of its application package, the project applicant shall submit a navigation risk assessment under the U.S. Coast Guard's Navigation and Vessel Inspection Circular 02-07, "Guidance on the Coast Guard's Roles and Responsibilities for Offshore Renewable Energy Installations."

10. Applications for projects proposed to be sited in state waters pursuant to the Ocean SAMP shall not have a significant impact on marine transportation, navigation, and existing infrastructure. Where the Council, in consultation with the U.S. Coast Guard, the U.S. Navy, NOAA, the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement, the U.S. Army Corps of Engineers, marine pilots, the R.I. Port Safety and Security Forums, or other entities, as applicable, determines that such an impact on marine transportation, navigation, and existing infrastructure is unacceptable, the Council shall require that the applicant modify the proposal or the Council shall deny the proposal. For the purposes of Chapter 7, Marine Transportation, Navigation and Infrastructure policies and standards 770.1.1 to 770.2.1, impacts will be evaluated according to the same criteria used by the U.S. Coast Guard, as follows; these criteria shall not be construed to apply to any other Ocean SAMP chapters or policies:
    i. Negligible: No measurable impacts.
    ii. Minor: Adverse impacts to the affected activity could be avoided with proper mitigation; or impacts would not disrupt the normal or routine functions of the affected activity or community; or once the impacting agent is eliminated, the affected activity would return to a condition with no measurable effects from the proposed action without any mitigation.

iii. Moderate: Impacts to the affected activity are unavoidable; and proper mitigation would reduce impacts substantially during the life of the proposed action; or the affected activity would have to adjust somewhat to account for disruptions due to impacts of the proposed action; or once the impacting agent is eliminated, the affected activity would return to a condition with no measurable effects from the proposed action if proper remedial action is taken.

iv. Major: Impacts to the affected activity are unavoidable; proper mitigation would reduce impacts somewhat during the life of the proposed action; the affected activity would experience unavoidable disruptions to a degree beyond what is normally acceptable; and once the impacting agent is eliminated, the affected activity may retain measurable effects of the proposed action indefinitely, even if remedial action is taken.

11. Prior to construction, the Applicant shall provide a letter from the U.S. Coast Guard showing it meets all applicable U.S. Coast Guard standards.

860.2.8 Standards for Construction Activities

1. The Assent Holder shall use the best available technology and techniques to minimize impacts to the natural resources and existing human uses in the project area.

2. The Council shall require the use of an environmental inspector to monitor construction activities. The environmental inspector shall be a private, third-party entity that is hired by the Assent Holder, but is approved and reports to the Council. The environmental inspector shall possess all appropriate qualifications as determined by the Council. This inspector service may be part of the CVA requirements.

3. Installation techniques for all construction activities should be chosen to minimize sediment disturbance. Jet plowing and horizontal directional drilling in nearshore areas shall be required in the installation of underwater transmission cables. Other technologies may be used provided the applicant can demonstrate they are as effective, or more effective, than these techniques in minimizing sediment disturbance.

4. All construction activities shall comply with the policies and standards outlined in the Rhode Island Coastal Resources Management Program (aka the 'Red Book'), as well as the regulations of other relevant state and federal agencies.

5. The applicant shall conduct all activities on the applicant's permit under this part in a manner that conforms with the applicant's responsibilities in § 860.2.3, and using:
    i. Trained personnel; and

ii. Technologies, precautions, and techniques that shall not cause undue harm or damage to natural resources, including their physical, atmospheric, chemical and biological components.

6. The Assent Holder shall be required to use the best available technology and techniques to mitigate any associated adverse impacts of offshore renewable energy development.
    i. As required, the applicant shall submit to the Council:
        1. Measures designed to avoid or minimize adverse effects and any potential incidental take of endangered or threatened species as well as all marine mammals;
        2. Measures designed to avoid likely adverse modification or destruction of designated critical habitat of such endangered or threatened species; and
        3. The applicant's agreement to monitor for the incidental take of the species and adverse effects on the critical habitat, and provide the results of the monitoring to the Council as required; and

7. If the Assent Holder, the Assent Holder's subcontractors, or any agent acting on the Assent Holder's behalf discovers a potential archaeological resource while conducting construction activities, or any other activity related to the Assent Holder's project, the applicant shall:
    i. Immediately halt all seafloor disturbing activities within the area of the discovery;
    ii. Notify the Council of the discovery within 24 hours; and
    iii. Keep the location of the discovery confidential and not take any action that may adversely affect the archaeological resource until the Council has made an evaluation and instructed the applicant on how to proceed.
        1. The Council may require the Assent Holder to conduct additional investigations to determine if the resource is eligible for listing in the National Register of Historic Places under 36 CFR 60.4. The Council shall do this if:
            a. The site has been impacted by the Assent Holder's project activities; or
            b. Impacts to the site or to the area of potential effect cannot be avoided.
        2. If the Council incurs costs in protecting the resource, under section 110(g) of the NHPA, the Council may charge the applicant reasonable costs for carrying out preservation responsibilities.

8. Post construction, the Assent Holder shall provide a side scan sonar survey of the entire construction site to verify that there is no post construction debris left at the

project site. These side-scan sonar survey results shall be filed with the Council within 90 days of the end of the construction period. The results of this side-scan survey shall be verified by a third-party reviewer, who shall be hired by the Assent Holder but who is pre-approved by and reports to the Council.

9. All pile-driving or drilling activities shall comply with any mandatory best management practices established by the Council in coordination with the Joint Agency Working Group and which are incorporated into the RICRMP.

10. The Council may require the Assent Holder to hire a CVA to perform periodic inspections of the structure(s) during the life of those structure(s). The CVA shall work for and be responsible to the council.

860.2.9 Monitoring Requirements

1. The Council in coordination with the Joint Agency Working Group, as described in Section 860.1.2.2 shall determine requirements for monitoring prior to, during, and post construction. Specific monitoring requirements shall be determined on a project-by-project basis and may include but are not limited to the monitoring of:
    i. Coastal processes and physical oceanography
    ii. Underwater noise
    iii. Benthic ecology
    iv. Avian species
    v. Marine mammals
    vi. Sea turtles
    vii. Fish and fish habitat
    viii. Commercial and recreational fishing
    ix. Recreation and tourism
    x. Marine transportation, navigation and existing infrastructure
    xi. Cultural and historic resources

2. The Council shall require where appropriate that project developers perform systematic observations of recreational boating intensity at the project area at least three times: pre-construction; during construction; and post-construction. Observations may be made while conducting other field work or aerial surveys and may include either visual surveys or analysis of aerial photography or video photography. The Council shall require where appropriate that observations capture both weekdays and weekends and reflect high-activity periods including the July 4th holiday weekend and the week in June when Block Island Race Week takes place. The quantitative results of such observations, including raw boat counts and average number of vessels per day, will be provided to the Council.

3. The items listed below shall be required for all Offshore Developments:
    i. A biological assessment of commercially and recreationally targeted species shall be required within the project area for all Offshore Developments. This assessment shall assess the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. Such an assessment shall be performed at least four times: pre-construction (to assess baseline conditions); during construction; and at two different intervals during operation (i.e. 1 year after construction and then post-construction). At each time this assessment must capture all four seasons of the year. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site. The Council will not require this assessment for proposed

projects within the Renewable Energy Zone that are proposed within 2 years of the adoption of the Ocean SAMP.

ii. An assessment of commercial and recreational fisheries effort, landings, and landings value shall be required for all proposed Offshore Developments. Assessment shall focus on the proposed project area and alternatives. This assessment shall evaluate commercial and recreational fishing effort, landings, and landings value at three different stages: pre-construction (to assess baseline conditions); during construction; and during operation. At each stage, all four seasons of the year must be evaluated. Assessment may use existing fisheries monitoring data but shall be supplemented by interviews with commercial and recreational fishermen. Assessment shall address whether fishing effort, landings, and landings value has changed in comparison to baseline conditions. The Council will not require this assessment for proposed projects within the Renewable Energy Zone that are proposed within 2 years of the adoption of the Ocean SAMP.

4. The Council in coordination with the Joint Agency Working Group may also require facility and infrastructure monitoring requirements, that may include but are not limited to:
    i. Post construction monitoring including regular visual inspection of inner array cables and the primary export cable to ensure proper burial, foundation and substructure inspection.

Section 870. Potential Areas for Offshore Renewable Energy Development in Federal Waters of the Ocean SAMP Area.

1. The studies and datasets formulated and developed during the Ocean SAMP process have encompassed not only Rhode Island state waters, but also waters that are under Federal jurisdiction. During the course of the Ocean SAMP process, the CRMC has identified areas in Federal waters that, at this stage of the research, appear appropriate for development of offshore renewable energy.

2. For instance, the CRMC believes the areas depicted in Figures 8.56-8.60 below show the most promise as potential areas for offshore renewable energy development and recommend these areas to the appropriate Federal agencies with jurisdiction as areas for future study and/or future development. The areas depicted in the maps were derived using data and analysis collected based on a range of geological, oceanographic, commercial, environmental, climatic and other considerations; for further information on this site selection process, see section 830.2 above. These areas shown as having the most promise for offshore renewable energy development now constitute the "Area of Mutual Interest" between Rhode Island Massachusetts; see section 870.4 below for further discussion.

3. The CRMC is well aware that the identification of these areas in Federal waters or CRMC's recommendations that Federal agencies consider these areas are not an enforceable policy or enforceable component of the Ocean SAMP; rather they are merely recommendations to the Federal agencies with jurisdiction for further refinement and consideration. Further, CRMC recognizes that at this time, discussions of these areas in the Ocean SAMP cannot be used as a basis for any future state decisions through the CZMA Federal Consistency provisions.

4. In addition to the Renewable Energy Zone in Rhode Island state waters depicted in 830.4, the states of Rhode Island and Massachusetts have expressed a mutual interest in the potential for renewable energy in a portion of Federal waters along the eastern boundary of the Ocean SAMP area. This area is depicted in Figure 8.56 below and is referred to as the Area of Mutual Interest (AMI) in the Memorandum of Understanding (MOU) between the two states, signed on July 26, 2010. The map of the AMI is provided in this document to show the level of interest in this area between the two states and is not intended to be an enforceable policy or enforceable component of the Ocean SAMP. While the AMI is of interest to the states based on a range of geological, oceanographic, climatic and other considerations, the discussion of the AMI in the Ocean SAMP cannot be used by the states as the basis for any future state decisions through the CZMA federal consistency provision; state CZMA federal consistency decisions must be based on the reasonably foreseeable coastal effects of a proposed activity and a state's enforceable policies approved by NOAA as part of the state's federally approved CZMA program. The lead federal agency with jurisdiction over the permitting of offshore wind energy in the federal waters of the Ocean SAMP area is the U.S. Bureau of Ocean Energy Management, Regulation

and Enforcement (BOEMRE as described in detail in Section 820.4). BOEMRE, through its state/regional task forces, has encouraged states to be engaged in and make recommendations on renewable energy development on the Outer Continental Shelf in Federal waters. Therefore, the AMI and the information on which Rhode Island's and Massachusett's interest in the AMI is based, is available to BOEMRE and potential applicants when considering specific site locations within the AMI.

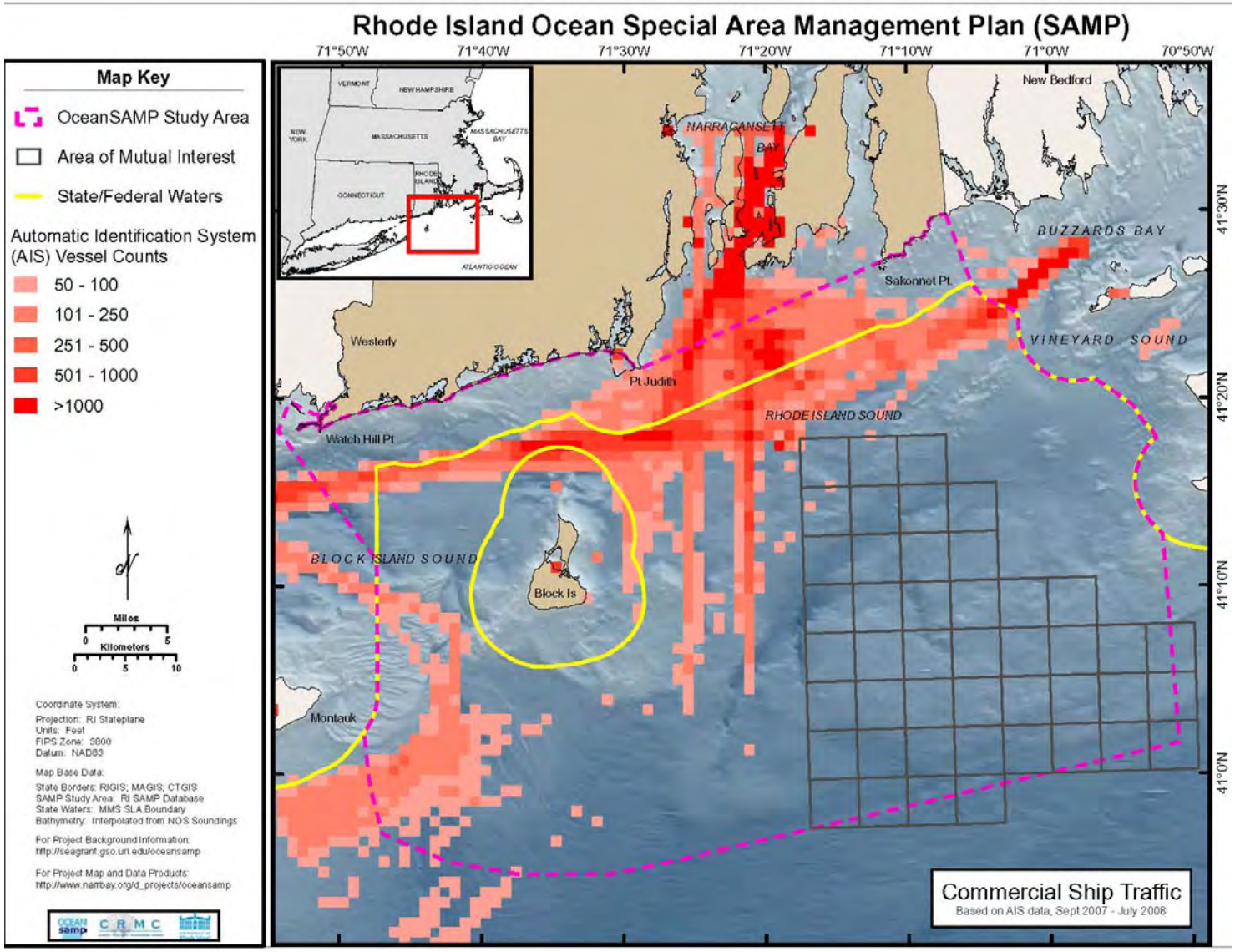


Figure 8.56. Commercial ship traffic patterns based on AIS data (50 or more records per square kilometer) with the Area of Mutual Interest.

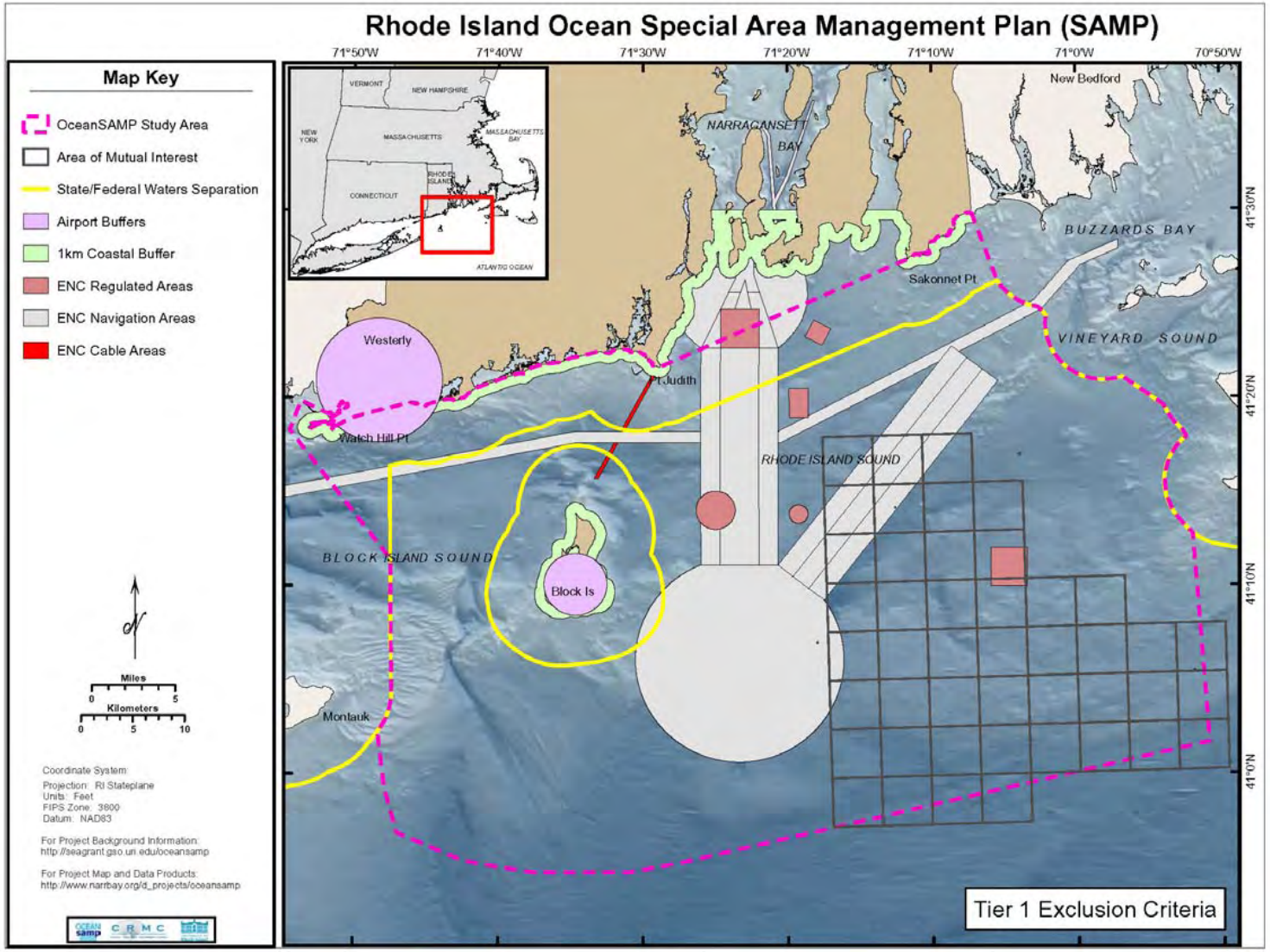


Figure 8.57. Tier 1 Exclusion Criteria with the Area of Mutual Interest. (See section 830.2 for further information on Tier 1 Exclusion Criteria.)

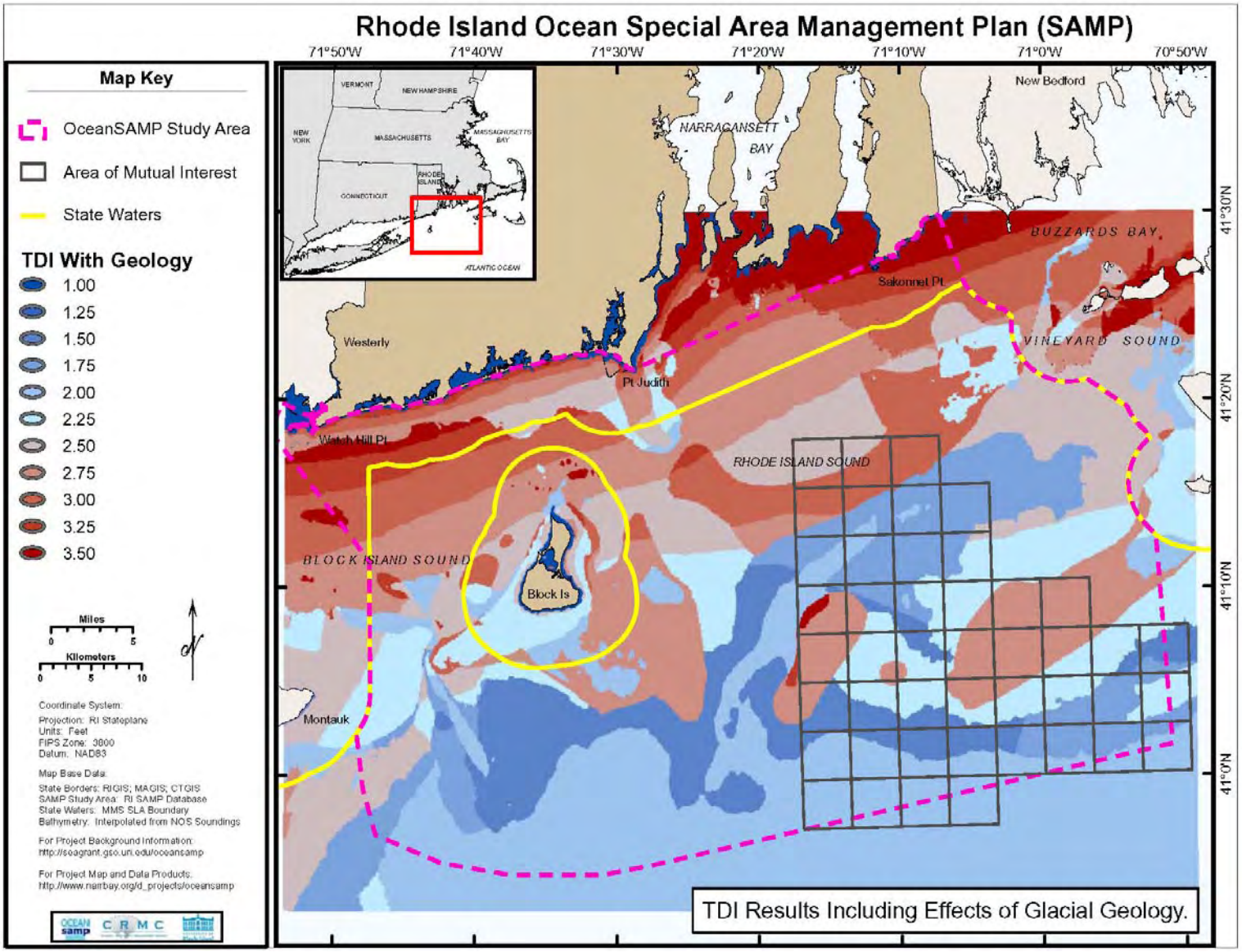

Rhode Island Ocean Special Area Management Plan (SAMP)
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
Map Key
OceanSAMP Study Area
Area of Mutual Interest
State Waters
TDI With Geology
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
Miles
0
5
Kilometers
0
5
10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
Map Base Data:
State Borders: RIGIS; MAGIS; CTGIS
SAMP Study Area: RI SAMP Database
State Waters: MMS SLA Boundary
Bathymetry: Interpolated from NOS Soundings
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
NARRAGANSETT BAY
New Bedford
BUZZARDS BAY
Sakonnet Pt
VINEYARD SOUND
Westerly
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
TDI Results Including Effects of Glacial Geology.

Figure 8.58. TDI results including effects of glacial geology with Area of Mutual Interest. (See section 830.2 for further information on the TDI analysis.)

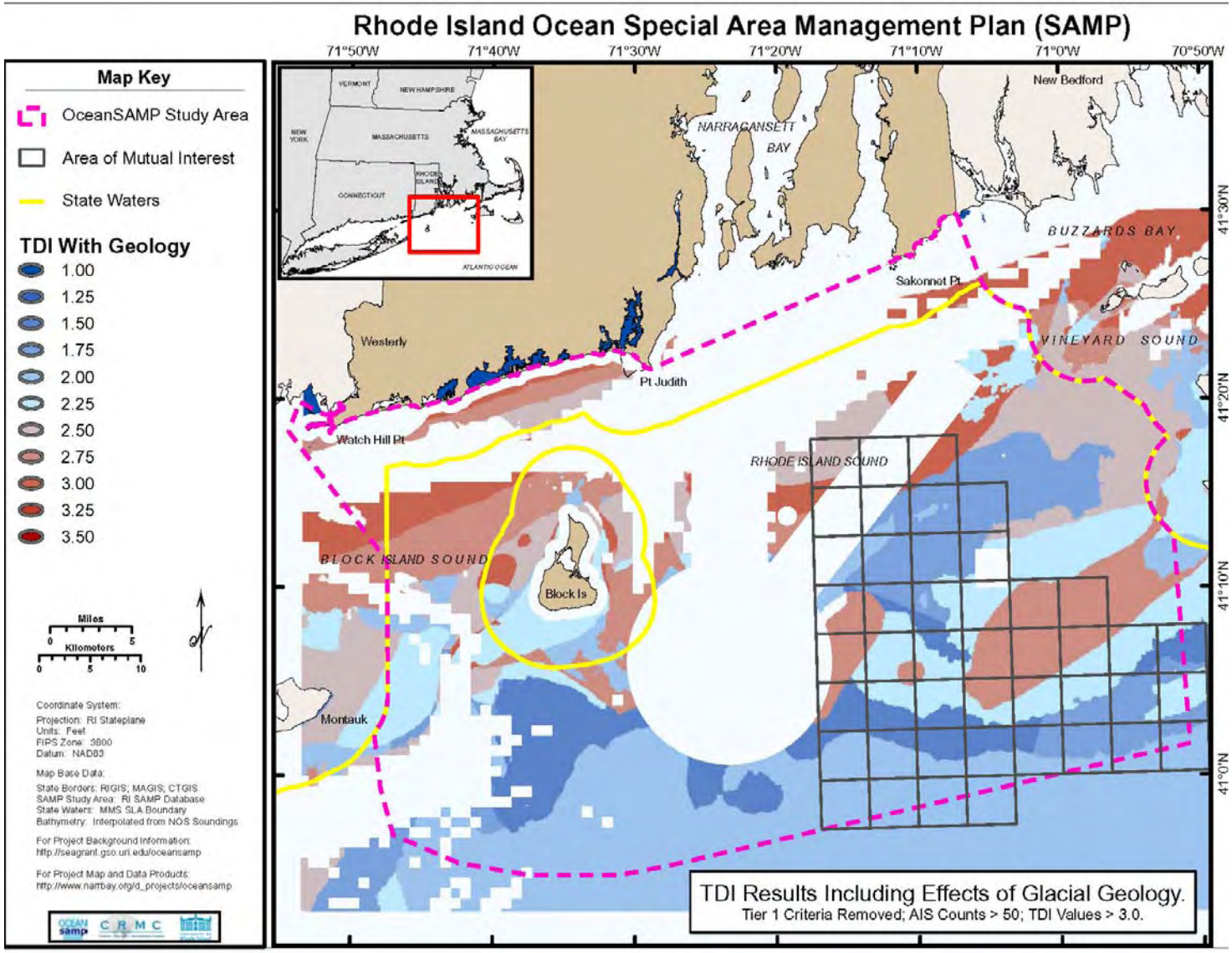


Figure 8.59 TDI results including effects of glacial geology, commercial ship traffic, and Tier 1 exclusion criteria with Area of Mutual Interest.

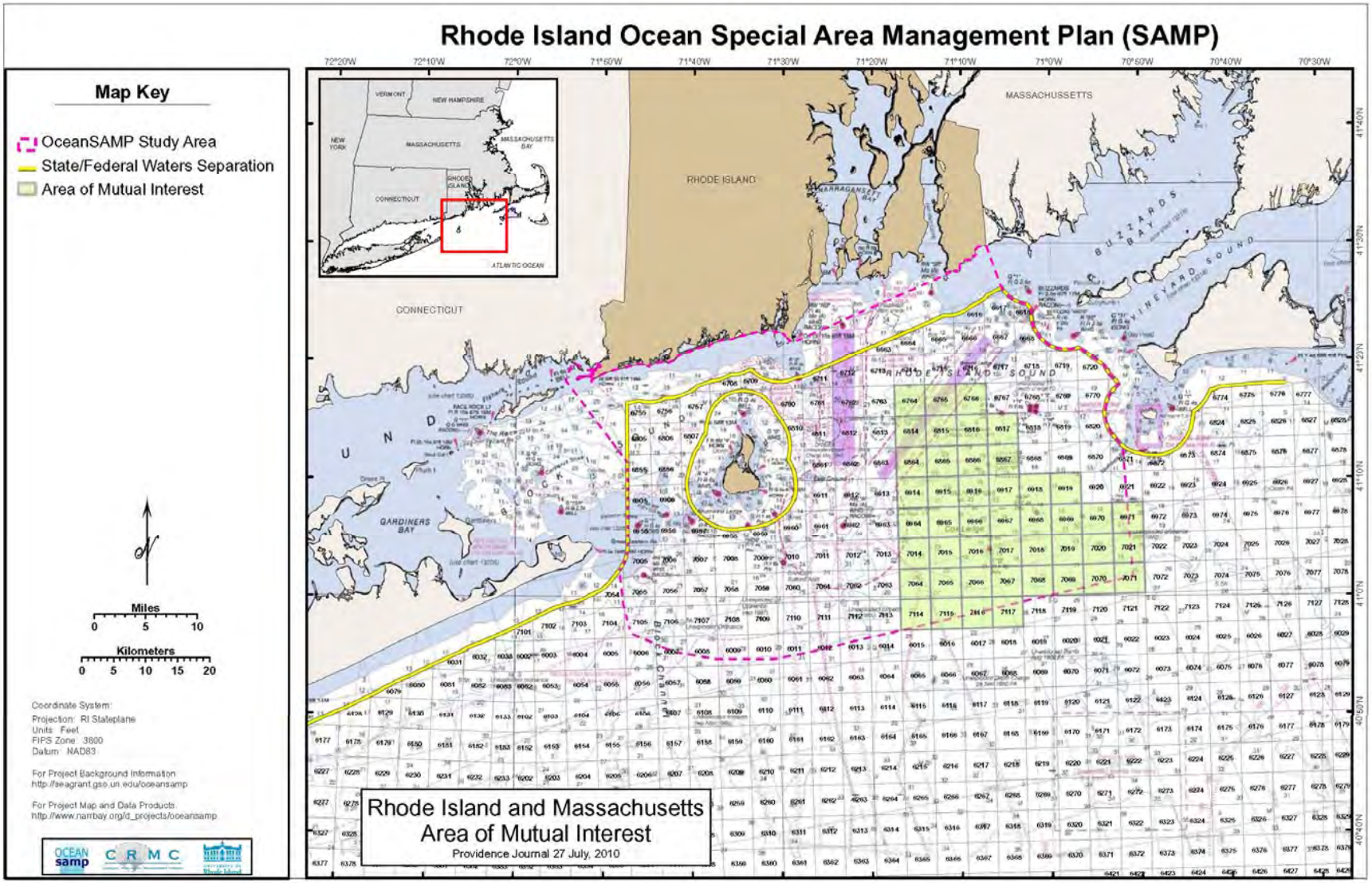


Figure 8.60. Area of Mutual Interest for future offshore renewable energy development identified in the Memorandum of Understanding signed between Rhode Island and Massachusetts on July 26, 2010

Section 880. Literature Cited

ABP Marine Environmental Research Ltd. 2002. *Potential Effects of Offshore Wind Developments on Coastal Processes.* ETSU W/35/00596/00/REP.

Advisory Council on Historic Preservation. April 2, 2010. Comments of the Advisory Council on Historic Preservation on the proposed authorization by the Minerals Management Service for Cape Wind Associates, LLC to construct the Cape Wind Energy project on Horseshoe Shoal in Nantucket Sound, Massachusetts. Online at http://www.achp.gov/docs/CapeWindComments.pdf

American Wind Energy Association (AWEA). 2009. *Wind Energy Basics*, American Wind Energy Association, Washington, D.C. Available online at: http://www.awea.org/newsroom/pdf/Wind_Energy_Basics.pdf. Last accessed May 6, 2010.

Armsby, M. 2009. *Government Incentives for the Development of Offshore Wind Energy in the United States: A Study of Incentives Needed to Support A New Clean-Energy Industry.* University of Rhode Island, Department of Marine Affairs Master's Thesis.

ASA (Applied Science Associates, Inc.) 2010. *Ecological Services: WILDMAP™*. Available online at: http://www.asascience.com. Last accessed May 18, 2010.

ASA (Applied Science Associates, Inc.) 2006. *Simulation of Oil Spills from the Cape Wind Energy Project Electric Service Platform in Nantucket Sound,* Report 05-128, prepared by ASA, Narragansett, RI, for Cape Wind Associates LLC, Boston, MA, Aug.

ASA (Applied Science Associates, Inc.) 2005. *Analysis of Effects of Wind Turbine Generator Pile Array of the Cape Wind Energy Project in Nantucket Sound* Report 05-128, prepared by ASA, Narragansett, RI, for Cape Wind Associates LLC, Boston, MA, Aug.

Asher, T.G., Grilli, A.R., Grilli, S.T. and M.L. Spaulding 2008. Analysis of Extreme Wave Climates in Rhode Island Waters South of Block Island. Year 1 report for *State of RI Ocean Special Area Management Plan* (Ocean SAMP) project. Dept. Ocean Eng., Univ. of Rhode Island, 37 pps.

Astolfi, P., Baron, S. Small, M.J. 2008. "Financing Renewable Energy." *Commercial Lending Review* Mar/Apr 2008: 3-8.

ATM. 2007. *RI Winds Summary Report,* Applied Technology and Management for RI Office of Energy Resources, Providence, RI. Available online at: http://www.energy.ri.gov/documents/renewable/RIWINDS_RANKING.pdf. Last accessed March 15, 2010.

Au, W. W. L. 1993. *The Sonar of Dolphins.* Springer, New York.

BERR (U.K. Department for Business Enterprise and Regulatory Reform). 2008. Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Industry. Technical Report 2008.

Bioconsult A/S. 2003. *Infauna Monitoring Horns Rev Offshore Wind Farm.* Annual Status Report 2003.

Bioconsult A/S. 2002. Possible Effects of the Offshore Wind Farm at Vindeby on the Outcome of Fishing: the possible effects of electromagnetic fields and noise.

Blanco, M. I. 2009. "The Economics of Wind Energy." *Renewable and Sustainable Energy Reviews,* 13 (2009):1372–1382.

Blew, J., Diederichs, A., Grünkorn, T., Hoffman, M. and Nehls, G. 2006. *Investigations of the bird collision risk and the response of harbour porpoises in the offshore wind farms Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark.* Report from Universität Hamburg and BioConsult SH, 165 pp.

BMT Cordah Limited. 2003. *Offshore Wind Energy Generation: Phase 1 - Proposals and Environmental Report.* Report No. Cordah/DTI.009.04.01.06/2003.

Bochert, R., and Zettler, M.L. 2004. Long-term exposure of several marine benthic animals to static magnetic fields. *Bioelectromagnetics*, 25: 498-502.

Bordage, D. and Savard, J.L. 1995. Black Scoter (*Melanitta nigra*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/177. Last accessed July 9, 2010.

British Wind Energy Association (BWEA). 2007. *Investigation of Technical and Operational Effects on Marine Radar Close to Kentish Flats Offshore Wind Farm.* Available online at: http://www.bwea.com/pdf/radar/BWEA_Radar.pdf. Last accessed November 13, 2009.

British Wind Energy Association (BWEA). 2006. *The Impact of Wind Farms on the Tourist Industry in the UK*. Prepared by the British Wind Energy Association for the All-Party Parliamentary Group on Tourism, May 2006. Online at www.bwea.com/pdf/tourism.pdf. Last accessed November 13, 2009.

Brower, M. 2007. Wind resource maps of Southern New England, prepared by TrueWind Solutions, LLC.

Brown, C. 2008. "Deepwater Wind: Clean Energy is Just Over the Horizon." Presented at Roger William's Marine Law Symposium: A Viable Marine Renewable Energy Industry: Solutions to Legal, Economic and Policy Challenges. Bristol, RI, October 23-

24. Available online at: http://law.rwu.edu/sites/marineaffairs/symposia/seventhMLS.aspx. Last accessed January, 31 2010.

Brown, C. 2005. *Offshore Wind Farm Helicopter Search and Rescue Trials Undertaken at the North Hoyle Wind Farm,* United Kingdom Maritime and Coastguard Agency. Available online at http://www.mcga.gov.uk/c4mca/research_report_561.pdf. Last accessed July 9, 2010.

Brown, C., and Howard, M. 2004, *Results of the Electromagnetic Investigations and Assessments of Marine Radar, Communications, and Positioning Systems Undertaken at the North Hoyle Wind Farm by QinetiQ and the Maritime and Coastguard Agency*, MCA Report MNA 53/10/366, United Kingdom Maritime and Coastguard Agency, Nov. Available at http://www.mcga.gov.uk/c4mca/mcga-safety_information/nav-com/offshore- renewable_energy_installations/mcga_north_hoyle_windfarm_report.htm.

Bullard, S., Lambert, G., Carman, M., Byrnes, J., Whitlatch, R., Ruiz, G., Miller, R., Harris, L., Valentine, P., and Collie, J. 2007. The colonial ascidian *Didemnum sp*. A: Current distribution, basic biology and potential threat to marine communities of the northeast and west coasts of North America. *Journal of Experimental Marine Biology and Ecology* 342:99-108. Last accessed July 9, 2010.

Caltrans. 2001. *Fisheries impact assessment.* San Francisco Oakland Bay Bridge East Span Seismic Safety Project. PIPD EA 012081

Cameron, I.L., Hardman, W.E., Winters, W.D., Zimmerman, S., and Zimmerman, A.M. 1993. Environmental magnetic fields: influences on early embryogenesis. *Journal of Cell Biochemistry*, 51: 417-425.

Cameron, I.L., Hunter, K.E., and Winters, W.D. 1985. Retardation of embryogenesis by extremely low frequency 60 Hz electromagnetic fields. *Physiological chemistry and physics and medical NMR*, 17: 135-138.

Carstensen, J., Henriksen, O.D., andTeilimann, J. 2006. "Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODS)." *Marine Ecology Process Series,* 321:295-308.

CEFAS (Centre for Environment, Fisheries and Aquaculture Science). 2005. Research Project Final Report, Defra Project Code A1227. Available online from: http://www.cefas.co.uk/media/49662/sid5_ae1227.pdf. Last accessed July 9, 2010.

Charles Rivers Associates. 2010. *Analysis of the Impact of Cape Wind on New England Energy Prices.* Report prepared for Cape Wind Associates, LLC. CRA Project No. D15007-00, February 2010.

Codiga, D. and Ullman, D. 2010a. *Characterizing the Physical Oceanography of Coastal Waters Off Rhode Island, Part 1: Literature Review, Available Observations, and A Representative Model Simulation*. Technical Report.

Codiga, D. and Ullman, D. 2010b. *Characterizing the Physical Oceanography of Coastal Waters Off Rhode Island, Part 2: New Observations of Water Properties, Currents, and Waves.* Technical Report.

Codiga, D. and Ullman, D. 2010c. "Characterizing the Physical Oceanography of Coastal Waters Off Rhode Island". Presented at the Rhode Island Ocean Special Area Management Plan Stakeholder Meeting, Narragansett, RI, January 5, 2010.

COWRIE (Collaborative Offshore Wind Research Into the Environment). 2007. *Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy.* January 2007. Available online at: http://www.offshorewind.co.uk/Pages/Publications/Archive/Cultural_Heritage/Guidance_for_Assessmen642afc68/.

Concerted Action on Offshore Wind Energy in Europe and the European Commission, 2001. *Offshore Wind Energy, Ready to Power a Sustainable Europe Final Report.* Report No. NNE5-1999-562. December 2001. Available online at: www.offshorewindenergy.org.

Connors, S.R., and McGowan, J.G. 2000. "Windpower: A Turn of the Century Review," *Annual Review of the Energy Environment*. 25:147–97.

Cottam, C. 1939. *Food habits of North American diving ducks*. Tech. Bull. No. 643. U.S. Dep. Agric., Washington, D.C.

Database of State Incentives for Renewables and Efficiency (DSIRE). 2010. http://www.dsireusa.org. Last accessed February 4, 2010.

Deepwater Wind. 2009. Presentation to the Virginia Commission on Energy and Environment, August 18, 2009. Available online at: http://dls.state.va.us/GROUPS/energy/meetings/081809/Lanard.pdf. Last accessed January 27, 2010.

Dernie, K.M., Kaiser, M.J., and Warwick, R.M. 2003. Recovery rates of benthic communities following physical disturbance. *Journal of Annual Ecology*, 72: 1043-1056.

Derraik, J.G.B. 2002. "The Pollution of the Marine Environment by Plastic Debris: A Review." *Marine Pollution Bulletin* 44:842–852.

Desholm, M., and Kahlert, J. 2005. Avian collision risk at an offshore wind farm. *Biology Letters* 1: 296–298.

Dickerman, R.W., and Goelet R.G. 1987. "Northern Gannet Starvation after Swallowing Styrofoam." *Marine Pollution Bulletin* 13:18–20.

Dominion. 2010. Brayton Point Power Station. Available online at: http://www.dom.com/about/stations/fossil/brayton-point-power-station.jsp Last accessed April 19, 2010.

DONG Energy and Vattenfall. 2006. *Review Report 2005: The Danish Offshore Wind Farm Demonstration Project: Horns Rev and Nysted Offshore Wind Farms Environmental impact assessment and monitoring.* The Environmental Group. 150 pp.

DONG Energy, Vattenfall, The Danish Energy Authority, and The Danish Forest and Nature Agency. 2006. *Danish Offshore Wind: Key Environmental Issues*. November 2006. Available from: www.ens.dk

Durinck, J., Christensen, K.D., Skov, H., and Danielsen, F. 1993. Diet of the Common Scoter *Melanitta nigra* and Velvet Scoter *Melanitta fusc*a wintering in the North Sea. *Ornis Fenn.* 70:215–218.

Edren, S., Teilmann, J., Dietz, R., and Carstensen, J. 2004. *Effect from the construction of Nysted Offshore Wind Farm on seals in Rødsand seal sanctuary based on remote video monitoring.* Technical report to Energi E2 A/S. 1-31. 2004. Ministry of the Environment, Denmark.

Ehrich, S., Kloppmann, M.H.F., Sell, A.F., and Böttcher, U. 2006. Distribution and assemblages of fish species in the German waters of North and Baltic Seas and potential impact of wind parks. In: *Offshore Wind Energy: Research on Environmental Impacts,* Köller, J.; Köppel, J.; Peters, W., eds. New York: Springer Publishing.

Energi E2 A/S. 2004. *Development of the Fouling Community on Turbine Foundations and Scour Protections in Nysted Offshore Wind Farm, 2003*. Report June 2004.

Engås, A., Lokkeborg, S., Ona, E., Soldal, A.V. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Science*: 53, 2238-2249.

EWEA (European Wind Energy Association). 2009a. "Wind Energy- The Facts." Accessed online at: www.ewea.org/fileadmin/ewea_documents/documents/publications/WETF.pdf Last accessed January 28, 2010.

EWEA. 2009b. *Operational offshore wind farms in Europe, end 2009.* Available online at: http://www.ewea.org. Last accessed January 28, 2010. \

Excelerate. 2010. *Northeast Gateway Deepwater Port.* Available online at: www.excelerateenergy.com. Last accessed June 30, 2010.

Fayram, A. H., and de Risi, A. 2007. The potential compatibility of offshore wind power and fisheries: An example using bluefin tuna in the Adriatic Sea. *Ocean & Coastal Management, 50*: 597-605.

Fox, A.D., Desholm, M., Kahlert, J., Christensen T. K. and Petersen, I. K. 2006. "Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds." *Ibis* 148 (2006):129–144.

Francfort, J.E. 1995. *U.S. Hydropower Resource Assessment for Rhode Island*. Idaho National Engineering Laboratory Renewable Energy Products Department, Lockheed Idaho Technologies Company, July 1995.

Fugro Oceanor AS. 2008. *WorldWaves Wave Energy Map.* Trondheim, Norway, March 2008.

Gill, A.B. 2005. Offshore renewable energy: ecological implications of generating electricity in the coastal zone. *Journal of Applied Ecology, 42*: 605-615.

Gill, A.B., Gloyne-Phillips, I., Neal, K.J., and Kimber, J.A. 2005. *The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review*. FINAL REPORT. COWRIE-EM FIELD 2-06-2004.

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J., and Wearmouth, V. 2009. COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry. Commissioned by COWRIE Ltd (project reference COWRIE-EMF-1-06).

Gill, A.B., Kimber, J.A. 2005. The potential for cooperative management of elasmobranchs and offshore renewable energy development in UK waters. *Journal of the Marine Biological Association of the United Kingdom, 85*: 1075-1081.

Gill, J.P., Sales, D., and Beasley, F. 2006. *Kentish Flats Offshore Wind Farm Monitoring Report.* Environmentally Sustainable Systems, Ltd. 100 pp.

Global Insight. 2003. *Impact Analysis of the Cape Wind Off-shore Renewable Energy Project on Local, State and Regional Economies.* A report prepared for Cape Wind Associates, September 2003.

Goudie, R.I., G.J. Roberston, and A. Reed. 2000. Common Eider (*Somateria mollissima*). *The Birds of North America*, 546:1-32.

Grilli, A.R., Grilli, S.T., Spaulding, M.L., Ford, K. and King, J. 2004. *Bathymetric and Wave Climate Studies in Support of Siting a Wave Energy Power Plant at Point Judith, RI.*

Final Technical Report prepared for RIREO Grant Phase I. Dept. Ocean Eng., Univ. of Rhode Island, 51 pps.

Guillemette, M., Himmelman, J.H., Barette, C., and Reed, A. 1993. Habitat selection by common eiders in winter and its interaction with flock size. *Canadian Journal of Zoology*, 71: 1259-1266.

Guillemette, M. Larsen, J.K. and Clausager, I. 1999. *Assessing the Impact of the Tuno Knob Wind Farm on Sea Ducks: The Influence of Food Resources.* NERI Technical Report No. 263. Ministry of Environment and Energy - Denmark, National Environmental Research Institute. 21 pp.

Guillemette, M., Larsen, J.K. and Clausager, I. 1998. *Impact Assessment of an Off-shore Wind park on Sea Ducks.* NERI Technical Report No. 227. Ministry of Environment and Energy - Denmark, National Environmental Research Institute.

Guillemette, M., Woakes, A.J., Henaux, V., Grandbois, J. and Butler, P. 2005. The effect of depth on the diving behavior of common eiders. *Canadian Journal of Zoology*, 82: 1818-1826.

Hagerman, G. 2001. "Southern New England Wave Energy Resource Potential." Paper presented at the Building Energy 2001, Tufts University, Boston, MA, March 23, 2001.

Hammond, J. 2008. "ACCIONA Energía, A Leader in Renewable Energy. *A Viable Marine Renewable Energy Industry: Pursuing Innovation and Reducing Lifecycle Costs."* Presented at Roger William's Marine Law Symposium: A Viable Marine Renewable Energy Industry: Solutions to Legal, Economic and Policy Challenges. Bristol, RI, October 23-24. Available online at: http://law.rwu.edu/sites/marineaffairs/symposia/seventhMLS.aspx. Last accessed January, 31 2010.

Hansen, M., Wahlberg, M. and Madsen, P.T. 2008. "Low-frequency components in harbor porpoise (*Phocoena phocoena*) clicks: communication signal, by-products, or artifacts?" *Journal of the Acoustic Society of America*, 124 (6): 4059-4068.

Harris, B. 2009. Roseate Tern Resighting: Breeding season and post-breeding movements and habitat use. Eco-index. Available online at: http://www.eco-index.org. Last accessed May 5, 2010.

Hastings M.C., Popper A.N. 2005. *Effects of Sound on Fish*. Contract 43A0139, Task Order 1, California Department Of Transportation.

HDR Engineering Inc. 2007. *Block Island Power Company: Electric Resource Planning Study*. Report prepared for the Block Island Power Company, the Town of New Shoreham and the Rhode Island Division of Public Utilities and Carriers. September 2007.

Hensel, J.V. 2009. *Jacket Structures for Offshore Wind Turbines in Rhode Island.* Master's thesis in Ocean Engineering, University of Rhode Island.

Hiddink, J.G., Hutton, T., Jennings, S., and Kaiser, M.J. 2006. Predicting the effects of area closures and fishing effort restrictions on the production, biomass, and species richness of benthic invertebrate communities. *ICES Journal of Marine Science*, 63: 822- 830

Hooker, S.K., Metcalfe, T.L., Metcalfe, C.D., Angell, C.M., Wilson, J.Y., Moore, M.J., and Whitehead, H. 2008. "Changes in persistent contaminant concentration and CYP1A1 protein expression in biopsy samples from northern bottlenose whales (*Hyperoodon ampullatus)* following the onset of nearby oil and gas development. *Environmental Pollution*, 152: 205-216.

Houser, D. S., and Finneran, J. J. 2006. "Variation in the hearing sensitivity of a dolphin population determined through the use of evoked potential audiometry," *Journal of the Acoustical Society of America*,120: 4090-4099.

Hvidt, C.B., et al., 2006, *Hydroacoustic Monitoring of Fish Communities at Offshore Wind Farms,* 2005 Annual Report, Horns Rev Offshore Wind Farm, Vattenfall A/S.

ICES (International Council for the Exploration of the Sea). 2003. *Report of the Benthos Ecology Working Group.* Fort Pierce, Florida, USA 28 April to 1 May 2003. Available online at: http://www.ices.dk/products/CMdocs/2003/E/E0903.PDF. Last accessed June 30, 2010.

Ichthys Marine. 2009. *Options and opportunities for marine fisheries mitigation associated with windfarms.* Draft list of fisheries and environmental mitigation options.

Idaho National Laboratory. 2010. *Geothermal Energy*. Available online at: www.inl.gov/. Last accessed January 19, 2010.

ISO New England Inc (Independent System Operation New England). 2009a. *ISO New England 2009 Regional System Plan.* ISO New England Inc., October 15, 2009. Available online at:www.iso-ne.com. Last accessed January 8, 2010.

ISO New England Inc. 2009b. *ISO New England Rhode Island Profile.* Available online at: www.iso-ne.com/nwsiss/grid_mkts/key_facts/ri_profile.pdf. Last accessed January 8, 2010.

ISO New England Inc. 2009c. *2007 New England Marginal Emission Rate Analysis.* July 2009. Available online from: www.iso-ne.com/genrtion_resrcs/reports/emission/index.html. Last accessed June 1, 2010.

Ingemansson A.B. 2003. *Utgrunden off-shore wind farm— measurements of underwater noise*. Rep 11-00329-03012700. Ingemansson Technology A/S, Göteborg.

International Cable Protection Committee. 2007. *Recommendation No. 13: Proximity of Wind Farm Developments and Submarine Cables.* Available online at: http://www.iscpc.org/. Last accessed November 19, 2009.

International Energy Agency. 2005, *Offshore Wind Experiences*, June. Available online at http://www.iea.org/textbase/papers/2005/offshore.pdf. Last accessed February 23, 2010.

Jensen, H., Kristensen, P.S. and Hoffman, E. 2004. *Sandeels in the Wind Farm Area at Horns Reef.* Elsam Engineering. 26 pp.

Jensen, A.S., and Silber, G.K. 2004. *Large Whale Ship Strike Database,* NOAA Technical Memorandum NMFS-OPR-January 2004, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S Department of Commerce, Silver Spring, MD.

Johnson, M.R., Boelke, C., Chiarella, L.A., Colosi, P.D., Greene, K., Lellis-Dibble, K., Ludemann, H., Ludwig, M., McDermott, S., Ortiz, J., Rusanowsky, D., Scott, M., and Smith, J. 2008. *Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States*. NOAA Technical Memorandum NMFS-NE-209.

JNCC (Joint Nature Conservation Committee). 2009. *ANNEX B - Statutory nature conservation agency protocol for minimising the risk of disturbance and injury to marine mammals from piling noise.* June 2009. JNCC, Aberdeen (www.jncc.gov.uk).

JNCC. 2004. *Guidelines for minimizing acoustic disturbance to marine mammals from seismic surveys*. JNCC, Aberdeen (www.jncc.gov.uk).

Kahlert, J., Petersen, I.K., Fox, A.D., Desholm, M. and Clausager, I. 2004. *Investigations of Birds During Construction and Operation of Nysted Offshore Wind Farm at Rødsand. Annual Status Report 2003.* National Environmental Research Institute Report Commissioned by Energi E2 A/S. Rønde: NERI. Available at: http://uk.nystedhavmoellepark.dk/upload/pdf/Birds2003.pdf. Last accessed March 30, 2010.

Kaiser, M. J., Galanidi, M., Shower, D.A., Elliot, A. J., Caldow, R. W. G., Rees, E. I. S., Stillman, R. A. and Sutherland, W. J. 2006. Distribution and behavior of Common Scoter *Melanitta nigra* relative to prey resources and environmental parameters. *Ibis*, 148:110-128.

Kaiser, M.J.; Spence, F.E., and Hart, P.J. 2000. Fishing-gear restrictions and conservation of benthic habitat complexity. *Conservation Biology*, 14 (5): 1512-1525.

Kenney, R.D. and Vigness-Raposa, K.J. 2009. *Marine Mammals and Sea Turtles of Narragansett Bay, Block Island Sound,Rhode Island Sound, and Nearby Waters: An Analysis of Existing Data for the Rhode Island Ocean Special Area Management Plan*.

Technical Report, May 31, 2009.

Köeller, J., Köeppel, J. and Peters, W. (editors). 2006. *Offshore wind energy: research on environmental impacts.* Springer Publishing, New York.

Koschinski, S., Culik, B.M., Henriksen, O.D., Tregenza, N., Ellis, G., Jansen, C., and Kathe, G. 2003. Behavioural reactions of free-ranging porpoises and seals to the noise of a simulated 2 MW windpower generator. *Marine Ecological Progress Series,* 265: 263-273.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S., and Podesta, M. 2001. "Collisions between Ships and Whales," *Marine Mammal Science*, 17(1):35–75.

Lazell, J.D. Jr. 1980. New England waters: critical habitat for marine turtles. *Copeia*, 2: 290-295.

LeBlanc, E. 2009. "Offshore Wind Farms and the Coast Guard Review Process." Presented at the Rhode Island Sea Grant Ocean SAMP Lecture Series, North Kingstown, RI, July 19, 2009.

LeBlanc, E. U.S. Coast Guard. Personal Communication. April 19, 2010.

Leonhard, S.B. and Pedersen, J. 2005. *Hard Bottom Substrate Monitoring: Horns Rev Offshore Wind Farm.* Annual Status Report 2004. Bio/consult AS.

Lewis et al. 2005. Nocturnal foraging behavior of wintering surf and white-winged scoters. *Condor,* 107:637-647.

Leya, T., Rother, A., Müller, T., Fuhr, G., Gropius, M., and Watermann, B. 1999. Electromagnetic antifouling shield (EMAS) – a promising novel antifouling technique for optical systems. 10th International Congress on Marine Corrosion and Fouling, University of Melbourne, February 1999.

LGL Ecological Research Associates, Inc. 1991, *Effects of Noise on Marine Mammals,* OCS Study MS 90-0093, prepared for U.S. Department of Interior, Minerals Management Service, Atlantic OCS Region, Feb.

Lilley, M.B., Firestone, J., and Kempton, W. 2009. *The Effect of Wind Power Installations on Beach Tourism*. Poster presented at WINDPOWER 2009, Chicago, IL, May 2009. Organized by the American Wind Energy Association.

Linley, E.A.S., Wilding, T.A., Black, K., Hawkins, A.J.S., and Mangi, S. 2007. *Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation.* Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department of Business, Enterprise, and Regulatory Reform (BERR), Contract No: RFCA/005/0029P.

Loder, J.W.B., Petrie, G., and Gawarkeiwicz, G. 1998. The coastal ocean off northeastern North America: a large-scale view. *The Sea*, 11 (Robinson, A.R., & Brink, K.H. eds.), Wiley and Sons, NY, pp. 105-133.

Love, M. S. and Schroeder, D. M. 2006. *Ecological Performance of OCS Platforms as Fish Habitat off California.* MMS OCS Study 2005-005. Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 1435-01-03-CA-72694.

Love, M.S., Schroeder, D.M. and Nishimoto. 2003. *The ecological role of oil and gas platforms and natural outcrops on fishes in southern and central California: a synthesis of information*. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, Seattle, Washington, 98104, OCS Study MMS 2003-032.

Maar, M., Bolding, K., Petersen, J.K., Hansen, J.L.S., and Timmerman, K. 2009. Local effects of blue mussels around turbine foundations in an ecosystem model of Nysted off-shore wind farm, Denmark. *Journal of Sea Research*, 62: 159-174.

Mackinson, S., Curtis, H., Brown, R., McTaggart, K., Taylor, N., Neville, S., and Rogers, S. 2006. *A report on the perceptions of the fishing industry into the potential socio-economic impacts of offshore wind energy developments on their work patterns and income.* Science Series Technical Report, Cefas Lowestoft, 133.

Madsen, F. J. 1954. On the food habits of diving ducks in Denmark. *Dan. Rev. Game Biol*., 2:157–266.

Madsen, P.T.,Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series,* 309: 279-295.

Marra, L.J. 1989. Sharkbite on the SL submarine lightwave cable system: history, causes and resolution. *IEEE Journal of Oceanic Engineering*, 14 (3): 230-237.

McBurnie, Craig. Personal communication. March 15, 2010.

Merrill, J. 2010. *Fog and Icing Occurrence, and Air Quality Factors for the Rhode Island Ocean Special Area Management Plan 2010*. Technical Report.

Michel, J., Dunagan, H. Boring, C., Healy, E., Evans, W., Dean, J. M., McGillis, A. and Hain, J. 2007. *Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf. OCS Report, MMS 2007- 038. July, 2007.*

Miller, J., Potty, G.R., Vigness-Raposa, K., Casagrande, D., Miller, L.A., Nystuen, J. and Cheifele, P.M. 2010. *Acoustic Noise and Electromagnetic Study in Support of the Rhode Island Ocean SAMP*. Technical Report.

MMS (Minerals Management Service). 2010. *Documentation of Section 106. Finding of Adverse Effect for the Cape Wind Energy Project* (Revised). Prepared by B.M. Carrier Jones, editor, Ecosystem Management & Associates, Inc. Lusby, Maryland.

MMS. 2009a. *Cape Wind Energy Project Final Environmental Impact Statement.* January 2009. MMS EIS-EA, OCS Publication No. 2008-040. Available online at: www.mms.gov/offshore/RenewableEnergy/CapeWindFEIS.htm. Last accessed December 9, 2009.

MMS. 2009b. "Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf; Final Rule." *Federal Register*, April 29, 2009, 74(81): 19638-19871.

MMS. 2007a. *Final Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use Facilities on the Outer Continental Shelf.* October 2007. Available online at: http://ocsenergy.anl.gov/documents/fpeis/index.cfm. Last accessed December 7, 2009.

MMS. 2007b. *Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf*. July 2007. OCS Study MMS 2007-038.

MMS. 2003. *OCS Environmental Assessment Revision to the Point Arguello Field Development and Production Plans to Include Development of the Eastern Half of Lease OCS-P0451*. Available at http://www.mms.gov/omm/pacific/enviro/FEA/0451_FEA_body.pdf. Last accessed June 30, 2010.

Minerals Management Service and the U.S. Fish and Wildlife Service. 2009. *Memorandum of Understanding Between the Department of the Interior U.S. Minerals Management Service and the Department of the Interior U.S. Fish and Wildlife Service Regarding Implementation of Executive Order 13186,"Responsibilities of Federal Agencies to Protect Migratory Birds."* Available online at: www.mms.gov. Last accessed April 12, 2010.

Mostello, C. S. 2007. Roseate Tern (*Sterna dougallii*). Massachusetts Natural Heritage Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Westborough, MA. Available online at: www.mass.gov/dfwele/dfw/nhesp/species_info/nhfacts/roseate_tern.pdf. Last accessed May 5, 2010.

Mueller-Blenkle, C., McGregor, P.K., Gill, A.B., Andersson, M.H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D.T. and Thomsen, F. 2010. *Effects of Pile Driving Noise on the*

Behaviour of Marine Fish. COWRIE Ref: Fish 06-08, Technical Report 31st March 2010. Available online at: http://www.offshorewindfarms.co.uk/Assets/COWRIE%20FISH%2006-8_Technical%20report_Cefas_31-03-10.pdf

Mueller-Blenkle, C., Jones, E., Reid, D., Lüdemann, K., Kafeman, R., and Elepfandt, A. 2008. Reactions of cod *Gadus morhua* to low-frequency sound resembling offshore wind turbine noise emissions. *Bioacoustics,* 17 (1-3): 207-209.

Musial, W. 2008a. *Status of Wave and Tidal Power Technologies for the United States.* Technical Report, NREL/TP-500-43240, August 2008.

Musial, W. 2008b. "Offshore Wind Technology." Presentation at the American Wind Energy Association Offshore Wind Power Workshop, Wilmington, DE, September 8-10, 2008.

Musial, W., Butterfield, S. and Ram, B. 2006. *Energy from Offshore Wind.* Conference Paper NREL/CP500-39450. National Renewable Energy Laboratories, February 2006.

National Renewable Energy Laboratory. 2004. Annual PV Solar Radiation (Flat Plate, Facing South, Latitude Tilt)—Static Map. Available online at: http://www.nrel.gov/gis/solar.html. Last accessed January 19, 2010.

National Research Council. 1996. An assessment of techniques for removing offshore structures: committee on techniques for removing fixed offshore structures. Marine Board Commission on Engineering and Technical Systems. Washington, D.C.: National Academy Press.

National Wind Power 2003. *North Hoyle Offshore Wind Farm Baseline Monitoring Report*: June 2003. National Wind Power Ltd.

Nedwell, J. R., Parvin, S. J., Edwards, B., Workman, R., Brooker, A. G. and Kynoch, J. E. 2007. *Measurement and interpretation of underwater noise during construction and operation of offshore windfarms in UK waters.* Subacoustech Report No. 544R0738 to COWRIE Ltd. ISBN: 978-0-9554279-5-4. Available online at: www.offshorewind.co.uk

Nedwell, J. and Howard, D. 2004. *A review of offshore windfarm related underwater noise sources.* COWRIE: Report No. 544 R 0308.

Nedwell, J., Langworthy, J., and Howell, D. 2003. *Assessment of Sub-Sea Acoustic Noise and Vibration from Offshore Wind Turbines and its Impact on Marine Wildlife; Initial Measurements of Underwater Noise During Construction of Offshore Windfarms, and Comparison with Background Noise.* COWRIE: Report No. 544 R 0424.

Nehls, G., Betke, K., Eckelmann, S., and Ros, M. 2007. *Assessment and costs of potential engineering solutions for the mitigation of the impacts of underwater noise arising from the construction of offshore windfarms.* COWRIE Ltd, Newbury, U.K

NERI Report 2006. *Final results of birds studies at the offshore wind farms at Nysted and Horns Rev, Denmark.*

Newell, R.C., Seiderer, L.J., and Hitchcock, D.R. 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanography and Marine Biology: An Annual Review*, 36: 127-178.

Nixon, D. Graduate School of Oceanography, University of Rhode Island. Personal Communication. April 8, 2010.

NOAA National Marine Fisheries Service. 2009. *NOAA Fisheries Biological Opinion*, Appendix J in the Cape Wind Energy Project Final Environmental Impact Statement. Minerals Management Service, January, 2009.

NOAA National Marine Fisheries Service. 2008. Endangered Fish and Wildlife; Final Rule To Implement Speed Restrictions to Reduce the Threat of Ship Collisions With North Atlantic Right Whales. *Federal Register* 73(198): 60173-60191. Friday, October 10, 2008

NOAA National Marine Fisheries Service. 2010. Listing Threatened and Endangered Wildlife and Plants; 90-Day Finding on Petitions to List Porbeagle Shark under the Endangered Species Act. *Federal Register* 75: 39656, 12 July 2010

NOAA National Marine Fisheries Service. 2002a. "Small Takes of Marine Mammals Incidental to Specified Activities; Seismic Reflection Data off Southern California," *Federal Register* 67(121):42541–42547, June 24.

NOAA National Marine Fisheries Service. 2002b. "Small Takes of Marine Mammals Incidental to Specified Activities; Seismic Hazard Investigations in Washington State." *Federal Register* 67 (98) 35793-35799, May 21.

NOAA National Marine Fisheries Service. n.d. "Reducing Ship Strikes to North Atlantic Right Whales." Available online at http://www.nmfs.noaa.gov/pr/shipstrike/. Last accessed October 30, 2009.

Northeast Fisheries Science Center. 2010. Media Advisory: "Record Number of North Atlantic Right Whales Sighted off Rhode Island", April 23, 2010. Available online from: http://www.nefsc.noaa.gov/press_release/2010/MediaAdv/MA1004/index.html

North Western and North Wales Sea Fisheries Committee. N.d. Officer's Report: Wind Farm Consultations.

Nowacek D, Johnson M, and Tyack P. 2004. "North Atlantic right whales *(Eubalaena glacialis)* ignore ships but respond to alarm stimuli." *Proceedings of the Royal Society of Biological Science*, 271: 227–231.

Nowacek, S.M., and R.S. Wells. 2001. Short-Term Effects of Boat Traffic on Bottlenose Dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Marine Mammal Science*, 17: 673–688.

NWP Offshore Ltd. 2007. *North Hoyle Offshore Wind Farm: Annual FEPA Monitoring Report* (2005-06). Available online from: http://www.rwe.com/web/cms/en/311620/rwe-npower- renewables/sites/projects-in-operation/wind/north-hoyle-offshore-wind-farm/environment/

OSPAR Commission. 2009a. *Overview of the impacts of anthropogenic underwater sound in the marine environment.* Publication number 441/2009. Available online at: www.ospar.org. Last accessed March 30, 2010.

OSPAR Commission. 2009b. *Assessment of the environmental impacts of cables.* OSPAR Commission, 2009. Publication number 437/2009. Available online at: www.ospar.org. Last accessed March 30, 2010.

OSPAR Commission. 2008. *Assessment of the Environmental Impact of Offshore Wind-Farms.* Biodiversity Series. Available online at: www.ospar.org. Last accessed March 30, 2010.

OSPAR Commission. 2006. *Review of the Current State of Knowledge on the Environmental Impacts of the Location, Operation and Removal/Disposal of Offshore Wind-Farms.* Status Report April 2006. Available online at: www.ospar.org. Last accessed March 30, 2010.

OSPAR Commission. 2004. *Problems and Benefits Associated with the Development of Offshore Wind-Farms.* Biodiversity Series. Online at: Available online at: www.ospar.org. Last accessed March 30, 2010.

Palmer, R. S. 1949. Maine birds. *Harvard Mus. Comp. Bull*., 102. Cambridge, MA.

Paton, P.W.C., Winiarski, K.J, Trocki, C. L, and McWilliams, S. R. 2010 *Spatial Distribution, Abundance and Flight Ecology of Birds in Nearshore and Offshore Waters of Rhode Island.* Technical Report. 304pp.

Pelc, R. and Fujita, R.M. 2002. "Renewable Energy from the Ocean." *Marine Policy*, 26: 471- 479.

Percival, S.M. 2001. *Assessment of the Effects of Offshore Wind Farms on Birds*. Crown Publishing. ETSU W/13/00565/REO, DTU/Pub URN 01/1434. 96 pp.

Perrin, W.F., Würsig, B., and Thewissen, J.G.M. (eds.) 2002. *Encyclopedia of Marine Mammals.* Second Edition. Academic Press, San Diego, CA.

Petersen, I.K., Christensen, J.K., Kahlert, J., Desholm, M. and Fox, A.D. 2006. *Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark.* NERI Report Commissioned by DONG energy and Vattenfall A/S 2006.

Petersen, J.K., and Malm, T. 2006. Offshore Windmill Farms: Threats to or Possibilities for the Marine Environment. *Ambio*, 35(2): 75-80.

Pettersson, J. 2005. *The Impact of Offshore Wind Farms on Bird Life in Southern Kalmar Sound, Sweden: A Final Report Based on Studies* 1999-2003.

Pilson, M.E.Q. 2008. Narragansett Bay amidst a globally changing climate. In: *Science for Ecosystem-based Management: Narragansett Bay in the 21st Century.* Desbonnet, A., and Costa-Pierce, B.A. (eds.) Springer. pp. 35–46.

Popper, A.N., Carlson, T.J., Hawkins, A.D., and Southall, B.L. 2006. *Interim criteria for injury of fish exposed to pile driving operations: a white paper*. Available at: www.wsdot.wa.gov/NR/rdonlyres/84A6313A-9297-42C9-BFA6750A691E1DB3/0/BA_PileDrivingInterimCriteria.pdf. Last accessed April 10, 2010.

Popper, A.N., Hastings, M.C. 2009. The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology*, 75: 455-489.

Popper, A.N., Smith, M.E., Cott, P.A., Hanna, B.W., MacGillivary, A.O., Austin, M., and Mann, D.A. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America*, 117:3958-3971

Redlinger, R., P.D., Andersen and P.E. Morthorst, 2002. *Wind energy in the 21st century: economics, policy, technology, and the changing electricity industry.* Palgrave Publishing, New York, NY.

Regional Greenhouse Gas Initiative (RGGI). 2010. Available online at: http://www.rggi.org. Last accessed January 18, 2010.

Reinert, S.E., Lapham, E., and Gaffett, K. 2002. Landbird migration on Block Island: community composition and conservation implications for an island stopover habitat. In: Paton, P.W., Gould, L.L., August, P.V., and Frost, A.O. (eds), *The Ecology of Block Island. Proceedings of the Rhode Island Natural History Survey Conference, October 28, 2000*. The Rhode Island Natural History Survey, Kingston, RI. pp. 151–168.

Rhode Island Economic Development Corporation. 2010a. *Jobs Development Act: Corporate Income Tax Reduction for Job Creation.* Available online at:

http://www.riedc.com/business-services/business-incentives/corporate-income-tax-reduction-for-job-creation. Last accessed February, 2010.

Rhode Island Economic Development Corporation. 2010b. "Rhode Island Receives $22.3 Million Stimulus Grant to Support Improvements at Quonset." Available online at: http://www.riedc.com/news/2010/02/stimulus-grant-quonset. Last accessed February 25, 2010.

Rhode Island Office of Energy Resources. 2010. *Rhode Island State Energy Plan*, Rhode Island Office of Energy Resources. Available online at: http://stac.ri.gov/files/0000/0148/RI_State_Energy_Plan_Working_Draft-1.pdf. Last accessed March 10, 2010.

Rhode Island Office of Statewide Planning. 2002. *Rhode Island Energy Plan 2002*. Report # 103 Element 781, August 2002. Available online at: www.planning.ri.gov/ed/rienp2002.htm. Last accessed January 8, 2010.

Rhode Island Public Utilities Commission. 2010a. *Block Island Power Company, Summary of Residential Electric Rates, January 2008- December 2009*.

Rhode Island Public Utilities Commission. 2010b. *Rhode Island Renewable Energy Standard Annual RES Compliance Report for Compliance Year 2008*. Rhode Island Public Utilities Commission, February 2010.

Rhode Island Public Utilities Commission. 2009. *Rhode Island Renewable Energy Standard Annual RES Compliance Report for Compliance Year 2007*. Rhode Island Public Utilities Commission, February 2009.

Rhode Island Resource Recovery Program. 2007. *Rhode Island Comprehensive Solid Waste Management Plan.* State Guide Plan Element 171.Adopted for the period April 12, 2007 through April 12, 2012.

Richardson, W.J., Malme, C.I., Green, C.R.Jr. and Thomson, D.H. 1995. *Marine Mammals and Noise.* Academic Press, San Diego, CA. 576 pp.

Roark, T. 2008. Offshore wind energy: An International Perspective. Presented at Roger William's Marine Law Symposium: A Viable Marine Renewable Energy Industry: Solutions to Legal, Economic and Policy Challenges. Bristol, RI, October 23-24. Available online at: http://law.rwu.edu/sites/marineaffairs/symposia/seventhMLS.aspx. Last accessed January, 31 2010.

Robinson, M. C. and Musial, W. 2006. "Offshore Wind Technology Overview." National Renewable Energy Laboratories (NREL) Report, NREL/PR-500-40462. Accessed online at: http://www.nrel.gov/docs/gen/fy07/40462.pdf. Last accessed September, 2008.

Rodmell, D.P., and Johnson, M.L. The Development of Marine Based Wind Energy Generation and Inshore Fisheries in UK Waters: Are They Compatible? In Johnson, M. and C. Wheatley, eds. *Who Owns the Sea* Workshop Proceedings, Tjarno, Sweden, 24 - 27 June 2002.

Ross, D. 1976. *Mechanics of Underwater Noise*. Pergammon Press, New York, NY.

Royal Yachting Association and the Cruising Association. 2004. *Sharing the Wind: Recreational Boating in the Offshore Wind Farm Strategic Areas.* Online at http://www.rya.org.uk/sitecollectiondocuments/legal/Web%20Documents/Environment/Sharing%20the%20Wind%20compressed.pdf as of

Ryan, P.G. 1988. "Effects of Ingested Plastic on Seabird Feeding: Evidence from Chickens." *Marine Pollution Bulletin*, 19:174–176.

Schroeder, C. L. 2000. *Population Status and Distribution of the Harbor Seal in Rhode Island Waters*. M.S. thesis. University of Rhode Island, Graduate School of Oceanography, Narragansett, RI. xiii + 197 pp.

Seimens Wind Power AS. 2008. *SWT- 3.6-107 Technical Specifications*. Document PG-R3-10- 0000-0054-06, PNI/15.08.2008.

Soldal, A.V., Svellingen, I., Jørgensen, T., and Løkkeborg, S. 2002. Rigs-to-reefs in the North Sea: hydroacoustic quantifications of fish in the vicinity of a "semi-cold" platform. *ICES Journal of Marine Secence*, 59: S281-S287.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R. Jr., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals 33: 411-521

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R. Jr., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Still, D., Little, B. and Lawrence, S. 1996. *The Effects of Wind Turbines on the Bird Population at Blyth Harbour*. DTI contract ETSU W/13/00394/REPORT.

Spaulding, M. L., Grilli, A. Crosb, A. and Sharma, R. 2010a. *Evaluation of wind statistics and energy resources in southern RI coastal waters.* Ocean Engineering, University of Rhode Island, Narragansett, RI. Technical Report.

Spaulding, M. L., Grilli, A., Damon, C., and Fugate, G. 2010b. *Application of Technology Development Index and Principal Component Analysis and Cluster Methods to Ocean Renewable Energy Facility Siting.* Technical Report.

Spaulding, M.L., Grilli, A, Damon, C. and Sharma, R. 2010c. *High Resolution Application of the Technology Development Index (TDI) in State Waters South of Block Island.* Ocean Engineering, University of Rhode Island, Narragansett, RI. Technical Report.

Spaulding, M. L, Sharma, R., Grilli, A., Bell, M., Crosby, A. and Decker, L. S. 2010d. *Wind Resource Assessment in the Vicinity of a Small, Low Relief Coastal Island.* Ocean Engineering, University of Rhode Island, Narragansett, RI. Technical Report.

Spaulding, M. 2008. Sources of Renewable Ocean Energy in Rhode Island. Presentation to the Coastal Resources Management Council, March 11, 2008.

Talisman Energy (UK) Limited and Scottish and Southern Energy. 2007. *The Beatrice Wind Farm Demonstrator Project Background.* Available online at: http://www.beatricewind.co.uk/home/. Last accessed February 2, 2010.

Technology Service Corporation. 2008. *Report of the Effect on Radar Performance of the Proposed Cape Wind Project.* Submitted to the United States Coast Guard, December 16, 2008. USCG Order #HSCG24-08-F-16A248, Cape Wind Radar Study.

Thomsen, F., Lüdemann, K., Kafemann, R., and Piper, W. 2006. Effects of offshore wind farm noise on marine mammals and fish, biola, Hamburg, Germany on behalf of COWRIE Ltd.

Thomson, D.H., and R.A. Davis, 2001. *Review of the Potential Effects of Seismic Exploration on Marine Animals in the Beaufort Sea,* prepared by LGL Limited, for Fisheries and Oceans Canada, Yellowknife, Northern Territories, Canada. Available at http://www.czc06.ca/ bsimpi/2001/REVIEW_OF_THE_POTENTIAL_EFFECTS_OF_SEISMIC_EXPLORATION_ON_M.pdf.

Tougaard, J., Tougaard, S., Jensen, R.C., Jensen, T., Teilmann, J., Adelung, D., Liebsch, N. and Muller, G. 2006. *Harbour seals at Horns Reef before, during and after construction of Horns Rev Offshore Wind Farm.* Final report to Vattenfall A/S. October 2006.

Tougaard, J., Carstensen, J., Teilmann, J., and Bech, N. I. 2005. *Effects of the Nysted Offshore wind farm on harbour porpoises.* Technical report to Energi E2 A/S. NERI, Roskilde.

Tougaard, J., Carstensen, J., Henriksen, O. D., Skov, H., and Teilmann, J. 2003. *Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef.* Technical report to Techwise A/S, HME/362-02662. Hedeselskabet, Roskilde.

Tulp, I., Schekkerman, H., Larsen, J.K., van der Winden, J., van de Haterd, R.J.W., van Horssen, P., Dirksen, S. and Spaans, A.L. 1999. *Nocturnal Flight Activity of Sea Ducks Near the Windfarm Tunø Knob in the Kattegat.* Novem, Utrecht, The Netherlands. 70 pp.

U.K. Department of Trade and Industry. 2007. "Study of the costs of offshore wind generation." A report to the Renewables Advisory Board & DTI. URN Number 07/779. Available online at: www.berr.gov.uk.

U.K. Department of Trade and Industry. 2006. *Aerial Surveys of Waterbirds in Strategic Windfarm Areas: 2004/05*. Final Report. 176 pp.

United Kingdom Maritime and Coastguard Agency. 2008. *Offshore Renewable Energy Installations (OREIs): Guidance to Mariners Operating in the Vicinity of UK OREIs.* Mariner Guidance Notice, MGN372 (M+F), August 2008.

U.S. Coast Guard. 2009. *Coast Guard Assessment of Potential Impacts to Marine Radar as it Relates to Marine Navigation Safety from the Nantucket Sound Wind Farm As Proposed by Cape Wind, LLC*. January 2009.

U.S. Coast Guard. 2007. *Guidance on the Coast Guard's Roles and Responsibilities for Offshore Renewable Energy Installations*. Navigation and Vessel Inspection Circular No. 02-07, COMDTPUB P16700.4.

U.S. Department of Commerce. 2008. Taking of Marine Mammals Incidental to Specified Activities; Construction of the East Span of the San Francisco-Oakland Bay Bridge. *Federal Register*, July 3, 2008. pp. 38180-38183.

U.S. Department of Defense, 2006, *Report to the Congressional Defense Committees: The Effect of Windmill Farms on Military Readiness*, Office of the Director of Defense Research and Engineering, Washington, DC.

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. 2010. *Wind Powering America, Rhode Island Wind Resource Map.* Available online at: http://www.windpoweringamerica.gov. Last accessed February 10, 2010.

U.S. Department of Energy. 2010a. *U.S. Geothermal Resource Map.* Office of Energy Efficiency and Renewable Energy. Available online at: http://www1.eere.energy.gov/geothermal/geomap.html.

U.S. Department of Energy. 2010b. *Ocean Thermal Energy Conversion.* Office of Energy Efficiency and Renewable Energy. Available online at: www.eere.energy.gov. Last accessed January 18, 2009.

U.S. Department of Energy. 2010c. State Assessment for Biomass Resources: Rhode Island Potential Biofuel Production. Available online at: www.afdc.energy.gov. Last accessed July 6, 2010.

U.S. Department of Energy. 2008. *20% Wind Energy by 2030*. U.S. Department of Energy, Washington, DC, July 2008, 248 pp.

U.S. Department of Energy. 2004. *White Paper: Natural Gas in the New England Region: Implications for Offshore Wind Generation and Fuel Diversity.*

U.S. Department of the Interior Bureau of Land Management and U.S. Department of Energy Energy Efficiency and Renewable Energy. 2003. *Assessing the Potential for Renewable Energy on Public Lands.* DOE/GO-102003-1704, February 2003.

U.S. Energy Information Administration. 2010. *Annual Energy Outlook 2010, Early Release Overview*. Report No. DOE/EIA-0383.Washington, DC: EIA. 2009. Available online at: http://www.eia.doe.gov. Last accessed March 14, 2010.

U.S. Energy Information Administration. 2009. *Expansion of the U.S. Natural Gas Pipeline Network: Additions in 2008 and Projects through 2011*. Energy Information Administration, Office of Oil and Gas, September 2009. Available online at: http://www.eia.doe.gov. Last accessed April 12, 2010.

U.S. Energy Information Administration. 2008a. Annual Energy Outlook 2008. Available online at: http://www.eia.doe.gov/. Last accessed February 25, 2010.

U.S. Energy Information Administration. 2008b. *Emissions of Greenhouse Gases in the United States 2007*, Department of Energy, Report No. DOE/EIA-0573, Washington, D.C. Available online at: http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html

U.S. Energy Information Administration. 2006. *Annual Energy Outlook 2006*. Report No. DOE/EIA-0383.Washington, DC: EIA. February 2006.

U.S. EPA, Office of Air and Radiation. 2009. Home page. Available online at: http://www.epa.gov/air/. Last accessed July 9, 2010.

U.S. Fish and Wildlife Service. 1996. *Piping Plover (Charadrius melodus) Atlantic Coast Population Revised Recovery Plan.* Prepared by the Atlantic Coast Piping Plover Recovery Team for the U.S. Fish and Wildlife Service Region Five. Hadley, Massachusetts.

Vaitkus, G., and Bubinas, A. 2001. Modelling of sea duck spatial distribution in relation to food resources in Lithuanian offshore waters under the gradient of winter climatic conditions. *Acta Zoologica Lituanica*, 11: 1392-1657.

Valentine, P., Collie, J., Reid, R., Asch, R., Guida, V., and Blackwood, D. 2007. The occurrence of the colonial ascidian *Didemnum sp.* on Georges Bank gravel habitat—Ecological observations and potential effects on groundfish and scallop fisheries. *Journal of Experimental Marine Biology and Ecology*, 342:179-181.

Wahlberg, M., and Westerberg, H. 2005. Hearing in fish and their reactions to sounds from offshore wind farms. *Marine Ecology Progress Series*, 288: 295-309.

Washington DOT. 2005. *Washington State Department of Transportation, 2006, WSDOT's Guidance for Addressing Noise Impacts in Biological Assessments.* Available at: http://www.wsdot.wa.gov/Environment/Biology/BA/BAguidance.htm#Noise. Last accessed March 9, 2010.

Westerberg, H., Lagenfelt, I. 2008. Sub-sea power cables and the migration behaviour of the European eel. *Fisheries Management and Ecology*, 15: 369-375.

White, S., and Kulsinski, G. 1998. Net Energy Payback and CO_2 Emissions from Wind Generated Electricity in the Midwest, Report No. UWFDM-1092, Madison, WI: Fusion Technology Institute, University of Wisconsin. Available online at: http://fti.neep.wisc.edu/pdf/fdm1092.pdf. Last accessed July 9, 2010.

Whitmarsh, D., Neves Santos, M., Ramos, J., and Costa Monteiro, C. 2008. Marine habitat modification through artificial reefs off the Algarve (southern Portugal): An economic analysis of the fisheries and the prospects for management. *Ocean and Coastal Management*, 51: 463-468.

Whormesley, P. and Picken, G.B. 2003. "Long-term dynamics of fouling communities found on offshore installations in the North Sea." *Journal of Marine Biological Association UK*, 83: 897-901.

Wilhelmsson, D., and Malm, T. 2008. Fouling assemblages on offshore wind power plants and adjacent substrata. *Estuarine, Coastal, and Shelf Science*, 79: 459-466.

Wilhelmsson, D., Malm, T., and Öhman, M.C. 2006. The influence of offshore windpower on demersal fish. *ICES Journal of Marine Science*, 63: 775-784.

Wizelius, T. 2007. *Developing wind power projects: theory and practice.* Sterling, VA, Earthscan Publishing.

Wright, S.D., et al. 2002. *Transmission Options for Offshore Wind Farms in the United States,* Renewable Energy Research Lab, University of Massachusetts. Available at: http://www.ecs.umass.edu/mie/labs/rerl/pubs/2002/AWEA2002Transmission.pdf. Last accessed February 1, 2010.

Ydenberg and Guillemetter. 1991. Diving and foraging in the Common Eider. *Ornis Scandinavica*, 22:349-352

Zimmermann, S., Zimmermann, A.M., Winters, W.D., and Cameron, I.L. 1990. Influence of 60- Hz magnetic fields on sea urchin development. *Bioelectromagnetics*, 11: 37-45.

Chapter 9: Other Future Uses

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Section 900. Introduction

1. It has been recognized globally that there is a need to conserve ocean ecosystems and use ocean space as efficiently as possible, thus requiring planning for multiple uses of compatible activities, and the development of strategies to promote, enhance, and optimize the multiple uses in order to protect ocean ecosystems and conserve ocean space (Mee 2006). Rhode Island has used SAMPs as innovative, ecosystem-based planning frameworks, each of which have unique policy drivers (Figure 9.1). Policy drivers will change over time and inform implementation actions for the future as multiple uses of ocean space and additional human interventions are considered. Adding new uses will continue changes to the natural, marine, and social ecosystems. The trajectory of these changes could result in a more vibrant, innovative, marine economy with compatible uses. This chapter is unlike others in the Ocean SAMP, as it not simply a compilation of and considerations of findings of fact about the Ocean SAMP region. Rather, this chapter explores opportunities for the future uses and conservation of the Ocean SAMP area—the inner shelf—of Block Island and Rhode Island Sounds, and discusses the potential of these to help develop and protect Rhode Island's ocean ecosystems and green economies. These possible future uses of the Ocean SAMP region are summarized in Table 9.1.

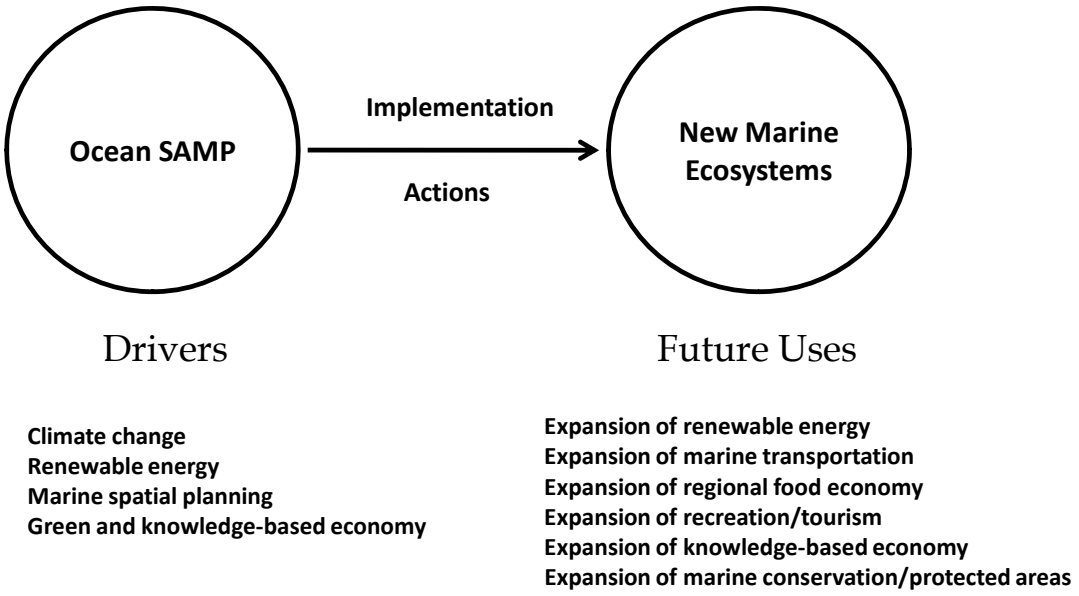


Figure 9.1. Policy drivers for the Ocean SAMP that will lead to implementation of future uses and result in "new" marine ecosystems.

2. The principles and practices of ecological engineering (Mitsch and Jorgesen 2004) could be helpful as an overall design and implementation pedagogy to determine compatible, multiple uses of similar ocean space. Industrial ecology is another important idea as an organizing framework for the analysis of potential multiple uses, and includes life cycle assessments and material flow accounting, as well as ecological economics. Engineering and ecological knowledge of processes occurring in the Ocean SAMP region will not be enough to move forward with social and policy changes for future uses. Stakeholder

interest will remain high throughout the implementation of any future uses. A participatory framework for the engagement of stakeholders, such as the one implemented during this Ocean SAMP process (Dalton 2005), will need to be continued throughout implementation of the Ocean SAMP in order to ensure social, economic, and environmental compatibility. There will be a rapid turnover of ideas associated with new opportunities for future uses of the Ocean SAMP area. This will require a continuation of an organized, participatory stakeholder process as new uses are explored so that information can be shared constructively and systematically, and, over the longer term, informed decisions can be made, and potentially significant benefits for all stakeholders could be realized.

Table 9.1. Possible benefits and management issues that need to be considered for possible future uses of the Ocean SAMP region as reviewed in this chapter.

Future Uses	**Potential Benefits**	**Management Considerations**
Use for Mining	Local sources for aggregates; decreased mining and transportation costs.	Economic viability vs. future alternatives questionable; environmental conflicts due to habitat destruction.
Use for LNG	Favorable economics; well developed infrastructure in place; offshore development viewed as safer.	Environmental, safety and regulatory concerns; increased ship traffic; increased underwater sound affecting marine mammals and fisheries; conflicts with increased recreational uses; increased security risks; increased ecological risks from the spread of invasive species.
Short Sea Shipping	Favorable economics and more efficient than land-based transportation; avoids land-based gridlock; new investments for R.I. ports.	Increased sea vessel traffic; increased underwater sound affecting marine mammals and fisheries; conflicts with increased recreational uses; increased security risks; increased ecological risks from the spread of invasive species.
Marine Reserves for Conservation	Ecosystem restoration; enhanced biodiversity; enhanced recreational opportunities; increased education/research values.	Space removed from extractive uses; conflicts with fisheries interests.
Marine Reserves for Fisheries Enhancement.	Fisheries restoration and localized biodiversity increases; enhanced recreational and education/research values.	Space removed from extractive uses; conflicts with fisheries interests.
Placement of Artificial Reefs for	Localized biodiversity increases; can create	Controversy over values to fisheries; replacement costs high;

Fisheries Enhancement	upwellings and possible fisheries enhancement; increased education/research values.	New permitting and regulatory issues; use conflicts.
Shellfish Biofouling Control	Removes drag on offshore structures/towers; new sources of local seafood production; new marine economic development.	Safety concerns due to the use of divers; seafood safety and regulatory issues; additional vessels present use conflicts.
Submerged Shellfish Aquaculture	Local seafood production; ecosystem benefits from improved habitats and water quality; most economically viable form of aquaculture in R.I.; replaces Canadian imports; new marine economic development.	Conflicts with industrial use of alternative energy structures; new lease and regulatory issues arise in offshore areas; regulatory changes needed due to scale of developments; increased use conflicts, especially vessel traffic.
Submerged Finfish Aquaculture	Local seafood production; new marine economic development.	Future competition with restored marine fisheries products; regulatory changes needed; no finfish aquaculture infrastructure in R.I. or Southern New England; concerns regarding environmental impacts; use conflicts.
Submerged Algae Aquaculture	Local seafood production; new developments of biotechnologies and bioactive compounds production; new marine economic development.	Existing technologies untested; ocean environment may be unsuitable; economics unfavorable; new regulatory regime needs to be put into place.
Enhanced Ecotourism	Recreation economy enhanced.	Increased vessel traffic; conflicts with commercial uses.
Burials and Cemeteries	Land saved; new economic/tourism development.	Displacement of benthic habitats; space removed from extractive uses; new regulations and changes to existing regulations needed; use conflicts.
Desalinization	Buffer droughts; conserve surface waters.	Currently only economically feasible in desert areas; discharges could impact marine ecosystems.

Research and Education Center	Builds the innovation and knowledge-based economy; attracts international/national cooperation and funding.	Space removed from commercial uses; sustainability of funding questionable; new institutional cooperation, coordination, logistics needed.

Section 910. Use for Mining

1. Demands for sand and gravels for beach nourishment and construction (concrete) are increasing, especially from marine resources on the continental shelf as traditional, land-based sources of these materials have been reduced. This shift to the use of offshore resources will expand, especially in marine areas having large concentrations of glacial deposits (Johnson et al. 2008).

2. Aggregates in Rhode Island are largely locked up by the needs for subdivisions, or these resources are held in R.I. Department of Environmental Management parks or open spaces. Much of the sand on Rhode Island beaches currently comes from glacial materials found in upland sources and coastal lagoons. With sea level rise there will be a greater need for aggregates for coastal armoring projects, which could outstrip supply. However, other "soft" shoreline solutions could be alternatives to armoring which can compound shoreline erosion downstream.

3. There is currently no information concerning the amount of usable sand or gravel deposits, or other aggregated material, located within the Ocean SAMP study area. Efforts are being made to conduct sub-bottom profiling and monitoring of Block Island's inner shelf to investigate the geological structure and mineral distribution within the area (Boothroyd pers. comm.).

4. Potential impacts from offshore mineral mining include removal of substrates that serve as important habitats for fish and invertebrates, creation of less productive marine benthic sites due to anoxia, release of harmful or toxic materials associated directly or indirectly with the mining process, burial of productive habitats during beach nourishment or other shoreline stabilization activities, and creation of harmful suspended sediment levels upon mineral extraction that can potentially have secondary and indirect adverse effects on fishery habitats at the mining sites and surrounding areas (Johnson et al. 2008).

Section 920. Use for Liquefied Natural Gas (LNG) Facilities

1. Natural gas is the fastest growing source of energy for consumption worldwide. Natural gas makes up about a quarter of all energy consumed in the United States every year (Foss 2007a, 2007b), with LNG accounting for approximately 2% of U.S. natural gas supply (Foss 2007a, 2007b). Demand for natural gas in the United States has accelerated due to environmental concerns about other energy resources, rising natural gas prices, and the possibility of domestic shortages (Parfomak et al. 2004).

2. Natural gas is used in homes for heating and cooking, and can also be used to generate electricity. In locations where pipeline capacity from supply areas is expensive and use is highly seasonal, LNG storage can help reduce pipeline capacity commitments, and can be an important fuel during peak power periods (Energy Information Administration 2003).

3. The physical properties of LNG allow for long-distance transport by ship and for local distribution by truck onshore. Liquefaction of natural gas also provides the opportunity to store it for use during high consumption periods close to demand centers, as well as in areas where geologic conditions are not suitable for developing underground storage facilities. In New England, underground storage is lacking, and LNG is a critical part of the region's supply during winter (Energy Information Administration 2003). To meet these needs, new onshore and offshore LNG plants have been proposed for southern New England. Rhode Island receives all of its LNG from shore-based pipelines; there is one existing jurisdictional peak shaving site in Providence operated by Keyspan LNG, Inc.

4. Current projects are expanding the capacity of existing pipelines into the Northeast (Gaul 2009). This report indicates there are multiple recent projects in the Northeast during 2008 to bring regasified natural gas to market from LNG import terminals, suggesting that domestic sources of natural gas supplies may now be able to meet projected future demands.

5. The U.S. has the largest number of LNG facilities in the world – 113 active facilities spread across the country, with a higher concentration of the peak shaving and satellite facilities in the Northeast. Peak shaving is the most common use of LNG in the U.S. It is a way local electric power and gas companies or utilities store gas for peak demand that cannot be met via typical pipeline sources; this can occur during the winter heating season or for air conditioning during the summer months (Foss 2007a). LNG is a hazardous liquid that, since 1959, has increasingly been transported by sea using specially designed ships (Spaulding et al. 2007). Ships are double-hulled and insulated to prevent leakage or rupture in an accident; a typical carrier measures 900' in length, 140' in width and 36' draft, and costs $160 million to build - similar in size to an aircraft carrier (Foss 2007a).

6. The U.S. uses more energy than it produces. There are currently nine operating receiving LNG terminals throughout the country (Center for LNG n.d.). One of these is an offshore terminal located in Massachusetts Bay, 13 miles offshore from Boston – Northeast Gateway Deepwater Port, Excelerate Energy's second buoy-based offshore receiving terminal, which received its first shipment in May 2008. The physical infrastructure of Northeast Gateway consists of a dual submerged turret loading buoy (STL Buoy) system

and an approximately 16 mile-long pipeline connecting into the existing HubLine pipeline (Excelerate Energy n.d.). LNG tankers unload their cargo at dedicated marine terminals which store and regasify the LNG for distribution to domestic markets. Offshore terminals regasify and pump the LNG directly into offshore natural gas pipelines (Figure 9.2), or may store LNG in undersea salt caverns for later injection into offshore pipelines.

7. There are currently no existing or proposed offshore LNG terminals in Rhode Island. Import terminals have been proposed in coastal regions throughout the United States, including Mt. Hope Bay in Fall River, Mass. and Long Island Sound, New York, which would present various impacts within the Ocean SAMP study area around Block Island and in Rhode Island Sound.

8. Rhode Island waters could be affected by increased traffic from LNG tankers through Narragansett Bay and Rhode Island Sound, through the Ocean SAMP study area, by proposed offshore LNG facilities in Mount Hope Bay, Fall River, Mass. and in Long Island Sound, New York/Connecticut. Weaver's Cove Energy has proposed to build an offshore berth in coastal waters of Mount Hope Bay to serve as an offshore unloading dock and buried LNG transfer pipelines. The proposed LNG terminal location is one mile southwest of Brayton Point, Somerset, MA and one mile from shore; the channel would be dredged to accommodate LNG vessel berthing and turning; four-mile LNG transfer lines would transfer imported fuel to storage tanks at the FERC-approved terminal site (Kirkland 2008).

9. There are safety concerns with offshore LNG. Spaulding et al. (2007) examined a partial spill due to an accident or a deliberate attack for an LNG tanker in Block island Sound, with the LNG spreading along the water, gradually evaporating, mixing with air until it could, potentially, catch fire. Depending on the direction of the wind and the size of the spill, they found harm could be substantial. Given these concerns, Spaulding has come up with a hypothetical new LNG terminal plan, for an offshore site in Block Island Sound, completing simulations and gathering information on similar proposals nationwide.

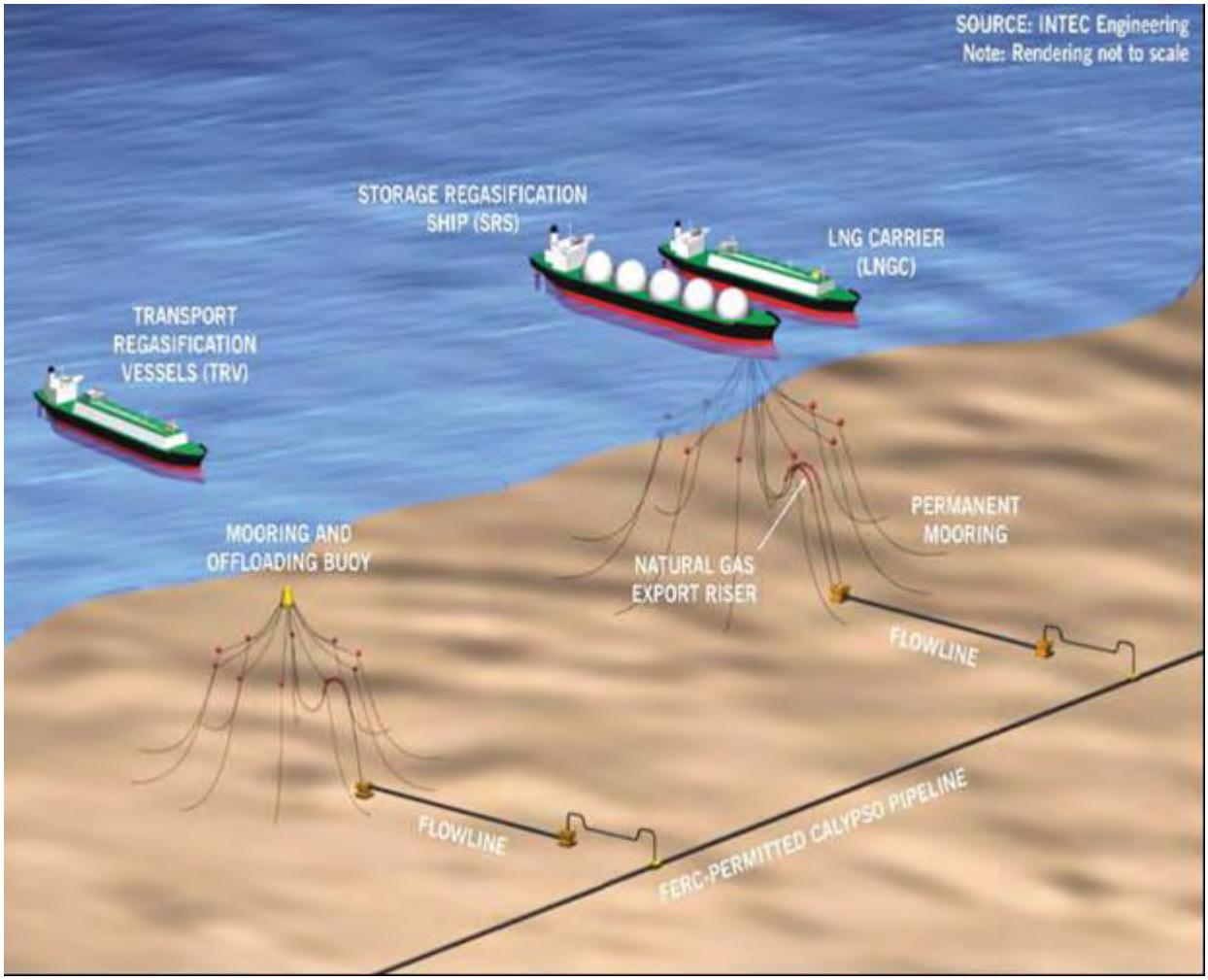


Figure 9.2. Example of an offshore LNG facility proposed eight to 10 miles off the coast of Florida by Suez Energy International (McGinnis 2008).

10. Existing and proposed facilities in the Northeast region are described in Table 9.2 below:

Table 9.2. Existing and proposed offshore LNG facilities in the Northeast region.

Places	**Projects**	**Descriptions**
Boston Harbor, Mass.	AES Battery Rock LNG, AES Corp (proposed)	11 million cubic meters per day facility in Boston Harbor.
Gloucester, Mass.	Neptune LNG, the GDF Suez S.A. (Euronext: GSZ, GSZB)	Currently building an LNG facility off the coast of Gloucester, Mass. that would handle 11 million cubic meters per day.

Cape Ann, Mass.	Northeast Gateway Project	Excelerate Energy owned terminal in Cape Ann, Mass. Received its first shipment in May 2008; capacity of 22.6 million cubic meters per day
Fall River, Mass.	Weaver's Cove LNG, Weaver's Cover Energy (proposed)	proposed 22.6 million cu m terminal in Mt. Hope Bay

11. Potential impacts of offshore LNG are: (a) increased marine traffic through Rhode Island Sound and around Block Island, (b) ecological disruption to fish populations, and whale migratory patterns, (c) decreased fisheries from the entrainment of fish eggs and larvae, and (d) habitat losses due to dredging and disposal for construction (Gallaway et al. 2007). In addition, there would be a limitation of use of waterways during ship transit due to the need for security zones.

12. In Massachusetts, Excelerate is operating a closed-loop system, where the water is recycled, mostly because North Atlantic waters are too cold most of the time to vaporize the LNG. Each ship in this system will suck in less than five million gallons a day. Closed-loop systems might have impacts on fish eggs and larvae and impact overall production of the ecosystem because other species feed on the larvae and eggs. In addition, fishermen have opposed the terminal location on the grounds that the site is located in prime lobster and ground fishing areas.

Section 930. Short Sea Shipping

1. Widely used in Europe, short sea shipping is the movement of goods domestically, usually containerized, aboard small vessels and barges, with the goal of reducing truck traffic on congested highways. Short sea shipping relies on small vessels rather than deep draft container ships. Instead of offloading containers at a large port and having them trucked along I-95, international shipments would instead arrive into a major port such as the Port of New York/New Jersey; then goods would be parceled out to smaller vessels and barges that would travel along the coast. Vessels would have roll-on-roll-off, 53-foot trailers. Smaller vessels and barges could carry hundreds of trailers and not require dredging for deep draft container ships.

2. There is great interest in short sea shipping (Institute for Global Maritime Studies 2008) because: (a) marine transportation systems are less expensive, and short sea ships could be powered by LNG; (b) the I-95 corridor faces gridlock by 2035 since no new upgrades for the highway system are planned over the next 20 years, and without any further improvements to the corridor, projected average daily traffic would be over 133,000, including over 20,000 trucks. Virtually 100% of the highway's urban segments would be congested and congestion for non-urban corridors would increase from the current 26% to over 55%; (c) with the prediction of future cap and trade systems, short sea shipping would be more efficient, profitable and environmentally friendly (Institute for Global Maritime Studies 2008); and (d) hurricanes may become more frequent due to climate warming globally, especially in the Northeast (see Chapter 3, Global Climate Change). A Category 3 northeast hurricane would cut off segments of both I-95 and Amtrak rail systems for substantial periods of time. In short, expansion of short sea shipping would create a redundant, more resilient, intermodal cargo transportation system.

3. Total tonnage of cargo processed by the Port of New York and New Jersey, the major gateway for southern New England, has grown rapidly from 2004 to 2007 (USACE 2004, 2007). The corridor between Boston, New York, and Washington DC has been proposed as an attractive region in which to develop short sea shipping routes due to the present and future projections of traffic congestion, the region's population density, and the availability of port facilities (Rhode Island Economic Monitoring Collaborative 2007). Providence could serve as a central hub for short sea shipping (Rhode Island Economic Monitoring Collaborative 2007; National Ports and Waterways Institute 2004). The Quonset Business Park was awarded $22.3 million in federal stimulus funds in 2010 to improve piers, roads, and rails, plus funds to install a crane in preparation for offshore wind development. Funds will allow the Port of Davisville to be developed as a short-sea shipping port that will accommodate shallow-draft barges loaded with containers from larger ports on the East Coast. The port's vision is to expand into the short sea shipping industry, and produce renewable energy. State officials estimate that new operations at the port could inject $120 million into the RI economy and create up to 1,000 long-term jobs. Of course, commercial ocean traffic in the Ocean SAMP area may increase in the future if a short sea shipping industry develops in Rhode Island (RIEDC 2009). For further information on ship traffic in the Ocean SAMP area see Chapter 7, Marine Transportation, Navigation, and Infrastructure.

4. Potential impacts of short sea shipping are: (a) increased sea vessel traffic, (b) increased underwater sound affecting marine mammals and fisheries, (c) conflicts with increased recreational uses, (d) increased security risks, and (e) increased ecological risks from the spread of invasive species.

Section 940. Marine Conservation and Fisheries Enhancement

1. The Ocean SAMP region could, as a whole, or in part, contain designated areas for single use, multiple uses, or the entire area could be designated as a closed, no use area, or any number of mixtures of these options. Figure 9.3 shows the wide range of options available and reviewed here. The Ocean SAMP region could as a whole, or in part, be allocated into a range of completely no take areas (marine reserves), an area of completely open access, or a mixture of these two with and without placement of additional structures (artificial reefs) which could have benefits for both marine conservation and marine fisheries. Reserves have also been used in combination with artificial reefs in a designed approach to enhance both marine ecosystems and fisheries.

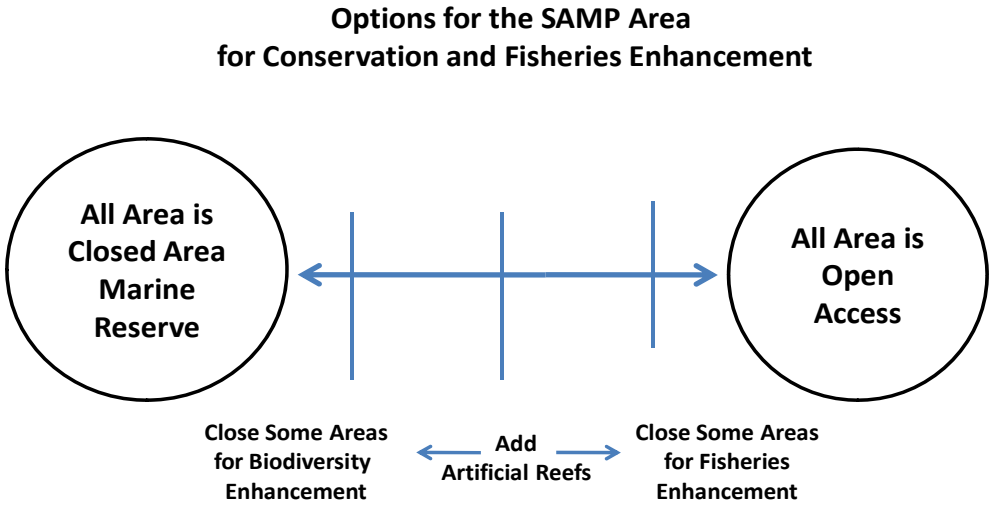


Figure 9.3. Options for the Ocean SAMP area for conservation and fisheries enhancement.
A range of marine area management options exist for the Ocean SAMP area for biodiversity and fisheries enhancement. Options span the gamut from complete to partial closures, plus adding artificial reefs for biodiversity, recreation and commercial benefits.

940.1 Enhancing Marine Conservation

1. According to the World Conservation Union (IUCN), an MPA is "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Laffoley 2008, 7). There are different types of MPAs: (a) reserves, (b) conservation areas, (c) parks, and (d) recreational management areas.

2. Marine reserves prohibit all extractive activities (removal of animals and plants and actions that alter habitats), except as needed for scientific monitoring. Examples of prohibited activities in marine reserves are fishing, aquaculture, dredging, and mining. In contrast, activities such as swimming, boating, and scuba diving are usually allowed (Sanchirico 2000). Marine conservation areas prohibit damage, take, or possession of living or non-living marine resources for commercial or recreational purposes. Agencies

may permit research, education, and recreational activities, and limited commercial and recreational harvests. Marine parks prohibit damage, take, or possession of living or non-living marine resources for commercial purposes. All other uses are allowed, including scientific collection, monitoring, public recreation, and recreational fishing, unless otherwise restricted. Marine parks prohibit commercial fishing but allow most recreational fishing. Marine parks allow restoration of indigenous ecological communities, improving ecosystem health and resilience with potential benefits for the larger marine ecosystems. Most coastal areas near population centers have been impacted anthropogenically to the point where the indigenous state of ecosystems is poorly understood. Designation of the Ocean SAMP area as a marine park would enable development of a novel understanding of the natural resilience and recovery potential of coastal ecosystems. In 2000, President Clinton issued an executive order calling for a national system of MPAs (Exec. Order No. 13,158, 65 Fed. Reg. 34909 (May 26, 2000)) and the establishment of a federal advisory committee on MPAs. The National Academy of Sciences (2001), the Pew Oceans Commission (2003), and a broad spectrum of scientists and conservation organizations have recommended designation of networks of protected areas as one of the essential tools for the preservation of threatened marine ecosystems, including no-take marine reserves.

940.2 Enhancing Marine Fisheries

1. MPAs have potential costs, benefits, and risks to marine fisheries, which have been summarized by Sanchirico (2000). Potential benefits are habitat improvement, increased numbers of larger, older, and more valuable fish, and larger fish stocks which could increase in harvests. Improvements to the environment and fisheries communities are thought to be a useful tool in the recovery of overfished stocks and may enhance the long-run sustainability of fisheries. MPAs have also been documented to produce beneficial “spillover effects” into non-protected areas. Rodwell et al. (2003) constructed predictive models based on habitat requirements of individual fish species and demonstrated specific contributions of habitat improvements to fisheries. They were able to show that improvements in habitat quality can increase biomass and catch levels, with the greatest benefits accruing to catch. Best results were achieved when locating the reserve where habitat can recover quickly once protected and where the area is not subject to other stresses such as pollution or sedimentation.

2. Most economic studies have failed to consider habitat quality improvement as an economic benefit of marine reserves (Sanchirico 2000). Costs are related directly to the reduction in the area of fishable waters and the resulting displacement of fishing efforts. Risks of MPAs to fisheries have been identified. The main risk is that MPAs are fixed in space while fish stocks are mobile and the ocean environment is susceptible to major environmental changes and human impacts (e.g., climate shifts due to North Atlantic Oscillation [NAO] and El Nino-Southern Oscillation [ENSO] events, or human perturbations such as pollution, oil spills, etc.). For example, if an area is selected for closure due to its unique role in the life cycle of a fish stock, there is no guarantee that this habitat will continue to provide the necessary ecological services if affected by pollution or environmental change (Sanchirico 2000).

3. The New England Fishery Management Council (NEFMC) is working to identify ocean areas in New England vulnerable to fishing gear. Browns Ledge in the Ocean SAMP planning area is one of seven areas that have been identified by the NEFMC habitat science team as an area vulnerable to mobile fishing gears (NEFMC 2010).

4. Fisheries interests are concerned worldwide about the designation of MPAs. Changes in fishing operations following siting of an MPA poses risk to fishing interests. For example, in response to area closures, boat captains might alter the configuration or design of their vessels to employ multiple gear types or might increase the number of trawls. In this example, increased effort or more detrimental practices could drive non-protected area fish stocks lower. MPAs could potentially affect one user group disproportionately (Holland 2000). For example, if an MPA is sited nearshore, the inshore fleet could potentially incur the highest cost (i.e., direct loss of fishable waters), while the offshore fleet could receive most of the benefits. Approximately, 60% of the case studies and empirical analyses on the impacts of protected areas found them to have varying degrees of significant positive effects on abundance, size, and density (Sanchirico 2000). Investigations on the views, perceptions and attitudes of commercial fishermen that influence support or opposition to marine protected areas have been accomplished (Stump and Kriwoken 2006). Main concerns are the potential negative impact of additional MPAs in terms of resource sustainability and the long-term economic viability of fisheries. Fishermen support MPAs if they sustained or increased fish populations, supported research, allowed fishing in multiple use areas, and if multiple use areas contained small no-take zones. Fishermen are concerned about the ability of the government to provide adequate MPA monitoring and compliance.

5. In Europe, displacement of fishermen and certain types of fishing such as trawling by offshore energy structures has occurred due to insurance and safety concerns (see Chapter 8, Renewable Energy and Other Offshore Development). Fishermen have supported the creation and management of no-take zones to coincide with the energy facility developments in cases where the benefits for fisheries in adjacent waters have been demonstrated (Mee 2006). It is important to be aware of the fact that fishermen displaced from areas that are closed to fishing may actually exert increased impacts on fish populations and the environments outside closed areas (Dinmore et al. 2003). Another possibility is that designation of no take zones for trawling may shift fishing pressure from one gear type (trawling) to others (i.e. fixed gear, recreational fishing).

6. The Nature Conservancy (TNC) is working with fishermen on California's Central Coast to develop environmentally sensitive fishing practices for harvesting groundfish. TNC's Central Coast Groundfish Project wishes to pioneer cutting-edge science, conservation tools and markets to encourage stewardship. TNC buys trawl-fishing permits and leases them back to fishermen, who are required to follow specific conservation practices. TNC is exploring similar approaches to provide incentives for fisheries conservation on the East Coast with a pilot planned for Maine (Littlefield pers. comm.).

940.2.1 Placement of Artificial Reefs

1. The post-glacial environment of the Ocean SAMP area has terminal moraines, which, when compared to other ocean areas, offer a substantial amount of structure and relief.

Boulder fields in moraines are not suitable for development of windfarms, nor are they good areas for bottom trawling by groundfish fisheries. The moraines have been observed to contain high biodiversity, and although they are not trawled by mobile fishing gears are still fished by an array of fixed or transitory gears (traps, lines, pots, nets, etc.; see Chapter 5, Commercial and Recreational Fisheries). Boulder fields in or outside of moraines are not suitable for development of offshore energy or other offshore structures, with sand/gravel areas considered the best. In such areas, erosion at the base of turbines is a major consideration and is often countered by placement of either rock for armoring and/or concrete mattresses or mats. Rock armor placed at the base of wind turbines effectively forms an artificial reef which is colonized by marine organisms.

2. In sand/gravel depositional areas, artificial reefs have been placed to enhance marine fisheries by creating additional habitat for selected species and/or life stages (Blaxter 2000; Sayer 2001); for habitat restoration (Caddy 1999); for protecting additional habitat from fishing gear impacts with access and/or effort restrictions (Wilson and Cook 1998; Pitcher et al. 2000); or to alter local circulation patterns, and therefore energy flows of marine ecosystems, in order to promote new production and help mitigate impacts of offshore developments (Steimle et al. 2002; Sheehy 2009, Sheehy and Vik 2010). In Japan, artificial reefs are widely used, and range from massive structures designed to force upwelling of deep, nutrient-rich waters to the surface to increase primary production and to increase fisheries, to smaller units designed to provide fish attraction or as substrate for algae and mollusk aquaculture (Morikawa 1996).

3. Baine (2002) reviewed more than 90 published articles on artificial reefs worldwide to enhance fisheries management objectives. He identified more than 300 materials used for reefs, with concrete, rocks, stones and boulders the most common, but tires, trees and wrecks all used, with purposes as varied as support for fisheries management, habitat creation/protection, waste management, sport diving, and seaweed culture. For fisheries enhancement, designed materials and natural rock are recommended, and a wide range of designed reef modules are currently in use worldwide that have undergone extensive testing to document their predicted stability and life expectancy. Sheehy and Vik (1992) developed valuable ideas on how to increase the ecological value via use of ecological engineering of reefs to enhance ecological functions. Turpin and Bortone (2002) conducted an assessment of artificial reefs pre- and post-hurricane to look for evidence for their potential use as fish refugia. Lighter materials were moved for distances of approximately 1000 m, while higher density materials were unaffected by the wave surge. Eklund (1997) studied the ecological processes limiting fish production in association with artificial reefs and concluded that it is possible to design and manage artificial reefs with the aim of promoting the development of benthic communities as possible forage areas for important fisheries species by providing greater availability and heterogeneity of refuge space, which supports more fish. The most important findings were that: (1) artificial reefs increased habitat complexity, fish densities, species richness and diversity over the short-term, and gradually over time; and (2) carrying capacities and catches per unit effort (CPUE) by numbers and weights, densities and biomasses were higher in artificial reefs than control areas (Baine 2002). Wilson et al. (2002) discussed the advantages of linking artificial reefs with the creation of marine reserves. Studies indicate that enhancing MPAs with artificial reefs can increase juvenile recruitment and enhance fisheries production (Bohnsack and Sutherland 1985).

4. A continuous scientific debate has existed for more than 30 years on whether artificial reefs merely aggregate or actually increase fishery biomass (Bortone 1998; Svane and Petersen 2001). Artificial reefs can only increase fisheries where there is habitat limitation for a given species, and where the resources utilized by a fishery on new, artificial reef habitats would not have been used by that, or another fishery, in another location (Linley et al. 2007). Bohnsack et al. (1997) deemed it unlikely that an exploited species, where individuals are constantly removed from their habitat by fishing, will be habitat-limited, at least in terms of the habitat for individuals of a large enough size to enter the fishery. Simard (1996) concluded that in spite of the massive investment Japan has made in artificial reef technology, only octopus productivity actually increased as a direct consequence of the construction of artificial reefs. In studies conducted over a 24-year period, Stephens and Pondella (2002) considered if artificial reefs in Southern California Bight acted as sources or sinks for fish by comparing annual densities of fish larvae from artificial reefs with control areas. They showed higher densities of larvae at the artificial reefs in comparisons to non-reef areas, indicating that mature artificial reefs contributed significantly to the fish larval pool, thereby acting as sources, and not sinks. Positive studies of marine fisheries enhancement by artificial reefs remain inconclusive, as local results cannot be generalized, and ecosystem processes cannot be assessed as systematic (Linley et al. 2007).

5. Surveys at offshore wind farms in Europe suggest an increased association of some commercial fisheries species with turbine towers (Dong Energy n.d.; Fayram and deRisi 2007). However, one important factor to consider is that the density of wind turbines needs to ensure that each is effectively independent and faces a non-turbulent air stream to attain maximum energy density. This results in turbines that are generally 0.5-1.0 km apart on the axis of the prevailing wind. This distance may increase if turbines increase in size. Wilhelmsson et al. (2006) investigated the potential of wind turbines off the southeast coast of Sweden to function as artificial reefs and alter fish assemblages. Fish abundances were greater near the turbines than in surrounding areas, but species richness and diversity were similar. Blue mussels and barnacles covered most of the submerged structures which offered good conditions for growth.

6. Researchers in Rhode Island have been investigating the use of artificial reefs for lobster enhancement, and for the recovery of lobsters from an oil spill, since the 1970's (Sheehy 1982; Castro et al. 2001). More recently, demolition of the Jamestown Bridge created debris which was used to create two inshore artificial reefs, the Gooseberry Island and Sheep Point Reefs in 2006-2007 (Travisono 2010).

7. Several types of designed artificial shelters for lobsters fabricated from concrete were deployed in several shallow sites off Point Judith to determine if the carrying capacity for lobster in sand bottom areas could be increased (Sheehy 1976, 1977, 1982). Results indicated that the addition of lobster shelters significantly increased resident lobster populations, and that abundances were equal to or greater than those observed on good natural habitats. Shelter spacing had a significant effect on occupancy by lobsters, and shelter orientation, with respect to predominant wave and current directions, affected the stability of the shelters on the bottom. Triple chamber shelters had the highest overall use and supported larger populations due to the compartmentalization. During studies, all benthic life stages of the lobster were observed on and within the reefs. Significant

seasonal variations in both lobster and other populations were also observed. Additional studies indicated that the addition of artificial shelters in areas devoid of natural shelter or substrate suitable for burrowing can significantly increase the abundance of lobsters. Sheehy (1982) stated that suitable sites for lobster reefs are limited, and that careful examinations of site factors, particularly maximum wave and current conditions, substrate, and available food resources, should be made prior to future construction.

8. Castro et al. (2001) investigated six experimental artificial reefs for hatchery-reared lobsters in Narragansett Bay in 1997 using a before-after-control-impact design. Juvenile and adult lobster densities at the reefs were significantly higher than the 2 control areas, and settlement of young-of-year lobsters also increased significantly. However, recoveries of hatchery-reared lobsters were poor. Field observations indicated possible behavior differences in the hatchery-reared lobsters that might have made them more susceptible to predation.

9. The Gooseberry Island Reef is located 1.5 miles south of Newport, R.I. in approximately 80 feet of water, while the Sheep Point Reef is located 1.1 miles east of Newport, R.I. in approximately 65 feet of water (Travisono 2010). The objectives for the reefs were to offer sites for recreational angling and diving. Reef construction did not lead to any significant increase in bottom profile (Fugate, pers. comm.). Pinckard (2009) evaluated the sites using bathymetry and side-scan sonar surveys, underwater photos, fish census, and conducted experimental reef habitat comparisons. Reefs had a "moderate degree of colonization" by encrusting organisms (e.g., hydroids, bryozoans, and mussels), lobsters, and various fish species (e.g., cunner and sea bass). Invasive species, including the tunicates *Didemnum* sp., *Botrylloides violaceus*, and *Ciona intestinalis*, were observed on the bridge debris. These findings raise the possibility that any additional structures such as artificial reefs or energy structures that are placed in RI's offshore waters—any additional artificial habitat—would be colonized by invasive tunicates (and other invasives such as macrophytic algae) in offshore areas (see Chapter 2, Ecology). *Didemnum* sp. has been found to colonize extensive areas of Georges Bank gravel habitats (Valentine et al. 2007).

940.2.2 Enhancement of Recreational Fisheries

1. In the U.S., especially off of the small coastline of the state of Alabama in the Gulf of Mexico, artificial reefs ("reef balls") are used extensively to enhance sport, recreational fishing and diving, especially with respect to the use of abandoned oil rigs as artificial reefs (Kaiser 2006). Enhancement of recreational fishing by placement of artificial reefs has been shown to be related to reef technology selection, site conditions, target species, and fishing communities. Site conditions, including water depth, substrate composition, wave, and currents, determine the types of reef designs and materials suitable for deployment. Enhancement of recreational fishing has been most successful for species showing a strong affinity for structures and homing to sites. Workman et al. (2002) studied juvenile red snappers and found that they had homing capabilities to smaller artificial structures, concluding that their habitat requirements were met by the presence of these small structures, including shells and burrows. However, as fish grew larger they preferred larger and more complex structures. Recruitment to larger structures was, however, limited by the presence of larger fish. They concluded that the proximity of

large artificial reefs to smaller structures influenced recruitment patterns. Marine recreational management areas have been designated in California in Morro Bay where recreational or commercial takes are not allowed in southern areas, but certain recreational and commercial takes are allowed in northern areas (California Dept. of Fish and Game 2007).

Section 950. Biofouling Control by Shellfish Harvests

1. Oil industry engineers are well aware of safety concerns due to continual build-up of large quantities of attached sessile marine organisms, especially masses of bivalve shellfish and barnacles which require regular removal to reduce stress on the platform legs and supporting cross members. Regular cleaning also allowed detection of structural cracks or weld failures. Design requirements developed by regulatory agencies and the American Petroleum Institute require regular cleaning and control of biofouling loads as a safety measure to reduce the increasing environmental stresses (hydrodynamic loading from waves and currents) on offshore oil platforms (Richards et al. 2009).

2. In temperate areas, the subtidal biological community of oil platform legs (Richards et al. 2009) and wind towers (Wilhelmsson et al. 2006) is dominated by mussels. Mussels outcompete earlier settlers such as tunicates and encrusting bryozoans (Bram et al. 2005). The biomass (g wet weight) of mussels at a depth of 12 m has been estimated (prior to cleaning) to reach up to 80% of the total wet weight of all attached invertebrates and macroalgae found at that depth on the platform (Page et al. 2010). Mussel mats have been documented on southern California oil platforms to reach 4 ft (1.2 m) in thickness (Page and Hubbard 1987).

3. Removal of this biofouling is a time-consuming and costly process for offshore operators, running into hundreds of thousands of dollars per oil platform, depending on the time between cleanings, platform location, and surface area of the platform "jacket" (submerged structure) (Richards et al. 2009). Removal of biofouling is done by high pressure washers by divers contracted by offshore operators, and sends thousands of kilograms of mussels and other invertebrates to the sea floor, forming massive shell mounds. Accumulations on the seabed of mussels, barnacles and other marine debris (Hiscock et al. 2002) that scavengers such as crabs, lobsters, starfish, whelks, urchins, and numerous species of fish. Accumulations of debris also offer additional habitats (Love and Schroeder 2006) that may make a contribution to local recruitment (Wilhelmsson et al. 2006).

4. The potential for mussel harvests from offshore structures and for mussel aquaculture has been evaluated as two of the best economic opportunities for multiple uses of offshore energy platforms themselves, and their lease areas (Linley et al. 2007; Richards et al. 2009). Mussels grow very rapidly on offshore oil platforms. Growth in California was reported to be among the highest recorded in the world, from at least 0.25 in (6 mm) to 0.5 in (13 mm) per month, reaching a size of 2 inches (50 mm) in six to eight months (Richards and Trevelyan 2001; Page et al. 2007).

5. Three California companies harvested mussels from the California oil platforms as a business and biofouling control strategy (Richards et al. 2009). The most successful was "ECOMAR," who over 20 years documented the business and environmental strategy and developed all regulatory approvals for human consumption. ECOMAR estimated it harvested $50-75,000 of shellfish per platform every 16-20 months (Meek 1989). Between 1992 and 1997, mussel production rose in California from 84,822 kg to 213,642 kg, with most production coming from southern California platform harvest. Development of shellfish harvesting as a biofouling control strategy and profitable

business was a win-win situation for both the oil and gas industry and shellfish harvesting entrepreneurs, allowing oil platform operators to reduce or eliminate costs for cleaning stress-load biofouling communities off platform legs and crossbeams and entrepreneurs (harvesters) an opportunity to develop the human food market for a valuable shellfish.

Section 960. Use for Aquaculture Developments

1. Aquaculture is defined as the farming of freshwater and saltwater organisms such as finfish, mollusks, crustaceans and aquatic plants under controlled conditions and with full ownership, in contrast to wild harvest or stock supplementation. It is estimated that aquaculture supplies about 47% of the fish and shellfish that is directly consumed by humans today (Food and Agriculture Organization [FAO] 2009). Ecological aquaculture plans, designs, develops, monitors and evaluates aquatic farming systems for food or non-food organisms that preserve and enhance the form and functions of the natural and social environments in which they are situated. Ecological aquaculture farms are "aquaculture ecosystems" (Soto et al. 2008; Costa-Pierce 2008).

960.1. Shellfish aquaculture

1. Buck et al. (2004) have demonstrated that offshore aquaculture of shellfish (mussels, oysters, clams) may benefit from a number of advantages in comparison with inshore sites in terms of increased growth, increase in product quality, and reduced levels of parasitic infections. These benefits need to be considered against the increases in time, labor and logistical resources needed to access sites and the difficulties in maintaining them in harsh offshore conditions. There may be more interest in pursuing offshore shellfish culture in the future as many inshore sites suffer from user conflicts and/or become unavailable due to problems with water quality.

2. Concerns and constraints regarding the expansion of marine aquaculture are much different for fed and non-fed aquaculture. For non-fed shellfish aquaculture, there has been a convergence over the past 10 years or so around the notion that user conflicts in shellfish aquaculture can be solved so that it can expand due not only to new technological advances, but also due to a growing global science/NGO consensus that shellfish aquaculture can "fit in" in an environmentally and socially responsible manner into many coastal and offshore marine environments, many of which are already crowded with existing users (National Research Council 2010). Included in this are: (a) development of submerged technologies for shellfish aquaculture such as longlines (Langan and Horton 2003), modified rack and bag shellfish gear (Rheault and Rice 1995), and upwellers for nursery stages of shellfish, some of which are placed unobtrusively under floating docks at marinas (Flimlin 2002); (b) scientific findings and reviews demonstrating the environmental benefits of shellfish aquaculture providing vital ecosystem and social services (National Research Council 2010) such as nutrient removal (Haamer 1996; Lindahl et al. 2005) and habitat enhancement (DeAlteris et al. 2004; National Research Council 2010); (c) research on natural and social carrying capacities for shellfish aquaculture, and sophisticated, collaborative work group processes (McKinsey et al. 2006; Byron et al. 2008); (d) development and wide use by industry of best and better management practices (National Research Council 2010); (e) diversification of traditional wild harvest fishing/shellfishing families into shellfish aquaculture as part-time enterprises, breaking down barriers between fishing/aquaculture user communities; and (f) publication of global comparisons with fed aquaculture, indicating a strong movement in shellfish aquaculture globally towards an adoption of ecological approaches to aquaculture at all scales of society (Costa-Pierce 2008).

3. Shellfish aquaculture such as longlines (Langan and Horton 2003) can be developed attached to offshore energy structures or within the leased areas. Food availability is vital to siting shellfish aquaculture, with rapid growth occurring at about 20 µg chlorophyll/liter, good growth at around 2 µg chlorophyll/liter, and poor growth in waters where phytoplankton concentrations fall below 0.8 µg chlorophyll/liter (Hawkins et al. 1999). Site specific models are required to determine the economic feasibility of shellfish aquaculture development and carrying capacities which describe hydrodynamics, primary production and seston availabilities and linking with feeding, metabolism, growth and population dynamics of each shellfish species, taking into account interrelations with other organisms that already exist (Dowd 1997; Bacher et al. 1998) prior to the development and investment in an offshore shellfish aquaculture development in the Ocean SAMP region. Maar et al. (2009) modeled biomass and growth of mussels on wind turbine foundations offshore in Denmark and found that mussels located higher up in the water column on turbine pillars had seven to 18 times higher biomass than those located deeper in the water on the scour protection, and attributed this to an enhanced advective food supply. The high mussel biomasses created local hot spots of biological activity and changed ecosystem dynamics. Model results were validated by field measurements.

4. The Woods Hole Oceanographic Institution and the Marine Biological Laboratory have both initiated pilot projects and experimental farms within the Ocean SAMP planning region to test the economic and environmental viability of offshore mussel aquaculture. The results from these projects are forthcoming, and should provide guidance for the regulation and permitting of potential future offshore shellfish aquaculture ventures (Paul 2000).

960.2. Finfish Aquaculture

1. Rhode Island has large seafood markets, both for local sales and for export. The largest distributor of frozen fish on the U.S. East Coast that supplies a national and global market is Seafreeze (Seafreeze, Ltd. 2009). Frozen fish are imported and exported from the Port of Davisville where Seafreeze is located. Seafreeze also supplies bait to both domestic and international longline fishing fleets.

2. Use of offshore energy sites for the development of finfish aquaculture is intuitively attractive and has received recent attention in Rhode Island and elsewhere (Buck et al. 2004; Mee 2006; James and Slaski 2006; Rhode Island Sea Grant 2009). A detailed analysis of offshore aquaculture has been completed (James and Slaski 2006) which concluded that economic, legal, environmental and technical constraints exist which must be overcome before investor confidence increases. The economic viability of offshore finfish aquaculture is highly dependent on external market forces that will likely drive the price of fish up in the long term – i.e. decreased supply from wild stocks, increased demand from consumers – thus potentially increasing the viability over time, but is also strongly dependent on the capital investment required for the new technologies that must be developed.

3. For offshore finfish aquaculture to develop within federal lease areas for offshore energy facilities, substantial legislative progress is required, some of which is already anticipated

in a bill introduced in the House, The National Sustainable Offshore Aquaculture Act of 2009 (H.R. 4363, 111th Cong., 2009). Discussions around this legislation suggest that many issues relating to aquaculture uses of offshore leased areas will need further stakeholder agreement, and will require additional legislative and regulatory changes.

4. Offshore finfish aquaculture is also constrained by available species (salmon and to a much lesser extent, cod are the only species with adequate hatchery and feed infrastructure in the region), and appropriate engineering and technology. Competition with land-based facilities is also an issue, and these facilities also avoid the legal/regulatory problems inherent in the development of commercial, offshore finfish aquaculture. Future opportunities exist with black sea bass (*Centropristis striata*) tautog or blackfish (*Tautoga onitis*) (Berlinsky et al. 2000; Howell et al. 2003; Perry et al. 2008).

5. Technical engineering advances in submersible, offshore cages with volumes 500 times or more greater than traditional surface, gravity cages have occurred. Submerged cages protect finfish from the stresses of wind, waves and currents generated by wind, tides and storms (Page 2011). Submerging cages significantly reduces stresses on structures and such units will likely be necessary in offshore areas where significant wave heights exceed 2 m. However, in such locations depth will be a constraining factor and there will need to be sufficient depth such that a submerged structure will have adequate clearance from both the surface and the sea bed.

960.3. Seaweed Aquaculture

1. Commercial aquaculture of seaweeds has grown rapidly in the last decade and is now estimated to comprise 86% of total seaweed supplies worldwide, with a significant proportion supplied by Japan, where seaweed culture is the most productive and economically profitable form of aquaculture (FAO 2009). Most seaweed aquaculture focuses upon high value export markets in Asia, with much research attention being given to future potential uses for seaweeds for the extraction of biotech/high value compounds.

2. Seaweeds settle where surfaces are available, generally within five hours of the release of spores, thus tides and wave action may restrict the potential colonization of novel surfaces which are beyond dispersal limits of spores. Evidence from offshore oil rigs show there is often good growth of kelps on these structures, and that it appears kelp spores may be robust enough to survive longer periods between release and settlement than some other species (Hiscock et al. 2002). In general, seaweeds do not grow well on vertical surfaces, although slopes which are in excess of 20° from the vertical are suitable for colonization. Buck et al. (2004) have investigated several possible designs for seaweed rafts in association with offshore wind farms, testing different construction methods and mooring systems, developing a new offshore-ring system for the open ocean seaweed aquaculture which can sustain rough weather conditions). Mee (2006) expressed concerns with potential conflicts with wind farm operations and maintenance, how the system could be maintained, and how the seaweed could be harvested. Buck and Buchholz (2005) developed a modeling approach for the culture of *Laminaria saccharina* indicating that culture is feasible in high energy environments. In Japan a new culture

method has been developed that is apparently able to withstand strong winds and large waves called the "modified triangular method". Reports state that it is an efficient and profitable seaweed aquaculture system in comparison with traditional mono-line culture methods (Linley et al. 2007). Bergman et al. (2002) suggest that synergies exist between seaweed aquaculture and fisheries that could be developed and applied within offshore sites. In this research, seaweed aquaculture increased associated fish fauna in terms of abundance, species richness, and fish community composition as a result of the additional habitat structure created, rather than the utilization of seaweeds as a direct food resource.

960.4. Harvesting and Culture of Bioactive Compounds

1. Schmitt et al. (2006) studied fouling organisms on the legs of seven oil platforms in the Santa Barbara Channel, California and found that invertebrates, such as sponges, tunicates, and bryozoans, which may contain potentially useful marine natural products, were abundant on offshore oil platforms. Significant biological activity in the crude extracts of a number of species were found in their studies, some of which showed potential to be harvested and processed into new drugs for cancer treatments. However, significant variation was found in the distribution, recruitment and growth of invertebrates among platforms, which suggested that factors such as location and temperature could affect the potential harvest of these organisms for use in the development of marine natural products.

Section 970. Expansion of Ecotourism and Underwater Cemeteries

1. Ecotourism is "responsible travel to natural areas that conserves the environment and improves the welfare of local people" (International Ecotourism Society 2006). Ecotourism is the fastest growing sector of tourism at approximately 26 to 34% per year (Honey 2010).

2. Offshore renewable energy structures may enhance marine tourism in the future by attracting recreational boaters, charter boat clients, cruise ship passengers, and other visitors (Minerals Management Service 2006). Land-based wind farms across North America have received significant interest from tourists. Palm Springs, California windfarms receive an estimated 12,000 tourist visits each year, and wind farms have seen the number of visitors requesting tours climb. (More information on this topic is presented in Chapter 8, Renewable Energy and Other Offshore Development.) Offshore wind farms have increased tourism in the U.K., Denmark (wind farm at Middelgrunden, near Copenhagen), and Ireland (Arlow Offshore Wind Power Plant; see Arklow Offshore Wind Park 2004). A British Wind Energy Association study (BWEA 2006) indicated that tourism increased at U.K. destinations adjacent to offshore wind farms, to the point that visitor centers had been developed at some of these sites. In Denmark, a study found that tourism in areas near wind farms had increased by 25% after project completion (Golubcow 2006). Flynn and Carey (2007), in a study examining the potential economic impacts of an offshore windfarm to South Carolina, assumed that 5,000 tourists a year would visit a farm after construction, with each paying an average $100 per sightseeing trip, generating $500,000 annually.

3. Burial at sea services and locations are changing rapidly, and underwater cemeteries are growing in popularity. Traditionally in the U.S., ashes have to be scattered at least three miles (4.8 km) from shore, and bodies can be given to the sea if the location is at least 600 feet (200 m) deep. Special regulations may also apply to urns and coffins. Local laws may differ; for example, in the Great South Bay, New York it is legal to drop ashes right from the dock. Underwater cemeteries are being constructed. Ashes of the deceased are mixed with concrete. Concrete blocks are dropped to the seafloor to form artificial reefs. Cremated remains are mixed to form different reef structures and columns. The Neptune Memorial Reef, also known as the Atlantis Memorial Reef, is an underwater cemetery located 3.25 miles off the coast of Key Biscayne, Florida. It is the world's largest man-made artificial reef (covering over 56,000 m^2 of seafloor). Phase I of the underwater cemetery holds an estimated 850 remains, with a goal of accommodating at capacity more than 125,000 remains. The Neptune Memorial Reef is designed as both an artificial reef and as a destination for divers (Nolin 2009).

970.1. Development of a Research and Education Center

1. There are no offshore wind farms in the United States, and no offshore research and education centers that can investigate and conduct field-based experimental projects to monitor the construction, performance and environmental interactions of offshore renewable energy developments. There are substantial opportunities to investigate the interactions between potential multiple uses of ocean observations (for example, Northeastern Regional Association of Coastal Ocean Observing Systems

[NERACOOS]), fisheries, aquaculture, reserves, and the ecological, economic, social and technological interactions. It is ventured that a permitted, marine technology research park in an ocean area could attract considerable federal, industry and state funding. The State of Rhode Island, the University of Rhode Island and a windfarm developer have discussed that one or two of the proposed commercial Block Island wind turbines could be used as research turbines. Extension of turbine use to allow use of a portion of the lease area would make progress toward establishment of a research and development area.

2. Some marine scientists have touted the considerable ancillary benefits of increases in non-consumptive use values for research, education, diving, photography, tourism, and conservation of marine biodiversity (Bohnsack 1993; Sobel 1993). Numerous research and development innovations could occur, including measurements of productivity and economic impacts following deployment of artificial reefs (Bohnsack and Sutherland 1985); experimental development of finfish, shellfish and seaweed aquaculture offshore in lease areas (Buck et al. 2004; Rhode Island Sea Grant 2009); and the use of artificial structures that alter nutrient regeneration mixed with aquaculture. Use of ecological design and engineering principles and practices could allow design optimization of energy generation, seafood production, biodiversity, and marine ecosystem health in a research and education center that could potentially benefit all stakeholders. In addition, scientific research could include the development of additional tools for understanding ecosystem function and the impacts of human activities as few such areas exist in New England ocean waters. As such, it is difficult to form a complete understanding of ocean ecosystems and the impacts of various existing and potential new stressors.

3. One model for Rhode Island is an innovative research and development strategy announced in Ireland at a 2010 meeting entitled, "Harnessing Ireland's Potential as a European and Global Centre for Ocean Technology" (Marine Institute n.d.). Ireland plans to develop 10 "Ocean Innovation Test Platforms" that will allow companies to form partnerships in order to test new concepts, equipment, technologies, and solutions in real-life situations. Called "SMARTOCEAN Innovation Clusters," they seek to target newly emerging niche markets (marine renewable energy, environmental monitoring, and water management), as well as established markets (oil and gas, aquaculture, maritime transport, tourism, coastal erosion) to develop innovative and competitive production systems and service models and target both niche and high value markets.

Section 980. Summary

1. The Ocean SAMP planning region faces the following challenges and potential threats in the near-term of approximately 10 years which will require consideration of new or revision of existing policies by the CRMC. Short sea shipping is likely to develop rapidly in the region which will increase marine traffic and add to the potential for increased, dispersed pollution inputs to the area. Development of offshore LNG buoys is unlikely in the near-term as southern Rhode Island has no land-based LNG storage infrastructure (exists only in Providence). Aquaculture operations proposing to use offshore energy structures such as wind turbines is unlikely in the near-term since design standards for turbines in the region do not yet exist. Studies will be required to measure impacts of storms and possible hurricanes which will require longer-term monitoring of stresses and wind/wave forcing using load cells, etc. Options for harvesting biofouling and mussels for food and bioactive products and to remove stresses through the development of private partnerships such as that developed by Ecomar, Inc. for oil/gas structures appear feasible in the near-term, but will require additional policy and legal studies. Placement of artificial reefs for commercial and recreational fishing and biodiversity enhancement is feasible, but studies would be needed to ascertain the site-specific effects and concerns over range extensions of invasive species to the offshore. Development of the Ocean SAMP region for additional ecotourism and even for underwater cemeteries and burials is likely in the near-term, which will lead to increased vessel traffic, recreational use, and the need for new policies for burials.

Section 990. Literature Cited

Arklow Offshore Wind Park. 2004. Ireland's Offshore Wind Power. Available online at http://www.ceoe.udel.edu/WindPower/docs/arklow_infosheet_final.pdf.

Bacher, C., P., Duarte, J. Ferreira, M. Héral and O. Raillard. 1998. Assessment and comparison of the Marennes-Oléron Bay (France) and Carlingford Lough (Ireland) carrying capacity with ecosystem models. *Aquat. Ecol.*, 31: 379–394.

Baine, M. 2002. The North Sea rigs-to-reefs debate. *ICES Journal of Marine Science* 59: S277-S280.

Bergman, K.C., Svensson, S. & Öhman, M.C. 2001. Influences of algal farming on fish assemblages. *Mar. Poll. Bull.* (42)**:** 1379–1389.

Berlinsky, D., Watson, M., Nardi, G. and Bradley, T.M. 2000. Aquaculture of black sea bass (*Centropristis striata*): Investigation of selected parameters for larval and juvenile growth. *J. World Aquaculture Soc*. 31(3): 426-435.

Blaxter, J. 2000. The enhancement of marine fish stocks. *Advances in Marine Biology* 38: 1-54.

Bohnsack, J., J. Ecklund, A. Szmant. 1997. Artificial reef research: is there more than the attraction-production issue. *Fisheries* 22: 14-16

Bohnsack, J. A. 1993. Marine Reserves: They enhance fisheries, reduce conflicts, and protect resources. *Oceanus* (Fall): 63-71.

Bohnsack, J. and D. Sutherland. 1985. Artificial reef research – a review with recommendations for future priorities. *Bulletin of Marine Science* 37: 11-39

Boothroyd, J. 2009. University of Rhode Island Department of Geosciences. Personal communication, March 8, 2009.

Bortone, S. 1998. Resolving the attraction-production dilemma in artificial reef research: some yeas and nays. *Fisheries* 23: 6-10

Bram, J.B., H.M. Page, and J.E. Dugan. 2005. Spatial and temporal variability in early successional patterns of an invertebrate assemblage at an offshore oil platform. *J. Mar. Exp. Biol. Ecol.* 2:223-237.

Buck, B. and C. Buchholz. 2005. Response of offshore cultivated *Laminaria saccharina* to hydrodynamic forcing in the North Sea. *Aquaculture* 250: 674-691.

Buck, B., G. Krause and H. Rosenthal. 2004. Extensive open ocean aquaculture development within wind farms in Germany: The prospect of offshore co-management and legal constraints. *Ocean and Coastal Management* 47: 95–122.

British Wind Energy Association (BWEA). 2006. The Impact of Wind Farms on the Tourist

Industry in the UK. Prepared by the British Wind Energy Association for the All-Party Parliamentary Group on Tourism. Online at www.bwea.com/pdf/tourism.pdf.

Byron, C., D. Alves, D. Bengtson, R. Rheault, and B. Costa-Pierce. 2008. Working towards consensus: application of shellfish carrying capacity in management of Rhode Island aquaculture. ICERS Session on Ecological carrying Capacity in Shellfish Culture, Halifax, N.S., Canada http://www.ices.dk/iceswork/asc/2008/themesessions/Theme%20synopses/H-list-ed.pdf

Caddy, J. 1999. Fisheries management in the twenty-first century: will new paradigms apply? *Reviews in Fish Biology and Fisheries* 9: 1-43

California Dept. of Fish and Game (2007). Guide to the Central California Marine protected Areas. Pigeon Point to Point Conception. California Resources Agency, 1416 Ninth Street, Suite 1311 Sacramento, CA 95814 http://www.dfg.ca.gov/mlpa/pdfs/ccmpas_guide.pdf

Castro, K., J.S. Cobb, R. Wahle, and J. Catena. 2001. Habitat addition and stock enhancement for American lobsters, *Homarus americanus*. *Marine and Freshwater Research* 52(8): 1253-1261

Center for LNG. n.d. Existing Import Terminals. Available at http://www.lngfacts.org/LNG-Today/Import-Terminals.asp. Last accessed November 1, 2010.

Costa-Pierce, B. 2008. An ecosystem approach to marine aquaculture: A global review. In: *Building An Ecosystem Approach to Aquaculture*, ed. D. Soto pp. 81-116. FAO Fisheries and Aquaculture Proceedings 14. FAO, Rome, Italy.

Dalton, T. 2005. Beyond biogeography: a framework for involving the public in planning of U.S. Marine Protected Areas. *Conservation Biology* 19: 1392–1401.

DeAlteris,J., Kilpatrick,B., & R. Rheault. 2004. A comparative evaluation of the habitat value of shellfish aquaculture gear, submerged aquatic vegetation and a non-vegetated seabed. *J. Shellfish Res.* 23: 867-874.

Dinmore, T., D. Duplisea, B. Rackham, D. Maxwell and S. Jennings. 2003. Impact of a large-scale area closure on patterns of fishing disturbance and the consequences for benthic communities. *ICES Journal of Marine Science* 60:371-380.

Dong Energy. n.d. Horns Rev offshore wind farm. Available at http://www.hornsrev.dk/Engelsk/default_ie.htm). Last accessed November 1, 2010.

Dowd, M. 1997. On predicting the growth of cultured bivalves. *Ecol. Model*., 104: 113–131.

Eklund, A. M. 1997. The importance of post-settlement predation and reef resources limitation on the structure of reef fish assemblages. Proceedings of the 8th International Coral Reef Symposium, 2: 1139–1142.

Energy Information Administration. 2003. U.S. LNG Markets and Uses: June 2004 Update. At http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2004/lng/lng2004.pdf

Excelerate Energy. n.d. Northeast Gateway Deepwater Port. Online at http://excelerateenergy.com/northeast.html. Last accessed October 29, 2010.

Fayram, A.H. and A. de Risi. 2007. The potential compatibility of offshore wind power and fisheries: An example using bluefin tuna in the Adriatic Sea. Ocean & Coastal Mgt. 50(8): 597-605.

Flimlin. G. 2002. Nursery and growout methods for aquacultured shellfish. Northeast Regional Aquaculture Center Publication No. 00-002.

Flynn, R. and R. Carey. 2007. The Potential Economic Impact of an Off-Shore Wind Farm to the State of South Carolina. The Strom Thurmond Institute, Clemson University, Clemson, S.C. Available at http://www.strom.clemson.edu/publications/flynn/Wind_Farm_Impact.pdfoffshore

Food and Agriculture Organization (FAO). 2009. *The State of World Fisheries and Aquaculture 2008.* Rome: Fisheries Department, Food and Agriculture Organization of the United Nations.

Foss, M. 2007a. Introduction to LNG: An overview of liquefied natural gas (LNG), its properties, organization of the LNG industry and safety considerations. Center for Energy Economics, Bureau of Economic Geology, The University of Texas at Austin. January, 2007. Available at http://www.beg.utexas.edu/energyecon/lng/documents/CEE_INTRODUCTION_TO_LNG_FINAL.pdf

Foss, M. 2007b. Offshore LNG Receiving Terminals: A Briefing Paper from the Guide to Commercial Frameworks for LNG in North America. Center for Energy Economics, Bureau of Economic Geology, The University of Texas at Austin. Available at http://www.beg.utexas.edu/energyecon/lng/documents/CEE_offshore_LNG.pdf

Fugate, G. 2009. R.I. Coastal Resources Management Council. Personal communication, December 13, 2009.

Gallaway, B., J. Gazey, J. William, J. Cole and R. Fechhelm. 2007. Estimation of Potential Impacts from Offshore Liquefied Natural Gas Terminals on Red Snapper and Red Drum Fisheries in the Gulf of Mexico: An Alternative Approach. *Transactions of the American Fisheries Society* 136: 655-677.

Gaul, D. 2009. Expansion of the U.S. natural gas pipeline network: additions in 2008 and projects through 2011. Office of Oil and Gas Energy Information Administration, Washington, DC. Available at http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2009/pipelinenetwork/pipelinenetwork.pdf.

Golubcow, M. 2006. Tourism That Blows. *Atlantic City Weekly* (August 9, 2006).

Haamer. J. 1996. Improving water quality in a eutrophied fjord system with mussel farming. *Ambio* 25:356-362.

Hawkins, A., M. James, R. Hickman, S. Hatton, S. and M. Weatherhead. 1999. Modelling of suspension-feeding and growth in the green-lipped mussel Perna canaliculus exposed to natural and experimental variations of seston availability in the Marlborough Sounds, New Zealand. *Marine Ecology Progress Series* 191: 217-323.

Hiscock, K., H. Tyler-Walters, and H. Jones. 2002. High level environmental screening study for offshore wind farm developments – marine habitats and species project. Report no. W/35/00632/00/00. Report to The Department of Trade and Industry. Marine Biological Association, Plymouth, U.K.

Holland, D.S. 2000. A bioeconomic model of marine sanctuaries on Georges Bank. *Can. J. Fish. Aquat. Sci.* 57:1307-1319.

Honey, M. 2010. Responsible tourism: growth and trends. Available at http://www.sustainabletourismlab.com/Responsible%20Tourism%20%20Growth%20&%20Trends.swf. Last accessed July 13, 2010.

Howell, R.A., Berlinsky, D.L. and Bradley, T.M. 2003. The effects of photoperiod manipulation on the reproduction of black sea bass, *Centropristis striata*. *Aquaculture* 218: 651-669.

Institute for Global Maritime Studies. 2008. *America's Deep Blue Highway: How Coastal Shipping Could Reduce Traffic Congestion, Lower Pollution, and Bolster National Security.*

James, M. and R. Slaski. 2006. Appraisal of the opportunity for offshore aquaculture in UK waters. Report of Project FC0934, commissioned by Defra and Seafish from FRM Ltd., 119 pp.

Johnson, M.R., Boelke, C., Chiarella, L.A., Colosi, P.D., Greene, K., Lellis-Dibble, K., Ludemann, H., Ludwig, M., McDermott, S., Ortiz, J., Rusanowsky, D., Scott, M., Smith, J. 2008. *Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States*. NOAA Technical Memorandum NMFS-NE-209.

Kaiser, M. 2006. The Louisiana artificial reef program. *Marine Policy* 30: 605-623.

Kirkland, J. 2008. Rhode Island AG urges FERC to broaden review of Weaver's Cove LNG import plan. Platt's *Inside FERC*, July 14, 2008.

Laffoley, D. d'A. 2008. Towards Networks of Marine Protected Areas. The MPA Plan of Action for IUCN's World Commission on Protected Areas. IUCN WCPA, Gland, Switzerland.

Langan. R. and Horton. C. 2003. Design, operation and economics of submerged longline mussel culture in the open ocean. *Bull. Aquacul. Assoc. Canada* 103(3):11-20.

Lindahl. O., Hernroth. B., Kollberg. S., Loo. O., Rehnstam-Holm. A., Svensson. J., Svensson. S. and Syversen. U. 2005. Improving marine water quality by mussel farming: A profitable solution for Swedish society. *Ambio* 34:131-138.

Linley, E., T. Wilding, K. Black, A. Hawkins and S. Mangi. 2007. Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd and the ScottishAssociation for Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No: RFCA/005/0029P.

Littlefield, C. 2010. The Nature Conservancy. Personal communication, February 25, 2010.

Love, M. and D. Schroeder. 2006. Ecological performance of OCS platforms as fish habitat off California. MMS OCS Study 2004-005. Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 1435-01-03-CA-72694.

Maar, M., K. Bolding, J. Kjerulf Petersen, J. Hansen and K. Timmermann 2009. Local effects of blue mussels around turbine foundations in an ecosystem model of Nysted off-shore wind farm, Denmark. *Journal of Sea Research* 62: 159-174.

Marine Institute. 2010. Harnessing Ireland's Potential as a European and Global Centre for Ocean Technology. Press release, May 26, 2010. Available at http://www.marine.ie/home/aboutus/newsroom/pressreleases/HarnessingIreland%E2%80%99sPotential+saEuropeanandGlobalCentreforOceanTechnology.htm.

McGinnis, D. 2008. Calypso LNG: Fueling Florida's Growth. Available at http://www.calypsodwp.com/docs/CalypsoDWP_Presentation5-28-08.pdf

McKinsey, C. W., H. Thetmeyer, T. Landry, W. Silvert. 2006. Review of recent carrying capacity models for bivalve culture and recommendations for research and management. *Aquaculture* 261(2): 451-462.

Mee L. 2006. Complementary benefits of alternative energy: suitability of offshore wind farms as aquaculture sites. Report to Seafish Project ref No: 10517. 36pp.

Meek, R. 1989. Mariculture on offshore development and production platforms. Pp.139-141. In: V.C. Reggio (comp.), *Petroleum Structures as Artificial Reefs: A Compendium*. Fourth International Conference on Artificial Habitats for Fisheries; Rigs-to-Reefs Special Session, Miami, FL. Nov. 2, 1987. U.S. Dept. Interior, MMS, Gulf of Mexico OCS Regional Office, OCS Study MMS 89-0021.

Minerals Management Service, Renewable Energy and Alternate Use Program. 2006. Technology White Paper on Wave Energy Potential on the U.S. Outer Continental Shelf.

http://ocsenergy.anl.gov

Mitsch, W. and S.E. Jørgensen. 2004. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc., New York

Morikawa, T. 1996. Status and prospects on the development and improvement of coastal fishing ground International Symposium on Marine Ranching in Ishikawa, Kanazawa, Ishikawa Prefecture, Japan.

National Academy of Sciences. 2001. Marine Protected Areas: Tools for Sustaining Ocean Ecosystems. Ocean Studies Board, NAS, Washington, DC

National Research Council. 2010. Ecosystem Concepts for Sustainable Bivalve Mariculture. Committee on Best Practices for Shellfish Mariculture and the Effects of Commercial Activities in Drakes Estero, Pt. Reyes National Seashore, California. 2010. National Research Council, Washington, D.C. 147pp.

National Ports and Waterways Institute. 2004. The Public Benefits of The Short-Sea Intermodal System. University of New Orleans, Louisiana.

New England Fishery Management Council (NEFMC). 2010. Habitat/MPA/Ecosystems Oversight Committee Meeting Summary. June 10, 2010. Providence, RI http://www.nefmc.org/habitat/cte_mtg_docs/100812/100610_Habitat_Ctte_FINAL.pdf

Nolin, Robert. 2009. "Off Florida, a cemetery under the sea". Los Angeles Times. July 12, 2009. http://articles.latimes.com/2009/jul/12/nation/na-cremation-reef12. Retrieved November 2009.

Page, S. 2011. (*In press*). Aquapods for offshore aquaculture. In: *Encyclopedia of Sustainability Science and Technology*. Springer Science, N.Y.

Page, H.M., J.E. Dugan, and F. Piltz, 2010. Chapter 18. Fouling and antifouling in oil and other offshore Industries, p. 252-246. In: S. Dürr and J. Thomason (eds.) *Biofouling*. Wiley-Blackwell.

Page, H. M., C. S. Culver, J. E. Dugan and B. Mardian. 2007. Oceanographic gradients and patterns in invertebrate assemblages on offshore oil platforms. *ICES Journal of Marine Science.* 65: 851-861.

Page, H.M. and D.M. Hubbard. 1987. Temporal and spatial patterns of growth in mussels Mytilus edulis on an offshore platform: relationships to water temperature and food availability. *J. Exp. Mar. Biol. Ecol*. 111:159-179.

Parfomak, Paul.W; Flynn, Aaron M. 2004. Liquefied Natural Gas (LNG) Import Terminals: Siting, Safety and Regulation. CRS Report for Congress. May 27, 2004. Congressional Research Service, The Library of Congress.

Paul, W. 2000. An Offshore Mussel Aquaculture Experiment. Applied Ocean Physics and Engineering Department, WHOI http://www.whoi.edu/page.do?pid=12466&tid=282&cid=7301

Perry, D., G. Klein-MacPhee and A. Keller. 2008. Early induction of spawning of tautogs and comparison of growth rates of larvae from early and normally spawned broodstocks. *North American Journal of Aquaculture* 70: 365-369.

Pew Oceans Commission. 2003. *America's Living Oceans: Charting a Course for Sea Change*.

Pinckard, N. 2009. Recolonization and ecological succession of benthic communities at Rhode Island Sound artificial reefs. Paper presented at the Rhode Island Natural History Survey 13th Annual Conference, Quonset, RI.

Pitcher, T., R. Watson, N. Haggan, S. Guenette, R. Kennish, U. Sumaila, D. Cook, K. Wilson and A. Leung. 2000. Marine reserves and the restoration of fisheries and marine ecosystems in the South China Sea. *Bulletin of Marine Science* 66: 543-566.

Rheault, R. & M. Rice. 1995. Transient gear shellfish aquaculture. *World Aquaculture* 26(1): 26–31.

Rhode Island Economic Development Corporation (RIEDC. 2009. Quonset's Port of Davisville pursuing marine highway corridor program. May 9, 2009. Available at http://www.riedc.com/news/2009/05/quonsets-port-of-davisville-pursuing-marine-highway-corridor-program

Rhode Island Economic Monitoring Collaborative. 2007. FY 07 Economic Monitoring Report. Available at http://www.dem.ri.gov/bayteam/documents/FY%202007%20Economic%20Monitoring%20Report.pdf.

Rhode Island Sea Grant. 2009. The Ecology of Marine Wind Farms: Perspectives on Impact Mitigation, Siting, and Future Uses. 8th Annual Ronald C. Baird Sea Grant Science Symposium, November 2-4, 2009, Newport, R.I. Proceedings available at http://seagrant.gso.uri.edu/baird/2009/index.html.

Richards, J.B., C.S. Culver, and C. Fusaro. 2009. Shellfish Harvest as a Biofouling Control Strategy on Offshore Oil and Gas Platforms: Development of a profitable, symbiotic marine business in southern California. Presented at: The Ecology of Marine Wind Farms: Perspectives on Impact Mitigation, Siting, and Future Uses. 8th Annual Ronald C. Baird Sea Grant Science Symposium, November 2-4, 2009, Newport, R.I

Richards, J.B. and G.Trevelyan. 2001. Aquaculture: culture of mussels. Pp. 496-499. In: Leet, W., C. Dewees, R. Klingbile, and E. Larson (eds.) *California's living marine resources: a status report.* University of California, ANR Publication #SG01-11.

Rodwell, L. E. Barbier, C. Roberts and T. McClanahan. 2003. The importance of habitat quality for marine reserve—fishery linkages. *Canadian Journal of Fisheries and Aquatic Sciences*. 60:171–181.

Sanchirico, J.N. 2000. *Marine Protected Areas as Fishery Policy: A Discussion of Potential Costs and Benefits.* Resources for the Future, Washington, D.C.

Sayer, M. 2001. Fisheries: artificial fishery manipulation through stock enhancement or restoration. In: Steele J, Thorpe S, Turekian K (eds) *Encyclopedia of Ocean Sciences*. Academic Press, London.

Schmitt, R.J., R.S. Jacobs, H.M. Page, J.E. Dugan, L. Wilson, S.D. Gaines and S.A. Hodges. 2006. Advancing marine biotechnology: use of OCS oil platforms as sustainable sources of marine natural products. MMS OCS Study 2006-054. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-31063. 45 pages.

Seafreeze Ltd. 2009. Seafreeze, Ltd. Available at http://www.seafreezeltd.com. Last accessed November 1, 2010.

Sheehy, D. 2009. Constructed reefs for mitigation and fishery enhancement in marine wind farm development. Presented at: The Ecology of Marine Wind Farms: Perspectives on Impact Mitigation, Siting, and Future Uses. 8th Annual Ronald C. Baird Sea Grant Science Symposium, November 2-4, 2009, Newport, R.I. Available at http://seagrant.gso.uri.edu/baird/2009/abstracts/sheehy.pdf

Sheehy, D. 1982. The use of designed and prefabricated artificial reefs in the United States. *Marine Fisheries Review* 44: 4-15.

Sheehy, D.J. 1977. A study of artificial reefs constructed from unit shelters for the American lobster (*Homarus americanus*). Ph.D. Dissertation, Graduate School of Oceanography, University of Rhode island, Narragansett, R.I.

Sheehy, D. 1976. Utilization of Artificial Shelters by the American Lobster (*Homarus americanus*). *Journal of the Fisheries Research Board of Canada* 33: 1615-1622.

Sheehy, D.J and S.F. Vik. 2010. The role of constructed reefs in non-indigenous species introductions and range expansions. *Ecological Engineering* 36: 1–11.

Sheehy, D.J. and S.F. Vik. 1992. Developing Prefabricated Reefs: An Ecological Engineering Approach. In: *Restoring the Nation's Marine Environment,* G.W. Thayer, ed., Maryland Sea Grant, College Park, MD.

Simard, F. 1996. Socio-economic aspects of artificial reefs in Japan. In: Jensen AC (ed) *First European Artificial Reef Research Network Conference.* Southampton Oceanography Centre, Ancona, Italy, pp 233-240.

Sobel, J. 1993. Conserving Biological Diversity Through Marine Protected Areas. *Oceanus* (Fall): 19-26.

Soto, D. and 21 co-authors. 2008. Applying an ecosystem-based approach to aquaculture: principles, scales and some management measures. In: *Building an ecosystem approach to aquaculture*. Eds. D. Soto, J. Aguilar-Manjarrez and N. Hishamunda. Rome: FAO Fisheries and Aquaculture Proceedings 14. FAO, Rome.

Spaulding, M., C. Swanson, K. Jayko and N. Whittier. 2007. An LNG release, transport, and fate model system for marine spills. *Journal of Hazardous Materials* 140(3): 488-503.

Spaulding, M. 2005. Siting of Synergetics LLP Offshore LNG facility in Block Island Sound, RI. University of Rhode Island.

Steimle, F., K. Foster, R. Kropp, and B. Conlin. 2002. Benthic macrofauna productivity enhancement by an artificial reef in Delaware Bay, USA. *ICES Journal Marine Science* 59: S100-S105.

Stephens, J. and D. Pondella. 2002. Larval productivity of a mature artificial reef: the ichthyoplankton of King Harbor, California, 1974–1997. *ICES Journal of Marine Science* 59: 102-110.

Stump, N. and L.K. Kriwoken. 2006. Tasmanian marine protected areas: Attitudes and perceptions of wild capture fishers. *Ocean & Coastal Management* 49: 298-307

Svane, I. and J. Petersen. 2001. On the problems of epibioses, fouling and artificial reefs, a review. *Marine Ecology-Pubblicazioni Della Stazione Zoologica Di Napoli I* 22: 169-188.

The International Ecotourism Society. 2006. Fact Sheet. Available from http://www.ecotourism.org/site/c.orLQKXPCLmF/b.4832143/k.CF7C/The_International_Ecotourism_Society__Uniting_Conservation_Communities_and_Sustainable_Travel.htm

Travisono, N. 2010. Whatever happened to the Jamestown Bridge? *Wild Rhode Island*. 3(1): 3.

Turpin, R. and S. Bortone. 2002. Pre- and post-hurricane assessment of artificial reefs: Evidence for potential use as refugia in a fishery management strategy. *ICES Journal of Marine Science* 59:S74–S82.

U.S. Army Corps of Engineers (USACE). 2007. *Waterborne Commerce of the United States. Part 1—Waterways and Harbors Atlantic Coast.* Army Corps of Engineers, Institute for Water Resources, Alexandria, Virginia.

USACE. 2004. *Waterborne Commerce of the United States. Part 1—Waterways and Harbors Atlantic Coast.* Army Corps of Engineers, Institute for Water Resources, Alexandria, Virginia.

Valentine, P., J. Collie, R. Reid, R. Asch, V. Guida and D. Blackwood. 2007. The occurrence of the colonial ascidian *Didemnum* sp. on Georges Bank gravel habitat — Ecological observations and potential effects on groundfish and scallop fisheries. *Journal of Experimental Marine Biology and Ecology* 342: 179-181.

Wilhelmsson, D., T. Malm, and M.C. Öhman. 2006. The influence of offshore windpower on demersal fish. *ICES Journal of Marine Science* 63(5):775-784.

Wilson, K. and D. Cook. 1998. Artificial reef development: a marine protected area approach. In: Morton B (ed) 3rd International Conference on the Marine Biology of the South China Sea, Hong Kong, pp 529-539.

Workman, I., Shah, A., Foster, D., and Hataway, B. 2002. Habitat preferences and site fidelity of juvenile red snapper (*Lutjanus campechanus*). *ICES Journal of Marine Science* 59: 43–50.

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Section 1000. Introduction

1. A number of state statutes, regulations, and policies exist in Rhode Island which govern the uses of the areas contained within the Ocean SAMP. These Rhode Island statutes have associated regulatory provisions that provide policy direction for, and regulation and management of, these ocean resources and uses.

2. Additionally, there are a number of federal statutes, regulations and policies which govern the Ocean SAMP area. The federal authorities in some instances delegate authority to the state and in others reserve power for the federal government.

3. As will be set forth below, because the Ocean SAMP study area encompasses both state and federal waters a summary of the most pertinent federal and state authorities and regulatory provisions are detailed. This section is not a description of state enforceable policies for the RI Ocean SAMP, but is a description of the most relevant state and federal statutes and regulatory environment. Further, this overview is not an interpretation by the CRMC of any agency rule, regulation or statute but rather is a general overview of the statutory and regulatory environment.

Section 1010. State and Federal Jurisdiction

1. Jurisdiction over tidal waters in the United States, is divided between the federal government and the states. The Submerged Lands Act (SLA) of 1953 (43 U.S.C. §§ 1301-1315) gives states jurisdiction from the mean high tide line out to three (3) nautical miles.[1] The SLA grants coastal states "title to and ownership of the lands beneath navigable waters within the boundaries of the respective states, and the natural resources within such lands and waters." Although the federal government retains "the power to regulate commerce, navigation, power generation, national defense, and international affairs throughout state waters" (2004 U.S. Commission on Ocean Policy, An Ocean Blueprint for the 21st Century at 71), Section 1314 of the SLA underscores the fact that the federal government does not have "the rights of management, administration, leasing, use and development of the lands and natural resources which are specifically recognized, confirmed, established, and vesting in and assigned to the respective States and others by...this Act."

2. The federal waters of the United States contain three (3) primary zones: the federal territorial sea, the contiguous zone, and the Exclusive Economic Zone (EEZ). Established by Presidential Proclamation, these zones are consistent with customary international law as codified by the 1982 United Nations Convention on the Law of the Sea (UNCLOS). The zones are measured from a baseline that marks the boundary dividing land from sea, and is generally located at the "low-water line along the coast as marked on large-scale charts" (UNCLOS, Article 5).

3. The federal territorial sea extends seaward from the baseline out to twelve (12) nautical miles. When President Reagan proclaimed this zone, he did so "in accordance with international law" acknowledging that international law recognized coastal nations' authority to "exercise sovereignty and jurisdiction over their territorial seas." In the territorial seas the federal government can adopt laws pertaining to navigation, protection of cables and pipelines, fisheries, conservation of living resources and the environment, pollution, scientific research (UNCLOS, Article 21). In the contiguous zone, which extends from twelve (12) to twenty-four (24) nautical miles, the United States exercises its control over customs, fiscal, immigration, and sanitary laws (UNCLOS, Article 33).

4. The third zone, the EEZ, overlaps with the contiguous zone and extends from twelve (12) nautical miles seaward to two-hundred (200) nautical miles. In the EEZ the United States has extensive rights over natural resources. With the current movement to site new energy facilities offshore, it is important to note that international law recognizes coastal nations' "sovereign rights" for the "economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds" and "jurisdiction" with regard to "the establishment and use of...installations and structures" and marine scientific research and the protection and preservation of the marine environment (UNCLOS, Article 56).

5. The United States also claims jurisdiction over its continental shelf. The 1945 Truman Proclamation extended the federal government's jurisdiction to include the "natural

[1] In Texas, Puerto Rico, and the West Coast of Florida, states have jurisdiction out to nine nautical miles.

resources of the subsoil and sea bed of the continental shelf." The Outer Continental Shelf Lands Act (OSCLA) of 1953 (43 U.S.C. §§ 1331-1356) defines the outer continental shelf (OCS) as lands lying seaward of state waters. On OCS lands the Secretary of the Interior has authority to oversee mineral exploration and development, the power to grant leases of OCS lands on a competitive basis, and the right to formulate regulations to carry out the provisions of the Act. As amended by the 2005 Energy Policy Act. (P.L. 109-58), the OCSLA also gives the Secretary the power to authorize alternative energy projects on the OCS.

Section 1020. State Statutes, Regulations and Policies

1020.1 Coastal Resources Management Council State Authority

1. The Coastal Resources Management Council's enabling act, R.I.G.L. §§ 46-23-1 *et seq.* declares that the coastal resources of Rhode Island are a rich variety of natural, commercial, industrial, recreational and aesthetic assets which are of immediate and potential value to the present and future development of the state. It is the policy of the state to "preserve, protect, develop, and, where possible, restore" the coastal resources of the state (R.I.G.L. § 46-23-1(2)).

2. Under Article I, §17, the submerged lands of the state are impressed with a public trust and the state is responsible for the protection of the public's interest in these lands. The state maintains title in fee to all soil within its boundaries that lies below the high water mark, and it holds that land in trust for the use of the public. In benefiting the public, the state preserves certain public rights which include, but are not limited to, fishery, commerce, and navigation in these waters and the submerged lands that they cover.

3. The CRMC is the principal mechanism for management of the state's coastal resources. The state preserves certain public rights, which include, but are not limited to, fishery, commerce and navigation in tidal waters and the submerged lands that they cover. CRMC is delegated the sole and exclusive authority for the leasing of submerged and filled lands and giving licenses for the use of that land.

4. The primary responsibility of the CRMC is the continuing planning for and management of the resources of the state's coastal region. The Council is charged with identifying the state's coastal resources and formulating plans and programs for the management of each resource, identifying permitted uses, locations, and protection measures. The CRMC is charged with the authority for coordination of state, federal, local and private activities. Using both state and federal authorities the Council is authorized to adopt special area management plans ("SAMP's"), as necessary , to integrate and coordinate the protection of natural resources and promote of reasonable coastal-dependent economic growth.

1020.2 CRMC Coastal Zone Management Act Federal Consistency Review

1. Pursuant to the Federal Coastal Zone Management Act ("CZMA"), 16 U.S.C. §§ 1451 *et seq.* and the implementing regulations, states review federal actions (federal agency activities or federal license or permit activities) to ensure that such actions meet enforceable policies articulated in the state's federally-approved coastal zone management plan through a process called federal consistency review. R.I.G.L. § 46-23-15 delegates authority to the CRMC to administer land and water use regulations as necessary to fulfill its responsibilities under the CZMA.

2. Therefore, in Rhode Island a federal consistency decision by CRMC is required for projects that have reasonably foreseeable effects on any land or water use or natural resource of the Rhode Island coastal zone, regardless of whether the project or effect is within or outside the coastal zone.

1020.3 Rhode Island Endangered Species Act

1. R.I.G.L. §§ 20-37-1 *et seq.* prohibits the importation, sale, transportation, storage, traffic, ownership, or other possession or use of any animal or plant listed under the federal Endangered Species Act (ESA) (R.I.G.L. § 20-37-1). Under the state ESA, the Director of DEM may declare animal and plants endangered (R.I.G.L. § 20-37-2). The Director of DEM may acquire or control land within the state for the purpose of protecting, conserving, cultivating, or propagating any species of wildlife, plant or animals as provided by R.I.G.L. § 20-18-1.

1020.4 Rhode Island Aquaculture Regulations

1. Under R.I.G.L. §§ 20-10-1 *et seq.* applications for aquaculture permits are submitted to CRMC. After CRMC notifies the Director of DEM and the Marine Fisheries Council (MFC), the Director reviews applications to ensure that resulting aquaculture activities will not substantially effect marine life or indigenous fisheries of the state and are consistent with competing uses engaged in the exploitation of the marine fisheries (R.I.G.L. § 20-10-5). CRMC has authority to lease submerged lands of the state to applicants who have been granted aquaculture permits (R.I.G.L. § 20-10-6).

1020.5 Fisheries Management

1. The Rhode Island DEM has authority over fish and wildlife in the state (R.I.G.L. § 20-1-2). The Director of DEM is further authorized to promulgate, adopt, and enforce rules and regulations necessary to plan, manage, and regulate the marine fisheries of the state. (R.I.G.L. §§ 20-1-4, 20-1-5) and, in that capacity, the Director is charged with the obligation to promulgate and enforce regulations required to implement at the State level any fisheries management plans governing marine species developed by regional marine councils or commissions pursuant to the Magnuson-Stevens Fishery Conservation and Management Act and the Atlantic Coastal Fisheries Cooperative Management Act. (See *infra* Sections 1030.12 and 130.18.)

1020.6 Energy Facility Siting Act

1. The Rhode Island Energy Facility Siting Act (R.I.G.L. §§ 42-98-1 *et seq.*) consolidates the licensing and regulatory authority over major energy facilities into a single body. The Act establishes a three-member siting board with licensing and permitting authority for "major energy facilities," which are defined to include, facilities designed or capable of operating at a gross capacity of forty (40) megawatts or more and facilities with transmission lines of sixty-nine (69) Kv or over. (R.I.G.L. § 42-98-3). The board has power to promulgate regulations to further define "major energy facility" as necessary to carry out the purpose of the Act. The board is directed to give preference to energy projects based on eight criteria including the use of renewable fuels, maximization of efficiency, production of low levels of harmful air emissions and wastewater discharge**,** using low levels of high quality water, using the existing energy-generation facilities and sites, and having dual fuel capacity. (R.I.G.L. § 42-98-2). The authority of the DEM pursuant to R.I.G.L. §§ 2-1-1 *et seq.* and the CRMC under R.I.G.L. §§ 42-23-1 *et seq.* to issue licenses and permits remains with those agencies. (R.I.G.L. § 43-98-7).

1020.7 The Rhode Island Bays, Rivers, and Watersheds Coordination Team

1. The Rhode Island Bays, Rivers, and Watersheds Coordination Team (BRWCT) is a state interagency commission established in 2004 comprised of the RI Coastal Resources Management Council, the RI Department of Environmental Management, The RI Division of Planning, the RI Economic Development Corporation, the RI Water Resources Board, the Narragansett Bay Commission, and the RI Rivers Council. Its mandate is to coordinate executive agency functions, programs, and regulations for the management, restoration, and sustainable utilization of Rhode Island's fresh and marine waters and watersheds. It pursues this broad mandate via collaborative strategic planning and application of ecosystem-based management principles.

2. The BRWCT issued the Rhode Island Bays, Rivers, and Watersheds Systems-Level Plan (SLP) in July 2008 as a statement of the "overall goals and priorities for the management, preservation, and restoration of Rhode Island's bays, rivers, and watersheds and the promotion of sustainable economic development of the water cluster." The BRWCT assesses and evaluates how executive actions and programs at the state, federal, and local level are advancing toward SLP priorities, and funds projects and initiatives that advance SLP priorities.

Section 1030. Federal Statutes, Regulations and Policies

1. Many federal authorities affect the management of ocean uses and resources. The authorities listed below, however, are the most particularly pertinent for the Ocean SAMP.

1030.1 Coastal Zone Management Act

1. The CZMA (16 U.S.C. § 1452) establishes authority for states to prepare special area management plans ("SAMP's"). The CZMA states that it is the nation's policy:

> "to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great lakes, and improved predictability in governmental decision making."

2. Under 16 U.S.C. § 1456 and 15 CFR 930, states review federal actions (federal agency activities or federal license or permit activities) to ensure that such actions meet enforceable policies articulated in the state's federally-approved coastal zone management plan through a process called federal consistency review. Federal consistency review is required for projects that have reasonably foreseeable effects on any land or water use or natural resource of the Rhode Island coastal zone, regardless of whether the project or effect is within or outside the coastal zone.

3. For renewable energy projects sited in Federal waters as authorized by 30 CFR Part 285, the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) (formerly the Minerals Management Service) will prepare a consistency determination for the lease sale and site assessment activities for commercial leases issued competitively (30 CFR 285.612). For commercial leases issued by BOEMRE on a noncompetitive basis, consistency will be determined by 15 CFR 930, Subpart D, whereby the applicant must furnish the required consistency certification and associated documentation to CRMC and BOEMRE concurrently.

1030.2 National Energy Policy Act

1. Section 388 of the Energy Policy Act of 2005 (EPAct) (Pub. L. 109-58) amended the Outer Continental Shelf Lands Act, giving the Secretary of the Interior, via BOEMRE, authority to issue leases, easements, or rights-of-way on the OCS for activities including those that "produce or support production, transportation, or transmission of energy from sources other than oil and gas." Leases should be issued on a competitive basis where there is demand unless it is determined there is no competitive interest.

2. Agency jurisdiction was clarified in a signed Memorandum of Understanding in April 2009, which established a streamlined process through which BOEMRE and the Federal Energy Regulatory Commission (FERC) will lease, license, and regulate renewable

energy activities on the OCS. The agreement gives BOEMRE exclusive jurisdiction over the production, transportation, or transmission of energy from non-hydrokinetic renewable energy projects. FERC meanwhile, has exclusive jurisdiction to issue licenses for hydrokinetic projects after a BOEMRE lease is obtained.

3. The EPAct also called for the Secretary to issue regulations necessary to carry out section 388. Following the agreement discussed above, BOEMRE issued a final renewable energy framework in the Federal Register on April 22, 2009 (30 CFR Parts 250, 285, and 290). The BOEMRE regulations establish a program to issue leases for the siting and construction of renewable energy projects on the OCS. The program takes a "cradle to grave approach," considering from an initial leasing stage through the decommissioning stage at the project's end. The regulations state that BOEMRE may issue commercial and limited leases. Commercial leases "would convey the access and operational rights necessary to produce, sell and deliver power." Limited leases "will convey access and operational rights for activities on the OCS that support the production of energy, but do not result in the production of electricity or other energy project for sale, distribution, or other commercial use exceeding a limit specified in the lease." Leases will be issued on a competitive basis unless it has been determined that there is no competitive interest.

4. BOEMRE will also grant right-of-use and easement (RUE) and right-of-way (ROW) grants. RUE grants authorize the "use of a designated portion of the OCS to support renewable energy activities on a lease or other approval" while ROW grants" allow for the construction and use of a cable or pipeline for the purpose of gathering, transmitting, distributing, or otherwise transporting electricity or other energy product generated or produced from renewable energy not generated on a lease issued under this part."

5. During the life of a project the BOEMRE program details site assessment, construction and operations, general activities plans and their approval, and environmental and safety monitoring.

1030.3 Outer Continental Shelf Lands Act

1. The Outer Continental Shelf Lands Act (OCSLA) (Pub. L. 83-212; 43 U.S.C. §§ 1331-1356) as amended by the 2005 EPAct and previous amendments, gives the U.S. Department of the Interior, through BOEMRE, the authority to lease offshore tracts on a competitive basis, collect royalties on production of oil and natural gas, and consider economic, social and environmental values of renewable and nonrenewable resources in managing the Outer Continental Shelf (OCS). In 2005, Congress amended the OCSLA to grant primary authority to BOEMRE to authorize alternative energy projects on the OCS.

1030.4 National Environmental Policy Act

1. The National Environmental Policy Act (NEPA) (42 U.S.C. §§ 4321-4370) establishes environmental protection as a national policy goal and directs all federal agencies to consider, and disclose, the environmental consequences of their projects and permitting actions. NEPA sets up a system for formal evaluation of environmental impacts of the actions of federal agencies, the centerpiece of which is the Environmental Impact

Statement (EIS). The Council on Environmental Quality (CEQ) regulations for implementing NEPA state that federal agencies shall integrate the NEPA process at the earliest possible time to ensure that the agency makes informed permitting decisions to avoid delays in the process and to head off potential conflicts. Typically, a federal agency with an action on a project will first prepare an Environmental Assessment (EA). Following publication in the Federal Register and a comment period, the agency will either issue a Finding of No Significant Impact ("FONSI") or will decide to prepare an EIS to more fully examine alternatives, impacts and mitigation. One federal agency is usually designated as the "lead" agency, and this agency will prepare the EIS. Other federal and state agencies may play an official role in preparation by becoming "cooperating" agencies. At the completion of the EIS process, the lead agency issues a Record of Decision making environmental findings. NEPA does not direct an agency to choose any particular course of action; the only purpose of an EIS is to ensure that environmental consequences are considered.

1030.5 Marine Mammal Protection Act and Federal Endangered Species Act

1. The primary federal legislation that provides for the protection and management of marine mammals is the Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§ 1361-1421). The MMPA prohibits, with certain exceptions, the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas, as well as the importation of marine mammals and marine mammal products into the United States. Under the MMPA, the National Oceanic and Atmospheric Administration (NOAA) has responsibility for ensuring the protection of cetaceans (whales, porpoises, and dolphins) and pinnipeds (seals and sea lions), except walruses. The federal Endangered Species Act (ESA) (16 U.S.C. §§ 1531-1544, 50 CFR 17.00) prohibits any person, including private entities, from "taking" a "listed" species. "Take" is broadly defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect or to attempt to engage in any such conduct" (16 U.S.C. § 1532(19)).

1030.6 Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act

1. Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 401-413) prohibits the unauthorized obstruction or alteration of any navigable water of the U.S. The construction of any structure in or over any navigable water of the U.S., the excavating from or depositing of dredged material or refuse in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters is unlawful without prior approval from the United States Army Corps of Engineers (USACE). The legislative authority to prevent inappropriate obstructions to navigation was extended to installations and devices located on the seabed to the seaward limit of the OCS by Section 4(e) of the OSCLA of 1953, as amended.

2. Section 404 of the CWA (33 CFR 323) prohibits discharges of dredged or fill material into waters of the United States, including wetlands without a permit from the USACE. Waters of the United States include those waters and their tributaries, adjacent wetlands, and other waters or wetlands where degradation or destruction could affect interstate or foreign commerce. Section 404 of the CWA defines the landward limit of jurisdiction as the high tide line in tidal waters and the ordinary high water mark in non-tidal waters.

When adjacent wetlands are present, the limit of jurisdiction extends to the limit of the wetland. Coincident with the state's jurisdictional limit, USACE regulates section 404 activities seaward to 3 miles.

1030.7 Clean Water Act Section 401 Water Quality Certification

1. The federal Clean Water Act (CWA) Section 401 (33 U.S.C. § 1341 *et seq.* and R.I.G.L. §§ 46-12-1 *et seq.*) process is administered by the Rhode Island Department of Environmental Management (DEM) Office of Water Resources. Water Quality Certification is required for projects proposing dredging, filling, water withdrawals, or site disturbances in the state's inland and coastal waters. This certifies that a project avoids, minimizes, or mitigates impacts to areas subject to 401 and complies with Rhode Island Water Quality Regulations, which establish water quality standards for the state's surface waters. Section 401 applies to any project that is subject to federal regulation under the CWA. DEM coordinates Water Quality Certification permit reviews within the Agency and with the Division of Fish and Wildlife and the Office of Waste Management.

1030.8 Clean Air Act Air Pollution from Outer Continental Shelf Activities

1. The Clean Air Act (CAA) Section 328 (42 U.S.C. § 7627) regulates air pollution from OCS activities. The EPA is required to control air pollution from OCS sources in order to maintain Federal and State ambient air quality standards. The CAA provides that within 25 miles of a state's seaward boundary, state and local emission control requirements for emission controls, limitations, offsets, permitting, monitoring, testing, and reporting must be followed. Under CAA Section 328 emissions from any vessel servicing or associated with an OCS source, are considered direct emissions from the OCS source. The Office of Air Resources within DEM administers the Rhode Island CAA (R.I.G.L. §§ 23-23-1 *et seq.*).

1030.9 Federal Aviation Administration Authority

1. 49 U.S.C. § 44718 gives the Federal Aviation Administration (FAA) authority to promote safe and efficient use of the navigable airspace. To protect aircraft from encountering unexpected structures, the Objects Affecting Navigable Airspace (15 CFR 77) was adopted. It establishes notice criteria for proposed construction or alteration of structures. Vertical structures greater than 200 feet (61 meters) in height must have FAA approval to avoid or minimize obstruction to navigable airspace, and includes structures located within a state's territorial waters.

1030.10 U.S. Coast Guard Regulations

1. Pursuant to 33 CFR 66.01 and under provisions of 46 U.S.C. and 33 U.S.C. § 30, the United States Coast Guard (USCG) has safety and regulatory jurisdiction over projects located in navigable waters of the United States and is responsible for granting permits for private aids to navigation.

1030.11 Oil Pollution Act of 1990

1. The Oil Pollution Act of 1990 (OPA) (33 U.S.C. §§ 2701-2761) amended the CWA and created a comprehensive prevention, response, liability, and compensation regime to deal with vessel-caused and facility-caused oil pollution in navigable waters of the United States. The OPA requires oil storage facilities and vessels submit, to the authorizing federal agency, plans detailing how they will respond to their worst case discharge, and requires the development of Area Contingency Plans to prepare and plan for oil spill response on a regional scale. Oil Spill Response Plans must also comply with BOEMRE regulations (30 CFR 254), which require owners and operators of oil handling, storage, or transportation facilities located seaward of the coastline to submit a spill response plan to BOEMRE for approval prior to facility operation.

1030.12 Magnuson-Stevens Fishery Conservation and Management Act

1. The purposes of the Magnuson-Stevens Act (16 U.S.C. §§ 1801-1881) are to conserve and manage the fishery resources of the United States; manage the U.S. anadromous species and continental shelf fishery resources; support the implementation and enforcement of international fishery agreements for the conservation and management of highly migratory species; promote domestic, commercial and recreational fishing under sound conservation and management principles; provide for preparation and implementation of fishery management plans to achieve and maintain the optimum yield of each fishery on a continuing basis; establish Regional Fishery Management Councils to protect fishery resources through preparation, monitoring, and revision of plans that allow for participation of states, fishing industry, consumer and environmental organizations; encourage the development of underutilized U.S. fisheries and promote the protection of essential fish habitat (EFH). To promote the protection of EFH, federal agencies are required to consult on activities that may adversely affect designated EFH. The responsible agency is NOAA Fisheries.

1030.13 Migratory Bird Treaty Act

1. The Migratory Bird Treaty Act (16 U.S.C. §§ 703-712) is a domestic law that implements the United States' commitment to international conventions with Canada, Mexico, Japan, and Russia for protection of shared migratory bird resources. The Act generally prohibits the taking, killing, possession, transportation of, trafficking in, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. The Act has no provision allowing for an unauthorized take.

1030.14 Migratory Bird Executive Order 13186

1. The "Responsibilities of Federal Agencies to Protect Migratory Birds" Executive Order (EO) was designed to create a more comprehensive strategy for migratory bird conservation by the Federal government. The EO requires any federal agency taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations to develop and implement, within two years a Memorandum of Understanding (MOU) with the U.S. Fish and Wildlife Service that shall promote the conservation of migratory bird populations. The MOU shall support the conservation of

migratory birds by integrating bird conservation principles, measures and practices into agency activities and by avoiding or minimizing the impacts of activities on migratory birds. In addition, it shall restore and enhance the habitat of migratory birds, as practicable; prevent or minimize the pollution or destruction of the environment for the benefit of migratory birds; design migratory bird habitat and population conservation principles, measures and practices into agency plans and planning processes; ensure environmental analyses of federal actions or other environmental review processes; evaluate the effects of actions on migratory birds; and promote research and information exchange related to the conservation of migratory birds. Even before completion of a MOU federal agencies are encouraged to immediately begin implementing migratory bird conservation measures.

1030.15 National Historic Preservation Act

1. The goal of the National Historic Preservation Act (NHPA) (16 U.S.C. §§ 470-470-1) is to have Federal agencies act as responsible stewards for our nation's resources when their actions affect historic properties, including tribal historic and cultural resources. Section 106 of the NHPA requires federal agencies, including BOEMRE, to take into account the effects of their undertakings, including issuance of leases, on historic and cultural properties and resources and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings, including consultation with State Historic Preservation Officers and Tribal Historic Preservation Officers.

1030.16 National Estuary Program

1. The Narragansett Bay Estuary Program is part of the National Estuary Program (NEP) and receives base funding and federal oversight from the EPA. The cornerstone of the NEP is the development and implementation of a Comprehensive Conservation and Management Plan (CCMP) to identify actions that should be taken to maintain and improve the ecological integrity of the environmental resources within the bays and their surrounding watersheds and meet the goals of Section 320 of the CWA. The Narragansett Bay CCMP was accepted as part of the Rhode Island State Guide Plan, which requires state agency and municipal plan consistency with the CCMP. The program has limited relationship to the Ocean SAMP because the predominant focus of the SAMP is on activities that occur outside the Narragansett Bay CCMP planning area.

1030.17 Federal Power Act: Federal Energy Regulatory Commission

1. The Federal Energy Regulatory Commission ("FERC") was created under the Federal Power Act and has jurisdiction to issue licenses for up to fifty years to construct, maintain, and operate hydroelectric plants, electric "transmission lines, or other project works . . . for the development, transmission, and utilization of power across, . . . or in any of the streams or other bodies of water over which Congress has jurisdiction," and the FERC exercises regulatory powers over licensees for such projects (16 U.S.C. § 797(e), § 799). Accordingly, in the Rhode Island territorial seas extending three (3) nautical miles from the coastal low-water line, the FERC maintains authority to license hydrokinetic power generation facilities and electric transmission lines from any energy project passing through those waters. However, the FERC's jurisdiction over projects

three miles or further from shore, on the outer continental shelf ("OCS"), is limited by an agreement with BOEMRE to issuing licenses and exemptions for hydrokinetic projects, while BOEMRE retains exclusive jurisdiction not only to lease OCS lands and rights-of-way for energy projects, but over energy production and transmission from non-hydrokinetic projects (DOI-FERC MOU, April 9, 2009).

1030.18 Atlantic States Marine Fisheries Commission and Atlantic Coastal Fisheries Cooperative Management Act

1. The Atlantic States Marine Fisheries Commission ("ASMFC") was established by an interstate compact approved by Congress "to promote better utilization of the fisheries, marine, shell and anadromous, of the Atlantic" by developing "a joint program to promote, ... protect," and prevent waste of such fisheries (Pub. L. 77-539). The ASMFC is comprised of the Atlantic coastal states from Maine to Florida, plus Pennsylvania, and each member-state appoints three commissioners. Congress also enacted the Atlantic Coastal Fisheries Cooperative Management Act requiring the ASMFC to adopt coastal fishery management plans ("FMPs") for any fishery that moves among, or is broadly distributed across two or more states' waters, and for fisheries moving between one state's waters and the EEZ (16 U.S.C. § 5104(a)(1)). The ASMFC through Regional Councils will consult with and complement state plans in preparing FMPs for fisheries moving between state waters and the EEZ. (Id.). States are responsible for implementing and enforcing FMP measures, and failure can result in the Secretary of Commerce declaring a moratorium on fishing for the affected species in the noncompliant state (16 U.S.C. § 5106(c)).

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Section 1100. Introduction

1. The Rhode Island General Assembly mandates Rhode Island Coastal Resources Management Council (CRMC) to preserve, protect, develop, and where possible, restore the coastal resources of the state for this and succeeding generations through comprehensive and coordinated long range planning and management designed to produce the maximum benefit for society from these coastal resources; and that the preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured, judged and regulated [Rhode Island General Laws 46-23-1(a)(2)]. To more effectively carry out its mandate, the CRMC has established use categories for all state waters out to the three nautical mile boundary. The Rhode Island Coastal Resource Management Program (RICRMP) is a federally-approved coastal program under the federal Coastal Zone Management Act (16 U.S.C. 1451 *et seq.*).

2. The Ocean Special Area Management Plan (Ocean SAMP) is the regulatory, planning and adaptive management tool that CRMC is applying to uphold these regulatory responsibilities in the Ocean SAMP area.[1] Using the best available science and working with well-informed and committed resource users, researchers, environmental and civic organizations, and local, state and federal government agencies, the Ocean SAMP provides a comprehensive understanding of this complex and rich ecosystem. The Ocean SAMP also documents how the people of this region have used and depended upon these offshore resources for subsistence, work and play, and how the natural wildlife such as fish, birds, marine mammals and sea turtles feed, spawn, reproduce, and migrate throughout this region, thriving on the rich habitats, microscopic organisms, and other natural resources. To fulfill the Council's mandate, the Ocean SAMP lays out enforceable policies and recommendations to guide CRMC in promoting a balanced and comprehensive ecosystem-based management approach to the development and protection of Rhode Island's ocean-based resources.[2]

3. The Ocean SAMP region lies at the convergence of two bio-geographic provinces - the Acadian to the north (Cape Cod to the Gulf of Maine) and the Virginian to the south (Cape Cod to Cape Hatteras). Due to this unique position, the Ocean SAMP area is more susceptible than other areas along the eastern seaboard to the effects of climate change. Cognizant of this fact, the CRMC integrates climate concerns and adaptation and mitigation responses into relevant policies and plans. CRMC believes that with advanced planning, together with energy conservation, the harm and costs associated with these potential impacts can be reduced and may be avoided.

4. This Chapter presents how the Ocean SAMP builds upon CRMC's existing program as well as describes implementation mechanisms that support the application of the adaptive management approach. Section 1150 presents all Ocean SAMP general policies, while Section 1160 integrates the regulatory standards into a regulatory process that ensures the Council's ability to uphold its mandatory requirements. To review both general policies and regulatory standards by topic area, please see that specific chapter. The "General

[1] Adaptive management is defined in section 1130.1.
[2] Ecosystem-based management is defined in section 1110.4.

Policies" in Section 1150 are policies the CRMC applies through its various management and regulatory functions, but the General Policies are not "enforceable policies" for purposes of the Federal Coastal Zone Management Act (CZMA) Federal Consistency provision (16 U.S.C. § 1456 and 15 C.F.R. part 930). For CZMA Federal Consistency purposes the General Policies are advisory only and cannot be used as the basis for a CRMC CZMA Federal Consistency concurrence or objection. However, for State permitting purposes, Offshore Developments proposed to be sited in State waters are bound by both the General Policies (1150) and Regulatory Standards (1160) listed in Chapter 11, The Policies of the Ocean SAMP. The "Regulatory Standards" in Section 1160 are enforceable policies for purposes of the Federal CZMA Federal Consistency provision (16 U.S.C. § 1456 and 15 C.F.R. part 930). For CZMA Federal Consistency purposes the Regulatory Standards, in addition to other applicable federally approved RICRMP enforceable policies, shall be used as the basis for a CRMC CZMA Federal Consistency concurrence or objection.

5. States, generally, do not have jurisdiction in federal waters and the federal Coastal Zone Management Act (CZMA) does not confer such jurisdiction. Therefore, in order to meet CZMA requirements, state plans, enforceable policies, and Areas of Particular Concern (APCs) must only apply to areas of state jurisdiction. The Ocean SAMP is a planning and regulatory component for the State of Rhode Island and will be incorporated into the NOAA-approved Rhode Island Coastal Resource Management Program (RICRMP). As such, in order to meet the CZMA's definition of "enforceable policy" and NOAA's corresponding regulations, the Ocean SAMP only applies to state waters (out to 3 nautical miles). The enforceable policies, APCs and Areas Designated for Preservation (ADPs) in a NOAA-approved Ocean SAMP will apply to activities in federal waters through the CZMA federal consistency provision.

6. The Ocean SAMP includes maps of federal waters and identifies uses, resources and areas of federal waters. The data and maps pertaining to federal waters are not enforceable components of the Ocean SAMP. However, the data and maps contain a substantial amount of environmental, ecological, geologic, and human use information for state and federal waters. This information will be useful for environmental reviews (including reviews under the National Environmental Policy Act and coastal effects analyses under the CZMA), engineering issues (e.g., is the seafloor material compatible for a particular piece of equipment), and other planning and regulatory decisions. The CRMC may use the data and maps for federal waters to assess coastal effects, but Rhode Island's CZMA federal consistency concurrence or objection must be based on enforceable policies contained in the NOAA-approved RICRMP.

Section 1110. Building on CRMC's Existing Program

1. Ocean SAMP policies and recommendations build upon and refine the CRMC's existing Program and regulations presented in the Rhode Island Coastal Resources Management Plan (RICRMP). The policies, standards, and definitions contained in the RICRMP for Type 4 waters within the Ocean SAMP boundary, specifically from the mouth of Narragansett Bay seaward, between 500 feet offshore and the 3-nautical mile state water boundary, are hereby modified. In addition, RICRMP Sections 300.3 and 300.8 and the

1978 Energy Amendments are hereby superseded for this Ocean SAMP region. Aquaculture projects of any size shall follow Section 300.11 of the RICRMP. Dredging and dredge disposal activities remain governed by Section 300.9 of the RICRMP. An approved Ocean SAMP by NOAA's Office of Ocean and Coastal Resource Management will confer federal consistency authority to the Council for a boundary extension in federal waters within the Ocean SAMP area. However, it should be noted that the Ocean SAMP boundary does not limit the zone for federal consistency, and the CRMC may still exercise its federal consistency authority over future activities which may be proposed in federal waters beyond the Ocean SAMP area.

2. All federal consistency determinations for Large-Scale Offshore Developments, as defined in section 1160.1, will be concurred or objected to by the Full Council after receiving a timely recommendation from the CRMC Executive Director.

3. The Ocean SAMP polices for Type 4 waters require that CRMC accommodate and maintain a balance among the diverse activities, both traditional and future water dependent uses, while preserving and restoring the ecological systems. CRMC recognizes that large portions of Type 4 waters include important fishing grounds and fishery habitats, and shall protect such areas from alterations and activities that threaten the vitality of Rhode Island fisheries. Aquaculture leases shall be considered if the Council is satisfied there will be no significant adverse impacts on the traditional fishery. In addition, CRMC shall work to promote the maintenance and improvement of good water quality within the Type 4 waters (RICRMP Section 200.4).

4. The Ocean SAMP assists CRMC in upholding its mandate to preserve the state's coastal resources on submerged lands in accordance with the public trust. As stated in Article 1, §17 of the Rhode Island Constitution, applicable statutes, and restated in the RICRMP, the state maintains title in fee to submerged lands below the high water mark, and holds these lands in trust for the use of the public, preserving public rights which include but are not limited to fishing, commerce, and navigation in these lands and waters. Rhode Island public trust resources are defined in RICRMP as the tangible physical, biological matter substance or systems, habitat or ecosystem contained on, in or beneath the tidal waters of the state, and also include intangible rights to use, access, or traverse tidal waters for traditional and evolving uses including but not limited to recreation, commerce, navigation, and fishing.

5. As with the six existing Rhode Island SAMPs and CRMC's water type designations, CRMC implements the marine spatial planning (MSP) process to achieve ecosystem-based management (EBM) for the Ocean SAMP region. For the purposes of the Ocean SAMP, the CRMC adopts the definition of EBM put forth in the "Scientific Consensus Statement on Marine Ecosystem-Based Management" (McLeod et al. 2005), which defines EBM as "an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition that provides the services humans want and need."[3]

[3] The Scientific Consensus Statement on Marine Ecosystem-Based Management is signed by more than 220 scientists and policy experts from academic institutions throughout the United States. For further information see McLeod et al. 2005.

Ecosystems are places and marine spatial planning (MSP) is the process by which ecosystem-based management is organized to produce desired outcomes in marine environments. Since 1983 the CRMC has applied MSP to achieve EBM along Rhode Island's coastline.

Section 1120. Ocean SAMP Goals and Principles

1. The process to both develop the Ocean SAMP as well as establish policies and regulations was guided by the following goals and principles. These goals and principles were developed in coordination with the Ocean SAMP researchers and the Ocean SAMP stakeholder group. For more information on the Ocean SAMP goals and principles and the Ocean SAMP stakeholder group see Chapter 1, Introduction.

2. The Ocean SAMP Goals are to:

    i. Foster a properly functioning ecosystem that is both ecologically sound and economically beneficial;
    ii. Promote and enhance existing uses;
    iii. Encourage marine-based economic development that considers the aspirations of local communities and is consistent with and complementary to the state's overall economic development, social, and environmental needs and goals;
    iv. Build a framework for coordinated decision-making between state and federal management agencies.

3. The Ocean SAMP Principles are to:

    i. Develop the Ocean SAMP document in a transparent manner;
    ii. Involve all stakeholders;
    iii. Honor existing activities;
    iv. Base all decisions on the best available science;
    v. Establish monitoring and evaluation that supports adaptive management.

Section 1130. Applying Adaptive Management to Implement the Ocean SAMP

1. Since its inception in 1971, the CRMC has managed Rhode Island's coastal waters using an adaptive management approach. Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. Adaptive management requires careful implementation, monitoring, evaluation of results, and adjustment of objectives and practices. Adaptive management usually allows more reliable interpretation of results, and leads to more rapid learning and better management. To this end, CRMC will establish several mechanisms to ensure that the Ocean SAMP is implemented using this management approach.

2. CRMC will develop and implement the Ocean SAMP Science Research Agenda, in coordination with the Ocean SAMP researchers, federal, state, and local government and other parties, to improve management policies and practices. The Ocean SAMP Science Research Agenda will allow CRMC to: 1) Continue to learn about Rhode Island's offshore natural resources and human activities; 2) Better understand the potential effects of future development and other human impacts; and 3) Increase Rhode Island's understanding of the projected impacts of global climate change. To develop the Science Research Agenda, the Council will put together an advisory group including scientists, partner federal and state agencies, environmental organizations, and users of the Ocean SAMP area. This group will help the Council to identify data gaps, short- and long-term research priorities, potential partners, and potential funding sources.

3. A Progress Assessment and Monitoring Process by CRMC will be established with the purpose of assessing progress towards achieving the Ocean SAMP goals, objectives, and principles. This process will record decisions, capture lessons learned, note achievements, and document policy and management adaptations. This process will be ongoing, available on the project web site, and formally reported to the public on a biannual basis.

4. The Council will develop a work plan that will guide the proactive management of the Ocean SAMP region and implement the Ocean SAMP goals: 1) Foster a properly functioning ecosystem that is both ecologically sound and economically beneficial; 2) Promote and enhance existing uses; 3) Encourage marine-based economic development that meets the aspirations of local communities and is consistent with and complementary to the state's overall economic development, social, and environmental needs and goals; and 4) Build a framework for coordinated decision-making between state and federal management agencies. Major components of this work plan include the Ocean SAMP Science Research Agenda, the Progress Assessment and Monitoring Process, stakeholder involvement and education, and implementation of Ocean SAMP policies and recommendations.

5. Although the Ocean SAMP may be continually amended through an administrative process, the CRMC will conduct a major review of the Ocean SAMP document every five years from adoption. CRMC will implement this revision process using the principles honored during the development of the Ocean SAMP, including involving stakeholders and basing all decisions on the best available science. For more information on the Ocean SAMP principles, see Chapter 1, Introduction.

6. The Council will establish a mechanism to ensure that the public continues to be engaged in the implementation of the Ocean SAMP. The Ocean SAMP public forum will be held biannually. The public forum will feature reports and discussions of the Ocean SAMP condition and use, note progress toward goals and objectives, and recognize contributions to implementing the Ocean SAMP. The forum will highlight projects underway, report on the Progress Assessment and Monitoring Process and Science Research Agenda, including new research findings and updated global climate change projections, and provide opportunities for exchanging information, ideas, and strategies to strengthen implementation. The forum will address emerging issues and identify potential Ocean SAMP revisions. The Council will use this information to prepare its work plan. The forum may be followed up by other Ocean SAMP meetings that provide continuing opportunities to discuss progress, focus on specific issues, and coordinate ongoing actions by member groups. The public forum will be supported by the Ocean SAMP website and information systems maintained by Rhode Island Sea Grant and CRMC.

Section 1140. Decision-making

1. In accordance with and pursuant to the provisions of Rhode Island General Laws 46-23-6, the Council shall engage in the following coordination activities. The intent of establishing these coordination mechanisms is to ensure appropriate engagement of the stakeholders, including the resources users and the state and federal government agencies. These coordination mechanisms, although described here, are more thoroughly described in the identified sections:

    i. The Council shall work to the maximum extent practicable in coordination with the Ocean SAMP Joint Agency Working Group as defined in section 1160.1.4, a Group facilitated by the Council and made up of appropriate federal and state agencies, to establish project specific requirements that shall be followed by the applicant during the construction, operation and decommissioning phases of an Offshore Development. For more information on the Joint Agency Working Group, see Section 1160.1.4.

    ii. The Council shall engage commercial and recreational fishermen in the Ocean SAMP decision-making process through the Fishermen's Advisory Board (FAB), as defined in section 1160.1.6. The FAB will provide the Council with advice on the potential adverse impacts of Offshore Development on commercial and recreational fishermen and fisheries activities, and on issues including, but not limited to, the evaluation and planning of project locations, arrangements, and alternatives; micro-siting (siting of individual wind turbines within a wind farm to identify the best site for each individual structures); access limitations; and measures to mitigate the potential impacts of such projects. For more information on the FAB, see Section 1160.1.6.

    iii. The Council shall work to minimize use conflicts and ensure marine safety and navigational access around and through offshore structures and developments and along cable routes during the construction, operation and decommissioning phases of offshore development, by establishing communication and coordination mechanisms between the Council, Federal and state agencies, resource users including fishermen's organizations, marine pilots, recreational boating organizations, and marine safety organizations. See sections 1150.4 – 1150.7 for further information.

    iv. The Council shall convene a panel of scientists to advise on findings of current climate science for the region and the implications for Rhode Island's coastal and offshore regions, as well as the possible management ramifications. This information will allow the Council to proactively plan for and adapt to climate change impacts including, but not limited to, increased storminess, temperature change, and acidification in addition to accelerated sea level rise. For more information on the Science Advisory Panel for Climate Change, see Section 1150.2.3.

    v. The Council shall work to the maximum extent practicable with state and federal agencies, academic institutions, environmental organizations, and others to make

sure it is using the best available science and modeling tools to inform the decision making process. Tools including the Technology Development Index (TDI) and the Ecological Value Map (EVM) will inform site selection of future development and help to understand where areas of greatest ecological value exist in the Ocean SAMP area to then determine appropriate sites suitable for preservation and/or future development. For more information on these tools, see Chapter 2, Ecology of the SAMP Region, and Chapter 8, Renewable Energy and Other Offshore Development.

Section 1150. General Policies

1. Ocean SAMP policies and regulatory standards represent actions the CRMC must take to uphold its regulatory responsibilities mandated to them by the Rhode Island General Assembly and the CZMA to achieve the Ocean SAMP goals and principles described in the Introduction Chapter. The "General Policies" in Section 1150 are policies the CRMC applies through its various management and regulatory functions, but the General Policies are not "enforceable policies" for purposes of the Federal CZMA Federal Consistency provision (16 U.S.C. § 1456 and 15 C.F.R. part 930). For CZMA Federal Consistency purposes the General Policies are advisory only and cannot be used as the basis for a CRMC CZMA Federal Consistency concurrence or objection. However, for State permitting purposes, Offshore Developments proposed to be sited in State waters are bound by both the General Policies (1150) and Regulatory Standards (1160) listed in Chapter 11, The Policies of the Ocean SAMP. The "Regulatory Standards" in Section 1160 are enforceable policies for purposes of the Federal CZMA Federal Consistency provision (16 U.S.C. § 1456 and 15 C.F.R. part 930). For CZMA Federal Consistency purposes the Regulatory Standards, in addition to other applicable federally approved RICRMP enforceable policies, shall be used as the basis for a CRMC CZMA Federal Consistency concurrence or objection. Policies presented for cultural and historic resources, fisheries, recreation and tourism, and marine transportation promote and enhance existing uses and honor existing activities (Goal ii, Principle iii). Ecology, global climate change, and other future uses information and policies provide a context for basing all decisions on the best available science, while fostering a properly functioning ecosystem that is both ecologically sound and economically beneficial (Goal i, Principle iv). Renewable energy and offshore development policies and regulatory standards ensure there is a rigorous review for all ocean development so that the Council meets its public trust responsibilities. The Ocean SAMP also provides thoughtful direction to encourage marine-based economic development that meets the aspirations of local communities and is consistent with and complementary to the state's overall economic development, social, and environmental needs and goals (Goal iii). All chapters work towards establishing frameworks to coordinate decision-making between state and federal management agencies and the people who use the Ocean SAMP region (Goal iv), developing in a transparent manner (Principle i), and promoting adaptive management (Principle i). Ocean SAMP policies are all important to ensuring that the Ocean SAMP region is managed in a manner that both meets the needs of the people of Rhode Island, while protecting and restoring our natural environment for future generations.

2. Section 1150 presents all Ocean SAMP general policies, while Section 1160 integrates the regulatory standards into a regulatory process that ensures the Council's ability to uphold its mandatory requirements. To review both general policies and regulatory standards by topic area, please see that specific chapter.

1150.1. Ecology

1. The Council recognizes that the preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured. Proposed activities shall be designed to avoid impacts and, where unavoidable impacts may occur, those impacts shall be minimized and mitigated.

2. As the Ocean SAMP is an extension and refinement of CRMC's policies for Type 4 Multipurpose Waters as described in the RICRMP, CRMC will encourage a balance among the diverse activities, both traditional and future water dependent uses, while preserving and restoring the ecological systems.

3. The Council recognizes that while all fish habitat is important, spawning and nursery areas are especially critical in providing shelter for these species during the most vulnerable stages of their life cycles. The Council will ensure that proposed activities shall be designed to avoid impacts to these sensitive habitats, and, where unavoidable impacts may occur, those impacts shall be minimized and mitigated. In addition, the Council will give consideration to habitat used by species of concern as defined by the NMFS Office of Protected Resources.

4. Because the Ocean SAMP is located at the convergence of two eco-regions and therefore more susceptible to change, the Council will work with partner federal and state agencies, research institutions, and environmental organizations to carefully manage this area, especially as it relates to the projected effects of global climate change on this rich ecosystem.

5. The Council shall appoint a standing Habitat Advisory Board (HAB) which shall provide advice to the Council on the ecological function, restoration and protection of the marine resources and habitats in the Ocean SAMP area and on the siting, construction, and operation of off shore development in the Ocean SAMP study area The HAB shall also provide advice on scientific research and its application to the Ocean SAMP. The HAB is an advisory body to the Council and does not supplant any authority of any federal or state agency responsible for the conservation and restoration of marine habitats. The HAB shall be comprised of nine members, five representing marine research institutions with experience in the Ocean SAMP study area and surrounding waters, and four representing environmental non-governmental organizations that maintain a focus on Rhode Island. HAB members shall serve four-year terms and shall serve no more than two consecutive terms. The Council shall provide to the HAB a semi-annual status report on Ocean SAMP area marine resources and habitat-related issues and adaptive management of projects in the Ocean SAMP planning area, including but not limited to: protection and restoration of marine resources and habitats, cumulative impacts, climate change, environmental review criteria, siting and performance standards, and marine resources and habitat mitigation and monitoring. The Council shall notify the HAB in writing concerning any project in the Ocean SAMP area. The HAB shall meet not less than semi-annually with the Fishermen's Advisory Board and on an as-needed basis to provide the Council with advice on protection and restoration of marine resources and habitats in the Ocean SAMP areas and potential adverse impacts on marine resources and habitat posed by proposed projects reviewed by the Council. The HAB may also meet regularly to discuss issues related to the latest science of ecosystem-based management in the marine environment and new information relevant to the management of the Ocean SAMP planning area. In addition the HAB may aid the Council and its staff in developing and implementing a research agenda. As new information becomes available and the scientific understanding of the Ocean SAMP planning area evolves, the HAB may identify new areas with unique or fragile physical features, important natural

habitats, or areas of high natural productivity for designation by the Council as Areas of Particular Concern or Areas Designated for Preservation.

1150.2. Global Climate Change

1. The Council recognizes that the changes brought by climate change are likely to result in alteration of the marine ecology and human uses affecting the Ocean SAMP area. The Council encourages energy conservation, mitigation of greenhouse gasses and adaptation approaches for management. The Council, therefore, supports the policy of increasing offshore renewable energy production in Rhode Island as a means of mitigating the potential effects of global climate change.

2. The Council shall incorporate climate change planning and adaptation into policy and standards in all areas of its jurisdiction of the Ocean SAMP and its associated land-based infrastructure to proactively plan for and adapt to climate change impacts such as increased storminess and temperature change, in addition to accelerated sea level rise. For example, when evaluating Ocean SAMP area projects and uses, the Council will carefully consider how climate change could affect their future feasibility, safety and effectiveness. When evaluating new or intensified existing uses within the Ocean SAMP area, the Council will consider predicted impacts of climate change especially upon sensitive habitats, most notably spawning and nursery grounds, of particular importance to targeted species of finfish, shellfish and crustaceans.

3. The Council will convene a panel of scientists, biannually, to advise on findings of current climate science for the region and the implications for Rhode Island's coastal and offshore regions, as well as the possible management ramifications. The horizon for evaluation and planning needs to include both the short term (10 years) and longer term (50 years). The Science Advisory Panel for Climate Change will provide the Council with expertise on the most current global climate change related science, monitoring, policy, and development design standards relevant to activities within its jurisdiction of the Ocean SAMP and its associated land-based infrastructure to proactively plan for and adapt to climate change impacts such as increased storminess, temperature change, and acidification in addition to accelerated sea level rise. The findings of this Science Advisory Panel will be forwarded on to the legislatively-appointed Rhode Island Climate Change Commission for their consideration.

4. The Council will prohibit those land-based and offshore development projects which based on a sea level rise scenario analysis will threaten public safety or not perform as designed resulting in significant environmental impacts. The U.S. Army Corps of Engineers has developed and is implementing design and construction standards that consider impacts from sea level rise. These standards and other scenario analyses should be applied to determine sea level rise impacts.

5. The Council supports the application of enhanced building standards in the design phase of rebuilding coastal infrastructure associated with the Ocean SAMP area, including port facilities, docks, and bridges that ships must clear when passing underneath.

6. The Council supports the development of design standards for marine platforms that account for climate change projections on wind speed, storm intensity and frequency, and wave conditions and will work with the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement, Department of Interior, Department of Energy, and the Army Corps of Engineers to develop a set of standards that can then be applied in Rhode Island projects. The Council will re-assess coastal infrastructure and seaworthy marine structure building standards periodically not only for sea level rise, but also for other climate changes including more intense storms, increased wave action, and increased acidity in the sea.

7. The Council supports public awareness and interpretation programs to increase public understanding of climate change and how it affects the ecology and uses of the Ocean SAMP area.

1150.3. Cultural and Historic Resources

1. The Council recognizes the rich and historically significant history of human activity within and adjacent to the Ocean SAMP area. These numerous sites and properties, that are located both underwater and onshore, should be considered when evaluating future projects.

2. The Council has a federal obligation as part of its responsibilities under the Federal Coastal Zone Management Act to recognize the importance of cultural, historic, and tribal resources within the state's coastal zone, including Rhode Island state waters. It has a similar responsibility under the Rhode Island Historic Preservation Act. The Council will not permit activities that will significantly impact the state's cultural, historic and tribal resources.

3. The Council will engage federal and state agencies, and the Narragansett Indian Tribe's Tribal Historic Preservation Office (THPO), when evaluating the impacts of proposed development on cultural and historic resources. The Rhode Island Historic Preservation and Heritage Commission (RIHPHC) is the State Historic Preservation Office (SHPO) for the state of Rhode Island, and is charged with developing historical property surveys for Rhode Island municipalities, reviewing projects that may impact cultural and historic resources, and regulating archaeological assessments on land and in state waters. For other tribes outside of Rhode Island that might be affected by a federal action it is the responsibility of the applicable federal agency to consult with affected tribes.

4. Project reviews will follow the policies outlined in "Section 220: Areas of Historic and Archaeological Significance" and in "Section 330: Guidelines for the Protection and Enhancement of the Scenic Value of the Coastal Region" of the State of Rhode Island Coastal Resources Management Program, As Amended ("Red Book"). The standards for the identification of cultural resources and the assessment of potential effects on cultural resources will be in accordance with the National Historic Preservation Act Section 106 regulations, 36 CFR Part 800, *Protection of Historic Properties*.

5. Historic shipwrecks, archeological or historical sites located within Rhode Island's coastal zone are Areas of Particular Concern (APCs) for the Rhode Island coastal management program. Direct and indirect impacts to these resources must be avoided to the greatest extent possible. Other areas, not noted as APCs, may also have significant archeological sites that could be identified through the permit process. For example, the area at the south end of Block Island waters within the 30 foot depth contour is known to have significant archeological resources. As a result, projects conducted in the Ocean SAMP area may have impacts to Rhode Island's underwater archaeological and historic resources.

6. Archaeological surveys shall be required as part of the permitting process for projects which may pose a threat to Rhode Island's archaeological and historic resources. During the filing phase for state assent, projects needing archaeological surveys will be identified through the joint review process. The survey requirements will be coordinated with the SHPO and, if tribal resources are involved, with the Narragansett THPO.

7. Areas of Particular Concern may require a buffer or setback distance to ensure that development projects avoid or minimize impacts to known or potential historic or archaeological sites. The buffer or setback distance during the permitting process will be determined by the SHPO and if tribal resources are involved, the Narragansett THPO.

8. In addition to general Area of Particular Concern buffer/setback distances around shipwrecks or other submerged cultural resources, the Council reserves the right, based upon recommendations from RIHPHC, to establish protected areas around all submerged cultural resources which meet the criteria for listing on the National Register of Historic Places.

9. Projects conducted in the Ocean SAMP area may have impacts that could potentially affect onshore archaeological, historic, or cultural resources. Archaeological and historical surveys may be required of projects which are reviewed by the joint agency review process. During the filing phase for state assent, projects needing such surveys will be identified and the survey requirement will be coordinated with the SHPO and if tribal resources are involved, with the Narragansett THPO.

10. Guidelines for onshore archaeological assessments in the Ocean SAMP area can be obtained through the RIHPHC in their document, "Performance Standards and Guidelines for Archaeological Projects: Standards for Archaeological Survey" (RIHPHC 2007), or the lead federal agency responsible for reviewing the proposed development.

1150.4. Commercial and Recreational Fisheries

1. The commercial and recreational fishing industries, and the habitats and biological resources of the ecosystem they are based on, are of vital economic, social, and cultural importance to Rhode Island's fishing ports and communities. Commercial and recreational fisheries are also of great importance to Rhode Island's economy and to the quality of life experienced by both residents and visitors. The Council finds that other uses of the Ocean SAMP area could potentially displace commercial or recreational fishing activities or have other adverse impacts on commercial and recreational fisheries.

2. The Council recognizes that finfish, shellfish, and crustacean resources and related fishing activities are managed by a host of different agencies and regulatory bodies which have jurisdiction over different species and/or different parts of the SAMP area. Entities involved in managing fish and fisheries within the SAMP area include, but are not limited to, the Atlantic States Marine Fisheries Commission, the R.I. Department of Environmental Management, the R.I. Marine Fisheries Council, the NOAA National Marine Fisheries Service, the New England Fishery Management Council, and the Mid-Atlantic Fishery Management Council. The Council recognizes the jurisdiction of these organizations in fishery management and will work with these entities to protect fisheries resources. The Council will also work in coordination with these entities to protect priority habitat areas.

3. The Council's policy is to protect commercial and recreational fisheries within the Ocean SAMP area from the adverse impacts of other uses, while supporting actions to make ongoing fishing practices more sustainable. It should be recognized that scientific knowledge of the impacts of fishing on habitats and fish populations will advance. Improvements in more sustainable gear technology, fishing practices, and management tools may improve the state of fisheries resources. A general goal of the Council is to constantly improve the health of the Ocean SAMP area ecosystem and the populations of fish and shellfish it provides. Cooperative research, utilizing the unique skills and expertise of the fishing community, will be a cornerstone to this goal.

4. Commercial and recreational fisheries activities are dynamic, taking place at different places at different times of the year due to seasonal species migrations and other factors. The Council recognizes that fisheries are dynamic, shaped by these seasonal migrations as well as other factors including shifts in the regulatory environment, market demand, and global climate change. The Council further recognizes that the entire Ocean SAMP area is used by commercial and recreational fishermen employing different fishing methods and gear types. Changes in existing uses, intensification of uses, and new uses within the area could cause adverse impacts to these fisheries. Accordingly, the Council shall:

    i. In consultation with the Fishermen's Advisory Board, as defined in section 1160.1.6, identify and evaluate prime fishing areas on an ongoing basis through an adaptive framework.
    ii. Review any uses or activities that could disrupt commercial or recreational fisheries activities.

5. The Council shall work together with the U.S. Coast Guard, the U.S. Navy, the U.S. Army Corps of Engineers, NOAA, fishermen's organizations, marine pilots, recreational boating organizations, and other marine safety organizations to promote safe navigation, fishing, and recreational boating activity around and through offshore structures and developments, and along cable routes, during the construction, operation, and decommissioning phases of such projects. The Council will promote and support the education of all mariners regarding safe navigation around offshore structures and developments and along cable routes.

6. Discussions with the U.S. Coast Guard, the U.S. Department of Interior Bureau of Ocean Energy Management, Regulation, and Enforcement, and the U.S. Army Corps of Engineers have indicated that no vessel access restrictions are planned for the waters around and through offshore structures and developments, or along cable routes, except for those necessary for navigational safety. Commercial and recreational fishing and boating access around and through offshore structures and developments and along cable routes is a critical means of mitigating the potential adverse impacts of offshore structures on commercial and recreational fisheries and recreational boating. The Council endorses this approach and shall work to ensure that the waters surrounding offshore structures, developments, and cable routes remain open to commercial and recreational fishing, marine transportation, and recreational boating, except for navigational safety restrictions. The Council requests that federal agencies notify the Council as soon as is practicable of any federal action that may affect vessel access around and through offshore structures and developments and along cable routes. The Council will continue to monitor changes to navigational activities around and through offshore developments and along cable routes. Any changes affecting existing navigational activities may be subject to CZMA Federal Consistency review if the federal agency determines its activity will have reasonably foreseeable effects on the uses or resources of Rhode Island's coastal zone.

7. The Council recognizes that commercial and recreational fishermen from other states, such as the neighboring states of Connecticut, New York, and Massachusetts, often fish in the Ocean SAMP area. The Council also recognizes that many fish species that are harvested in adjacent waters may rely on habitats and prey located within the Ocean SAMP area. Accordingly, the Council will work with neighboring states to ensure that Offshore Development and other uses of the Ocean SAMP area do not result in significant impacts to the fisheries resources or activities of other states.

8. The Council shall appoint a standing Fishermen's Advisory Board (FAB) which shall provide advice to the Council on the siting and construction of other uses in marine waters. The FAB is an advisory body to the Council that is not intended to supplant any existing authority of any other federal or state agency responsible for the management of fisheries, including but not limited to the Marine Fisheries Council and its authorities set forth in R.I.G.L. 20-3-1 *et. seq*. The FAB shall be comprised of nine members, one representing each of the following six Rhode Island fisheries: bottom trawling; scallop dredging; gillnetting; lobstering; party and charter boat fishing; and recreational angling; and three members, including two commercial fishermen and one recreational fisherman, who are Massachusetts fishermen who fish in the Ocean SAMP area. FAB members shall serve four-year terms and shall serve no more than two consecutive terms. The Council shall provide to the FAB a semi-annual status report on Ocean SAMP area fisheries-related issues, including but not limited to those of which the Council is cognizant in its planning and regulatory activities, and shall notify the FAB in writing concerning any project in the Ocean SAMP area. The FAB shall meet not less than semi-annually with the Habitat Advisory Board and on an as-needed basis to provide the Council with advice on the potential adverse impacts of other uses on commercial and recreational fishermen and fisheries activities, and on issues including, but not limited to, the evaluation and planning of project locations, arrangements, and alternatives; micro-siting (siting of individual wind turbines within a wind farm to identify the best site for each individual structure); access limitations; and measures to mitigate the potential impacts of such projects on the fishery.

In addition the FAB may aid the Council and its staff in developing and implementing a research agenda. As new information becomes available and the scientific understanding of the Ocean SAMP planning area evolves, the FAB may identify new areas with unique or fragile physical features, important natural habitats, or areas of high natural productivity for designation by the Council as Areas of Particular Concern or Areas Designated for Preservation.

1150.5. Recreation and Tourism

1. The Council recognizes the economic, historic, and cultural value of marine recreation and tourism activities in the Ocean SAMP area to the state of Rhode Island. The Council's goal is to promote uses of the Ocean SAMP area that do not significantly interfere with marine recreation and tourism activities.

2. When evaluating proposed Offshore Developments, the Council will carefully consider the potential impacts of such activities on marine recreation and tourism uses. Where it is determined that there is a significant impact, the Council may modify or deny activities that significantly detract from these uses.

3. The Council will encourage and support uses of the Ocean SAMP area that enhance marine recreation and tourism activities.

4. The Council recognizes that the waters south of Brenton Point and within the 3-nautical mile boundary surrounding Block Island are heavily-used recreational areas and are commonly used for organized sailboat races and other marine events. The Council encourages and supports the ongoing coordination of race and marine event organizers with the U.S. Coast Guard, the U.S. Navy, and the commercial shipping community to facilitate safe recreational boating in and adjacent to these areas, which include charted shipping lanes and Navy restricted areas (see Chapter 7, Marine Transportation, Navigation, and Infrastructure). The Council shall consider these heavily-used recreational areas when evaluating Offshore Developments in this area. Where it is determined that there is a significant impact, the Council may suitably modify or deny activities that significantly detract from these uses. The Council also recognizes that much of this organized recreational activity is concentrated within the circular sailboat racing areas as depicted in Figure 11.6, and accordingly has designated these areas as Areas of Particular Concern. See section 1160.2 for requirements associated with Areas of Particular Concern.

5. See 1150.4.5 for a policy regarding safe navigation around and through offshore structures and developments and along cable routes.

6. See 1150.4.6 for a policy regarding vessel access around and through offshore structures and developments and along cable routes.

7. The Council recognizes that offshore wildlife viewing activities are reliant on the presence and visibility of marine and avian species which rely on benthic habitat, the availability of food, and other environmental factors. The Council shall consider these environmental factors when evaluating proposed Offshore Developments in these areas.

Where it is determined that there is a significant impact, the Council may modify or deny activities that significantly detract from these uses.

1150.6. Marine Transportation, Navigation, and Infrastructure

1. The Council recognizes the importance of designated navigation areas, which include shipping lanes, precautionary areas, recommended vessel routes, pilot boarding areas, anchorages, military testing areas, and submarine transit lanes to marine transportation and navigation activities in the Ocean SAMP area. The Council also recognizes that these and other waters within the Ocean SAMP area are heavily used by numerous existing users who have adapted to each other with regard to their uses of ocean space. Any changes in the spatial use patterns of any one of these users will result in potential impacts to the other users. The Council will carefully consider the potential impacts of such changes on the marine transportation network. Changes to existing designated navigational areas proposed by the U.S. Coast Guard, NOAA, the R.I. Port Safety and Security Forums, or other entities could similarly impact existing uses. The Council requests that they be notified by any of these parties if any such changes are to be made to the transportation network so that they may work with those entities to achieve a proper balance among existing uses.

2. The Council recognizes the economic, historic, and cultural value of marine transportation and navigation uses of the Ocean SAMP area to the state of Rhode Island. The Council's goal is to promote uses of the Ocean SAMP area that do not significantly interfere with marine transportation and safe navigation within designated navigation areas, which include shipping lanes, precautionary areas, recommended vessel routes, pilot boarding areas, anchorages, military testing areas, and submarine transit lanes. See section 1160.2 for discussion of navigation areas which have been designated as Areas of Particular Concern.

3. The Council will encourage and support uses of the Ocean SAMP area that enhance marine transportation and safe navigation within designated navigation areas, which include shipping lanes, precautionary areas, recommended vessel routes, pilot boarding areas, anchorages, military testing areas, and submarine transit lanes.

4. See 1150.4.5 for a policy regarding safe navigation around and through offshore structures and developments and along cable routes.

5. See 1150.4.6 for a policy regarding vessel access around and through offshore structures and developments and along cable routes.

1150.7. Offshore Renewable Energy and other Offshore Development

1. The Council supports offshore development in the Ocean SAMP area that is consistent with the Ocean SAMP goals, which are to:
    i. Foster a properly functioning ecosystem that can be both ecologically effective and economically beneficial;
    ii. Promote and enhance existing uses; and

iii. Encourage marine-based economic development that considers the aspirations of local communities and is consistent and complementary to the state's overall economic development needs and goals.

2. The Council supports the policy of increasing renewable energy production in Rhode Island. The Council also recognizes:
   i. Offshore wind energy currently represents the greatest potential for utility-scale renewable energy generation in Rhode Island;
   ii. Offshore renewable energy development is a means of mitigating the potential effects of global climate change;
   iii. Offshore renewable energy development will diversify Rhode Island's energy portfolio;
   iv. Offshore renewable energy development will aid in meeting the goals set forth in Rhode Island's Renewable Energy Standard;
   v. Marine renewable energy has the potential to assist in the redevelopment of urban waterfronts and ports.

   The Council's support of offshore renewable energy development shall not be construed to endorse or justify any particular developer or particular offshore renewable energy proposal.

3. The Council may require the applicant to fund a program to mitigate the potential impacts of a proposed Offshore Development to natural resources and existing human uses. The mitigation program may be used to support restoration projects, additional monitoring, preservation, or research activities on the impacted resource or site.

4. To the greatest extent possible, Offshore Development structures and projects shall be made available to researchers for the investigation into the effects of large-scale installations on the marine environment, and to the extent practicable, educators for the purposes of educating the public.

5. The Council shall work in coordination with the U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement to develop a seamless process for review and design approval of offshore wind energy facilities that is consistent across state and federal waters.

6. The Council shall work together with the U.S. Coast Guard, the U.S. Navy, the U.S. Army Corps of Engineers, NOAA, fishermen's organizations, marine pilots, recreational boating organizations, and other marine safety organizations to promote safe navigation, fishing, and recreational boating activity around and through offshore structures and developments, and along cable routes, during the construction, operation, and decommissioning phases of such projects. The Council will promote and support the education of all mariners regarding safe navigation around offshore structures and developments and along cable routes.

7. Discussions with the U.S. Coast Guard, the U.S. Department of Interior Bureau of Ocean Energy Management, Regulation, and Enforcement, and the U.S. Army Corps of Engineers have indicated that no vessel access restrictions are planned for the waters

around and through offshore structures and developments, or along cable routes, except for those necessary for navigational safety. Commercial and recreational fishing and boating access around and through offshore structures and developments and along cable routes is a critical means of mitigating the potential adverse impacts of offshore structures on commercial and recreational fisheries and recreational boating. The Council endorses this approach and shall work to ensure that the waters surrounding offshore structures, developments, and cable routes remain open to commercial and recreational fishing, marine transportation, and recreational boating, except for navigational safety restrictions. The Council requests that federal agencies notify the Council as soon as is practicable of any federal action that may affect vessel access around and through offshore structures and developments and along cable routes. The Council will continue to monitor changes to navigational activities around and through offshore developments and along cable routes. Any changes affecting existing navigational activities may be subject to CZMA Federal Consistency review if the federal agency determines its activity will have reasonably foreseeable effects on the uses or resources of Rhode Island's coastal zone.

8. To coordinate the review process for offshore wind energy developments, the Council shall adopt consistent information requirements similar to the requirements of the U.S. Department of the Interior's Bureau of Ocean Energy Management, Regulation and Enforcement for offshore wind energy. All documentation required at the time of application shall be similar with the requirements followed by the U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement when issuing renewable energy leases on the Outer Continental Shelf. For further details on these regulations see 30 CFR §§285 *et seq*. The Council shall continue to monitor the federal review process and information requirements for any changes and will make adjustments to the Ocean SAMP policies accordingly.

9. To the maximum extent practicable, the Council shall coordinate with the appropriate federal and state agencies to establish project specific requirements that shall be followed by the applicant during the pre-construction, construction, operation and decommissioning phases of an Offshore Development. To the maximum extent practicable, the Council shall work in coordination with a Joint Agency Working Group when establishing pre-construction survey and data requirements, monitoring requirements, protocols and mitigation measures for a proposed Offshore Development. State members of the Joint Agency Working Group shall coordinate with the Habitat Advisory Board and the Fishermen's Advisory Board and shall seek input from these Boards before establishing project specific requirements that shall be followed by the applicant for an Offshore Development. And, to the maximum extent practical, and consistent with the federal agency and tribal members' authorities, federal members of the Joint Agency Working Group, are strongly encouraged to coordinate with the Habitat Advisory Board and the Fishermen's Advisory Board. The Joint Agency Working Group shall comprise those state and federal agencies that have a regulatory responsibility related to the proposed project, as well as the Narragansett Indian Tribal Historic Preservation Office. The agency composition of this working group may differ depending on the proposed project, but will generally include the lead federal agency with primary jurisdiction over the proposed project and the CRMC. The pre-construction survey

requirements outlined in Section 860.2.5.1(i) may be reduced for small- scale offshore developments as specified by the Joint Agency Working Group.

10. The following are industry goals that projects should strive for. These are not required standards at this time but are targets project proponents should try to meet where possible to alleviate potential adverse impacts:

    i. A goal for the wind farm applicant and operator is to have operational noise from wind turbines average less than or equal to 100 dB re 1 μPa^2 in any 1/3 octave band at a range of 100 meters at full power production.

    ii. The applicant and manufacturer should endeavor to minimize the radiated airborne noise from the wind turbines.

    iii. A monitoring system including acoustical, optical and other sensors should be established near these facilities to quantify the effects.

Section 1160. Regulatory Standards

1. This section contains all the regulatory standards outlined by the Ocean SAMP. The regulatory standards have been organized according to the following stages: application; design, fabrication and installation; pre-construction; construction and decommissioning and; monitoring. Section 1160.1, Overall Regulatory Standards, applies to all stages of development. The regulatory standards contained within all previous chapters of the Ocean SAMP document have been incorporated into this section based upon the applicable stage of development. The "Regulatory Standards" in Section 1160 are enforceable policies for purposes of the Federal CZMA Federal Consistency provision (16 U.S.C. § 1456 and 15 C.F.R. part 930). For CZMA Federal Consistency purposes the Regulatory Standards, in addition to other applicable federally approved RICRMP enforceable policies shall be used as the basis for a CRMC CZMA Federal Consistency concurrence or objection.

2. The federal offshore renewable energy leasing process, and subsequent regulation of renewable energy projects located in federal waters, will remain under the jurisdiction of BOEMRE, in consultation and coordination with relevant federal agencies and affected state, local, and tribal officials, as per BOEMRE's statutory authority at 43 USC 1337(p) and the regulations found at 30 CFR 285.

1160.1 Overall Regulatory Standards

1. All Offshore Developments regardless of size, including energy projects, which are proposed for or located within state waters of the Ocean SAMP area, are subject to the policies and standards outlined in Sections 1150 and 1160 (except, as noted above, Section 1150 policies shall not be used for CRMC concurrence or objection for CZMA Federal Consistency reviews). For the purposes of the Ocean SAMP, Offshore Developments are defined as:
    i. Large-scale projects, such as:
        a. offshore wind facilities (5 or more turbines within 2 km of each other, or 18 MW power generation);
        b. wave generation devices (2 or more devices, or 18 MW power generation);
        c. instream tidal or ocean current devices (2 or more devices, or 18 MW power generation); and
        d. offshore LNG platforms (1 or more); and
        e. Artificial reefs (1/2 acre footprint and at least 4 feet high), except for projects of a public nature whose primary purpose is habitat enhancement.
    ii. Small-scale projects, defined as any projects that are smaller than the above thresholds;
    iii. Underwater cables;
    iv. Mining and extraction of minerals, including sand and gravel;
    v. Aquaculture projects of any size, as defined in RICRMP Section 300.11 and subject to the regulations of RICRMP Section 300.11;
    vi. Dredging, as defined in RICRMP Section 300.9 and subject to the regulations of RICRMP Section 300.9; or

vii. Other development (as defined in the RICRMP)[4] which is located from the mouth of Narragansett Bay seaward, in tidal waters between 500 feet offshore and the 3-nautical mile, state water boundary.

2. In assessing the natural resources and existing human uses present in state waters of the Ocean SAMP area, the Council finds that the most suitable area for offshore renewable energy development in the state waters of the Ocean SAMP area is the Renewable Energy Zone depicted in Figure 11.1 below. The Council designates this area as Type 4E waters. In the Rhode Island Coastal Resources Management Program these waters were previously designated as Type 4 (or multipurpose) but are hereby modified to show that this is the preferred site for large scale renewable energy projects in state waters. The Council may approve offshore renewable energy development elsewhere in the Ocean SAMP area, within state waters, where it is determined to have no significant adverse impact on the natural resources or human uses of the Ocean SAMP area. Large-scale Offshore Developments shall avoid areas designated as Areas of Particular Concern consistent with Section 1160.2. No large-scale offshore renewable energy development shall be allowed in Areas Designated for Preservation consistent with Section 1160.3.

[4] "Development" is defined in the RICRMP Glossary.

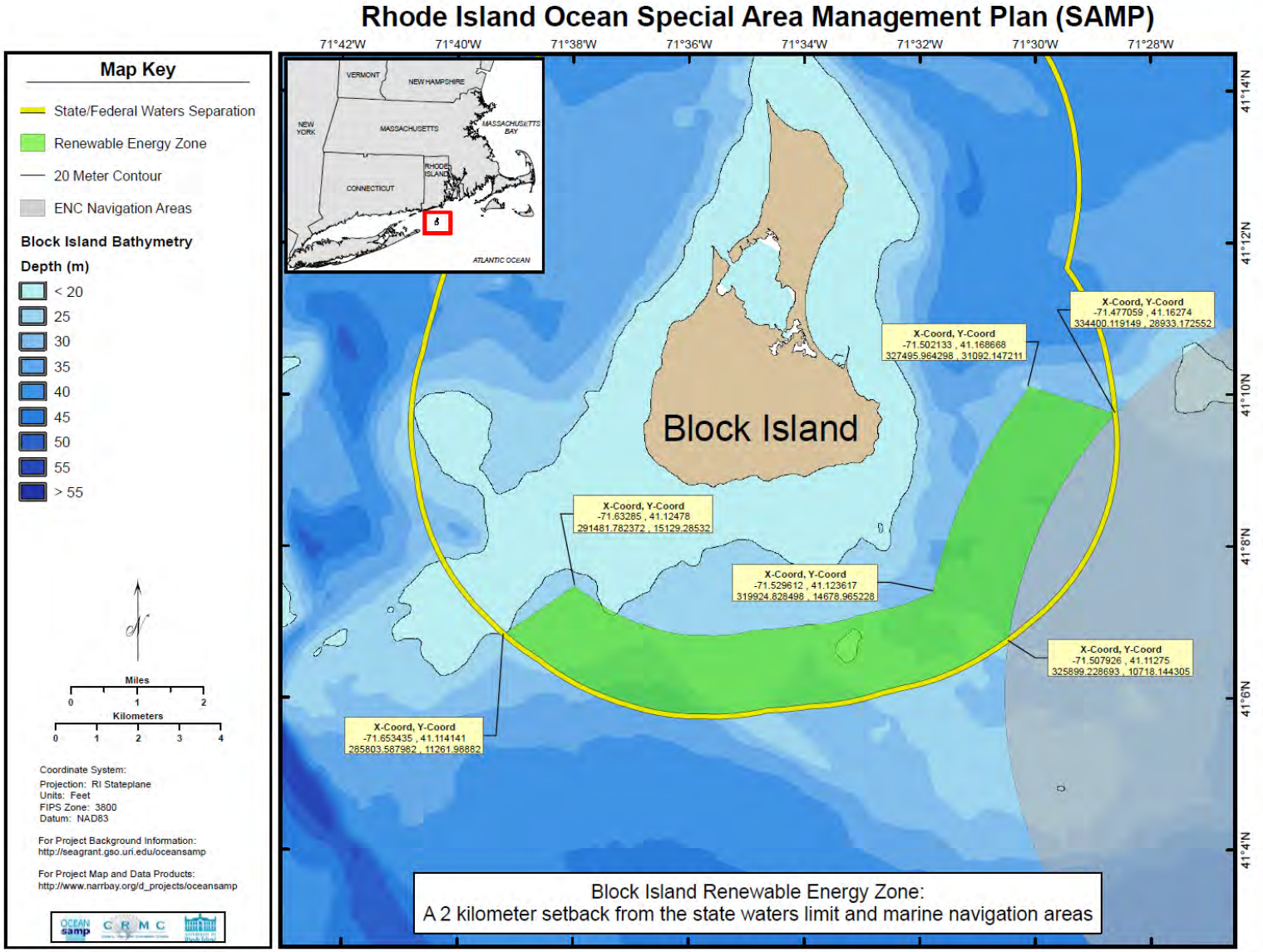


Figure 11.1. Renewable Energy Zone.

3. Offshore Developments shall not have a significant adverse impact on the natural resources or existing human uses of the Rhode Island coastal zone, as described in the Ocean SAMP. Where the Council determines that impacts on the natural resources or human uses of the Rhode Island coastal zone through the pre-construction, construction, operation, or decommissioning phases of a project constitute significant adverse effects not previously evaluated, the Council shall, through its permitting and enforcement authorities in state waters and through any subsequent CZMA federal consistency reviews, require that the applicant modify the proposal to avoid and/or mitigate the impacts or the Council shall deny the proposal.

4. Any assent holder of an approved Offshore Development shall:
    i. Design the project and conduct all activities in a manner that ensures safety and shall not cause undue harm or damage to natural resources, including their physical, chemical, and biological components to the extent practicable; and take measures to prevent unauthorized discharge of pollutants including marine trash and debris into the offshore environment.
    ii. Submit requests, applications, plans, notices, modifications, and supplemental information to the Council as required;
    iii. Follow up, in writing, any oral request or notification made by the Council, within 3 business days;
    iv. Comply with the terms, conditions, and provisions of all reports and notices submitted to the Council, and of all plans, revisions, and other Council approvals, as provided in section 1160.5;
    v. Make all applicable payments on time;
    vi. Conduct all activities authorized by the permit in a manner consistent with the provisions of this document, the Rhode Island Coastal Resources Management Program, and all relevant federal and state statutes, regulations and policies;
    vii. Compile, retain, and make available to the Council within the time specified by the Council any information related to the site assessment, design, and operations of a project; and
    viii. Respond to requests from the Council in a timeframe specified by the Council.

5. The Council shall appoint a standing Fishermen's Advisory Board (FAB) which shall provide advice to the Council on the siting and construction of other uses in marine waters. The FAB is an advisory body to the Council that is not intended to supplant any existing authority of any other federal or state agency responsible for the management of fisheries, including but not limited to the Marine Fisheries Council and its authorities set forth in R.I.G.L. 20-3-1 *et. seq*. The FAB shall be comprised of nine members, one representing each of the following six Rhode Island fisheries: bottom trawling; scallop dredging; gillnetting; lobstering; party and charter boat fishing; and recreational angling; and three members, including two commercial fishermen and one recreational fisherman, who are Massachusetts fishermen who fish in the Ocean SAMP area. FAB members shall serve four-year terms and will serve no more than two consecutive terms. The Council shall provide to the FAB a semi-annual status report on Ocean SAMP area fisheries-

related issues, including but not limited to those of which the Council is cognizant in its planning and regulatory activities, and will notify the FAB in writing concerning any project in the Ocean SAMP area. The FAB shall meet not less than semi-annually with the Habitat Advisory Board and on an as-needed basis to provide the Council with advice on the potential adverse impacts of other uses on commercial and recreational fishermen and fisheries activities, and on issues including, but not limited to, the evaluation and planning of project locations, arrangements, and alternatives; micro-siting (siting of individual wind turbines within a wind farm to identify the best site for each individual structure); access limitations; and measures to mitigate the potential impacts of such projects. Any Large-Scale Offshore Development, as defined in section 1160.1.1, shall require a meeting between the Fisherman's Advisory Board (FAB), the applicant, and the Council staff to discuss potential fishery-related impacts, such as, but not limited to, project location, construction schedules, alternative locations, project minimization and identification of high fishing activity or habitat edges. For any state permit process for a Large-Scale Offshore Development this meeting shall occur prior to submission of the state permit application. The Council cannot require a pre-application meeting for federal permit applications, but the Council strongly encourages applicants for any Large-Scale Offshore Development, as defined in Section 1160.1.1, in federal waters to meet with the FAB and the Council staff prior to the submission of a federal application, lease, license, or authorization. However, for federal permit applicants, a meeting with the FAB shall be necessary data and information required for federal consistency reviews for purposes of starting the CZMA 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930, subpart E, pursuant to 15 C.F.R. § 930.58(a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project.

6. The Council shall prohibit any other uses or activities that would result in significant long-term negative impacts to Rhode Island's commercial or recreational fisheries. Long-term impacts are defined as those that affect more than one or two seasons.

7. The Council shall require that the potential adverse impacts of Offshore Developments and other uses on commercial or recreational fisheries be evaluated, considered, and mitigated as described in section 1160.1.9.

8. For the purposes of Fisheries Policies and Standards as summarized in Chapter 5, Commercial and Recreational Fisheries, sections 560.1-560.2, mitigation is defined as a process to make whole those fisheries user groups that are adversely affected by proposals to be undertaken, or undertaken projects, in the Ocean SAMP area. Mitigation measures shall be consistent with the purposes of duly adopted fisheries management plans, programs, strategies and regulations of the agencies and regulatory bodies with jurisdiction over fisheries in the Ocean SAMP area, including but not limited to those set forth above in 1150.4.2. Mitigation shall not be designed or implemented in a manner that substantially diminishes the effectiveness of duly adopted fisheries management programs. Mitigation measures may include, but are not limited to, compensation, effort reduction, habitat preservation, restoration and construction, marketing, and infrastructure improvements. Where there are potential impacts associated with proposed projects, the need for mitigation shall be presumed. Negotiation of mitigation agreements shall be a

necessary condition of any approval or permit of a project by the Council. Mitigation shall be negotiated between the Council staff, the FAB, the project developer, and approved by the Council. The reasonable costs associated with the negotiation, which may include data collection and analysis, technical and financial analysis, and legal costs, shall be borne by the applicant. The applicant shall establish and maintain either an escrow account to cover said costs of this negotiation or such other mechanism as set forth in the permit or approval condition pertaining to mitigation. This policy shall apply to all Large-Scale Offshore Developments, underwater cables, and other projects as determined by the Council.

9. The Council recognizes that moraine edges, as illustrated in Figures 11.3 and 11.4, are important to commercial and recreational fishermen. In addition to these mapped areas, the FAB may identify other edge areas that are important to fisheries within a proposed project location. The Council shall consider the potential adverse impacts of future activities or projects on these areas to Rhode Island's commercial and recreational fisheries. Where it is determined that there is a significant adverse impact, the Council will modify or deny activities that would impact these areas. In addition, the Council will require assent holders for Offshore Developments to employ micro-siting techniques in order to minimize the potential impacts of such projects on these edge areas.

10. The finfish, shellfish, and crustacean species that are targeted by commercial and recreational fishermen rely on appropriate habitat at all stages of their life cycles. While all fish habitat is important, spawning and nursery areas are especially important in providing shelter for these species during the most vulnerable stages of their life cycles. The Council shall protect sensitive habitat areas where they have been identified through the Site Assessment Plan or Construction and Operation Plan review processes for Offshore Developments as described in section 160.5.3 (i).

11. Any Large-Scale Offshore Development, as defined in Chapter 11 in section 1160.1.1, shall require a meeting between the HAB, the applicant, and the Council staff to discuss potential marine resource and habitat-related issues such as, but not limited to, impacts to marine resource and habitats during construction and operation, project location, construction schedules, alternative locations, project minimization, measures to mitigate the potential impacts of proposed projects on habitats and marine resources, and the identification of important marine resource and habitat areas. For any state permit process for a Large-Scale Offshore Development, this meeting shall occur prior to submission of the state permit application. The Council cannot require a pre-application meeting for federal permit applications, but the Council strongly encourages applicants for any Large-Scale Offshore Development, as defined in Section 1160.1.1, in federal waters to meet with the HAB and the Council staff prior to the submission of a federal application, lease, license, or authorization. However, for federal permit applicants, a meeting with the HAB shall be necessary data and information required for federal consistency reviews for purposes of starting the CZMA 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930,

subpart E, pursuant to 15 C.F.R. § 930.58 (a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project.

12. The potential impacts of a proposed project on cultural and historic resources will be evaluated in accordance with the National Historic Preservation Act and Antiquities Act, and the Rhode Island Historical Preservation Act and Antiquities Act as applicable. Depending on the project and the lead federal agency, the projects that may impact marine historical or archaeological resources identified through the joint agency review process shall require a Marine Archaeology Assessment that documents actual or potential impacts the completed project will have on submerged cultural and historic resources.

13. Guidelines for Marine Archaeology Assessment in the Ocean SAMP Area can be obtained through the RIHPHC in their document, "Performance Standards and Guidelines for Archaeological Projects: Standards for Archaeological Survey" (RIHPHC 2007), or the lead federal agency responsible for reviewing the proposed development.

14. The potential non-physical impacts of a proposed project on cultural and historic resources shall be evaluated in accordance with 36 CFR 800.5, *Assessment of Adverse Effects, (v) Introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features.* Depending on the project and the lead federal agency, the Ocean SAMP Interagency Working Group may require that a project undergo a Visual Impact Assessment that evaluates the visual impact a completed project will have on onshore cultural and historic resources.

15. A Visual Impact Assessment may require the development of detailed visual simulations illustrating the completed project's visual relationship to onshore properties that are designated National Historic Landmarks, listed on the National Register of Historic Places, or determined to be eligible for listing on the National Register of Historic Places. Assessment of impacts to specific views from selected properties of interest may be required by relevant state and federal agencies to properly evaluate the impacts and determination of adverse effect of the project on onshore cultural or historical resources.

16. A Visual Impact Assessment may require description and images illustrating the potential impacts of the proposed project.

17. Guidelines for Landscape and Visual Impact Assessment in the Ocean SAMP Area can be obtained through the lead federal agency responsible for reviewing the proposed development.

1160.2 Areas of Particular Concern

1. Areas of Particular Concern (APCs) have been designated in state waters through the Ocean SAMP process with the goal of protecting areas that have high conservation value, cultural and historic value, or human use value from Large-Scale Offshore

Development.[5] These areas may be limited in their use by a particular regulatory agency (e.g. shipping lanes), or have inherent risk associated with them (e.g. unexploded ordnance locations), or have inherent natural value or value assigned by human interest (e.g. glacial moraines, historic shipwreck sites). Areas of Particular Concern have been designated by reviewing habitat data, cultural and historic features data, and human use data that has been developed and analyzed through the Ocean SAMP process. Currently designated Areas of Particular Concern are based on current knowledge and available datasets; additional Areas of Particular Concern may be identified by the Council in the future as new datasets are made available. Areas of Particular Concern may be elevated to Areas Designated for Preservation in the future if future studies show that Areas of Particular Concern cannot risk even low levels of Large-Scale Offshore Development within these areas. Areas of Particular Concern include:

i. Areas with unique or fragile physical features, or important natural habitats;
ii. Areas of high natural productivity;
iii. Areas with features of historical significance or cultural value;
iv. Areas of substantial recreational value;
v. Areas important for navigation, transportation, military and other human uses; and
vi. Areas of high fishing activity.

2. The Council has designated the areas listed below in section 1160.2.3 in state waters as Areas of Particular Concern. All Large-scale, Small-scale, or other offshore development, or any portion of a proposed project, shall be presumptively excluded from APCs. This exclusion is rebuttable if the applicant can demonstrate by clear and convincing evidence that there are no practicable alternatives that are less damaging in areas outside of the APC, or that the proposed project will not result in a significant alteration to the values and resources of the APC. When evaluating a project proposal, the Council shall not consider cost as a factor when determining whether practicable alternatives exist. Applicants which successfully demonstrate that the presumptive exclusion does not apply to a proposed project because there are no practicable alternatives that are less damaging in areas outside of the APC must also demonstrate that all feasible efforts have been made to avoid damage to APC resources and values and that there will be no significant alteration of the APC resources or values. Applicants successfully demonstrating that the presumptive exclusion does not apply because the proposed project will not result in a significant alteration to the values and resources of the APC must also demonstrate that all feasible efforts have been made to avoid damage to the APC resources and values. The Council may require a successful applicant to provide a mitigation plan that protects the ecosystem. The Council will permit underwater cables, only in certain categories of Areas of Particular Concern, as determined by the Council in coordination with the Joint Agency Working Group. The maps listed below in section 1160.2.3 depicting Areas of Particular Concern may be superseded by more detailed, site-specific maps created with finer resolution data.

3. Areas of particular concern that have been identified in the Ocean SAMP area in state waters are described as follows.

[5] Areas of Particular Concern are identified in the federal Coastal Zone Management Act and associated CFRs; see 15 CFR 923.21.

i. Historic shipwrecks, archeological or historical sites and their buffers as described in Chapter 4, Cultural and Historic Resources, section 440.1.1 through 440.1.4, are Areas of Particular Concern. For the latest list of these sites and their locations please refer to the Rhode Island State Historic Preservation and Heritage Commission.

ii. Offshore dive sites within the Ocean SAMP area, as shown in Figure 11.2, are designated Areas of Particular Concern. The Council recognizes that offshore dive sites, most of which are shipwrecks, are valuable recreational and cultural ocean assets and are important to sustaining Rhode Island's recreation and tourism economy.

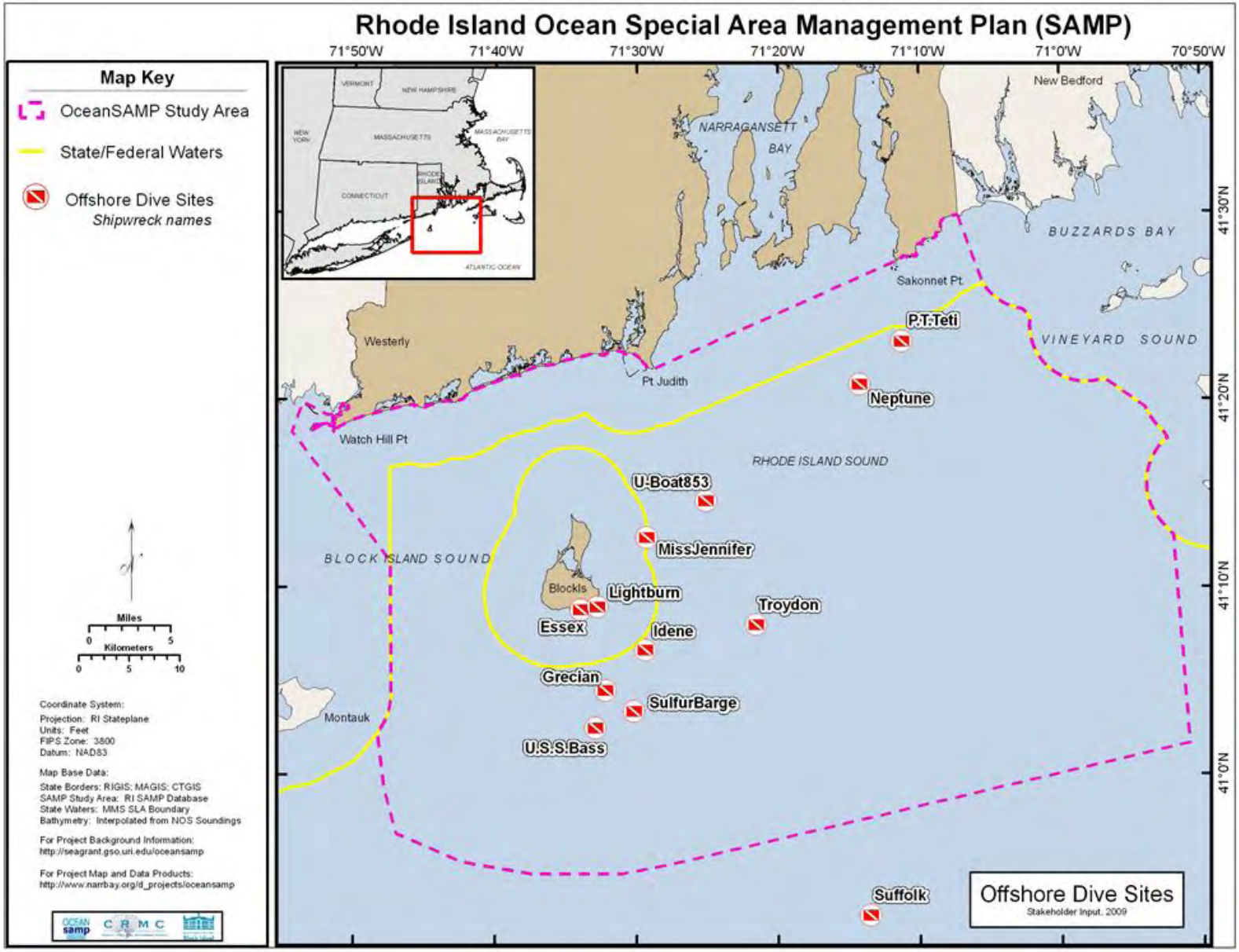


Figure 11.2. Offshore dive sites designated as Areas of Particular Concern in state waters.

iii. Glacial moraines are important habitat areas for a diversity of fish and other marine plants and animals because of their relative structural permanence and structural complexity. Glacial moraines create a unique bottom topography that allows for habitat diversity and complexity, which allows for species diversity in these areas and creates environments that exhibit some of the highest biodiversity within the entire Ocean SAMP area. The Council also recognizes that because glacial moraines contain valuable habitats for fish and other marine life, they are also important to commercial and recreational fishermen. Accordingly, the Council shall designate glacial moraines as identified in Figures 11.3 and 11.4 as Areas of Particular Concern.

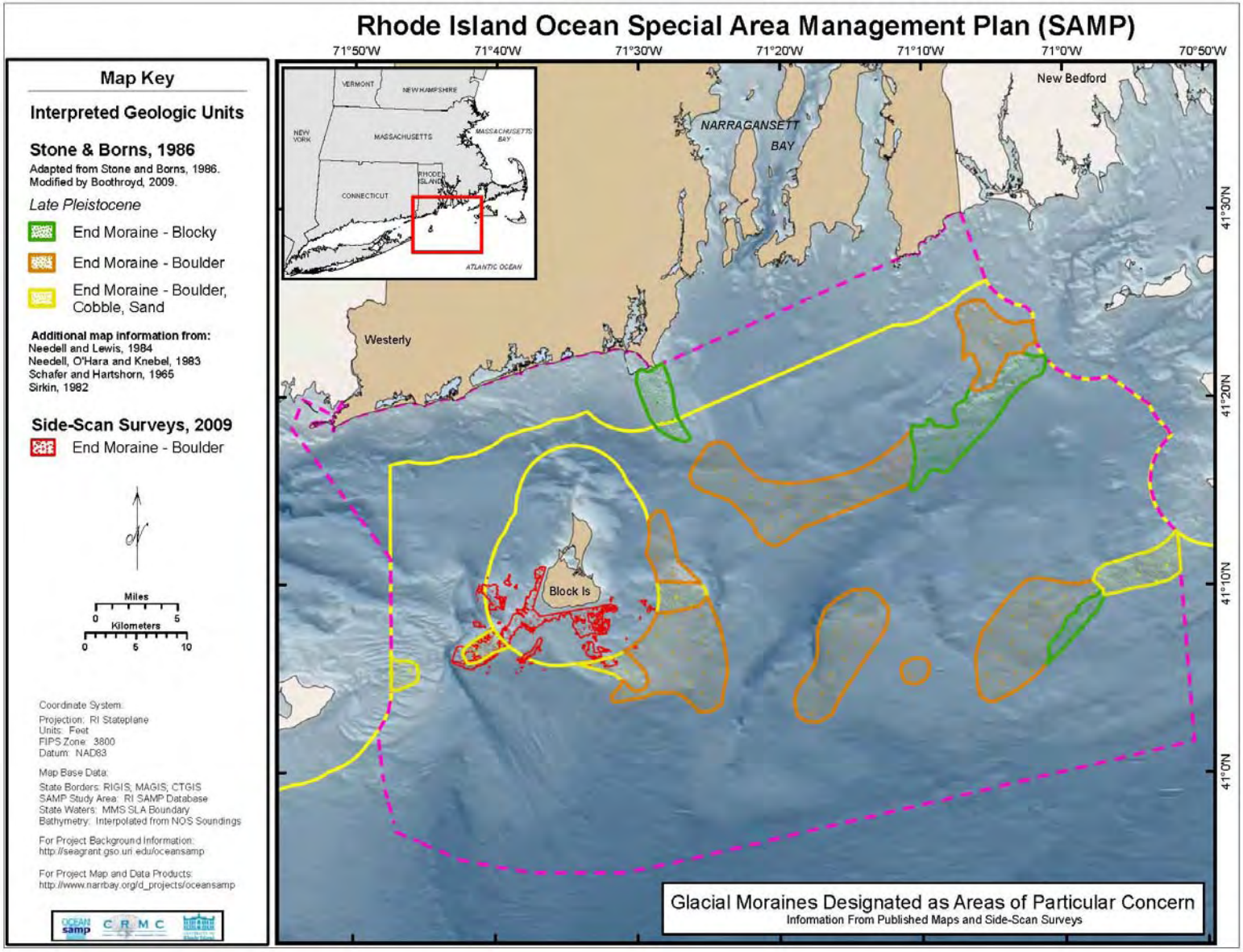


Figure 11.3. Glacial moraines designated as Areas of Particular Concern in state waters.

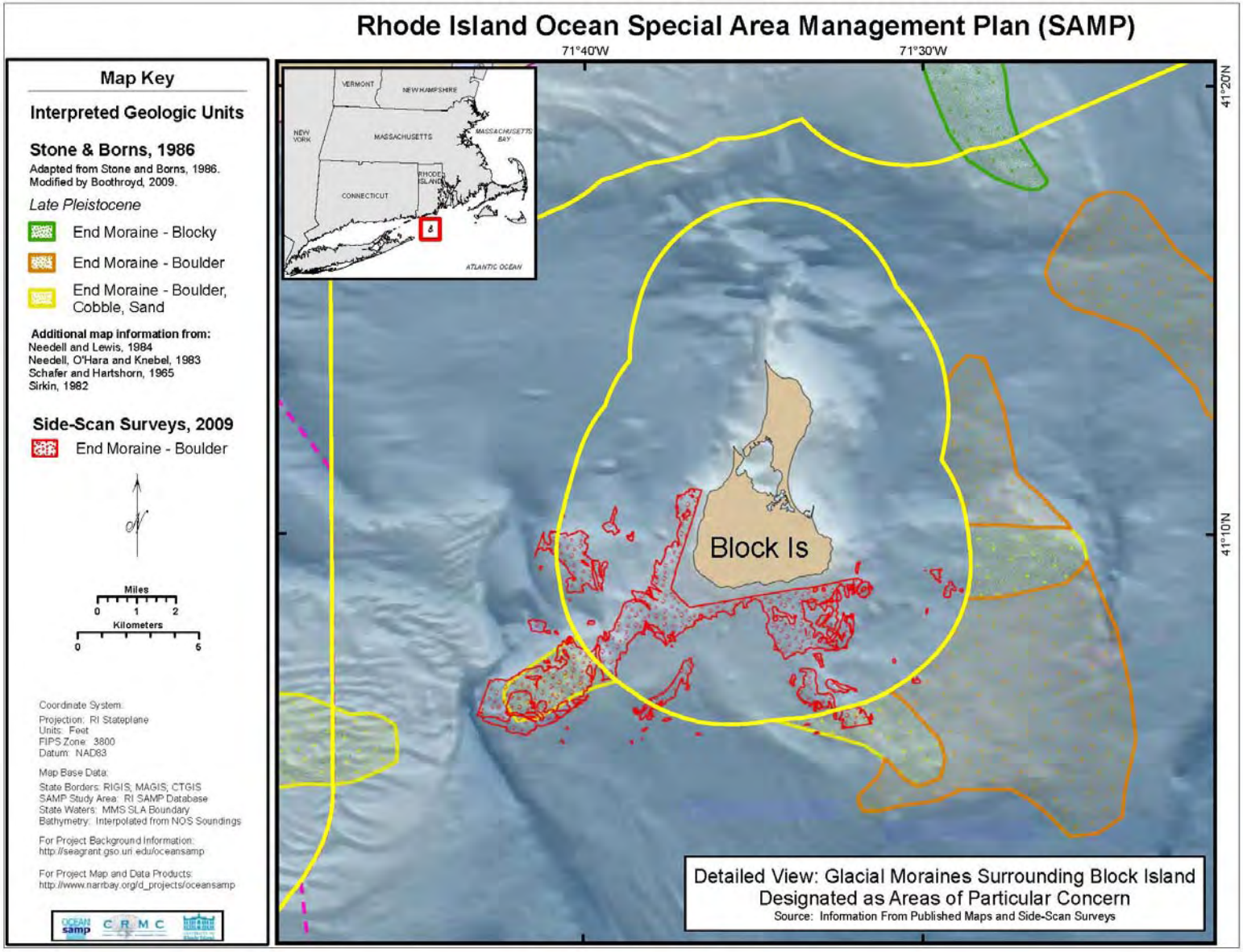


Figure 11.4. Detailed view: Glacial moraines surrounding Block Island designated as Areas of Particular Concern in state waters.

iv. Navigation, Military, and Infrastructure areas including: designated shipping lanes, precautionary areas, recommended vessel routes, ferry routes, dredge disposal sites, military testing areas, unexploded ordnance, pilot boarding areas, anchorages, and a coastal buffer of 1 km as depicted in Figure 11.5 are designated as Areas of Particular Concern. The Council recognizes the importance of these areas to marine transportation, navigation and other activities in the Ocean SAMP area.

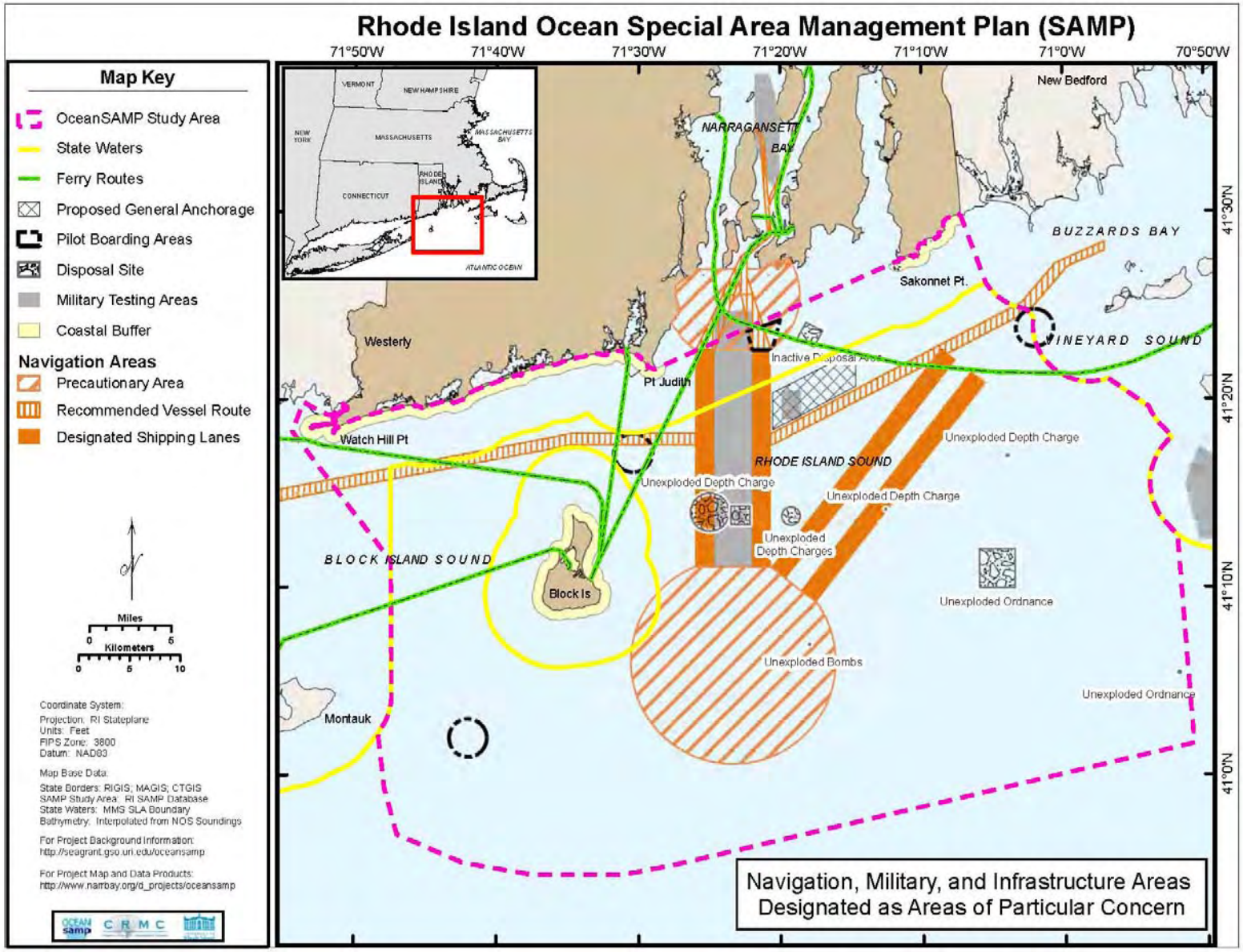


Figure 11.5. Navigation, military, and infrastructure areas designated as Areas of Particular Concern in state waters.

v. Areas of high fishing activity as identified during the pre-application process by the Fishermen's Advisory Board, as defined in section 1160.1.6, may be designated by the Council as Areas of Particular Concern.

vi. Several heavily-used recreational boating and sailboat racing areas, as shown in Figure 11.6, are designated as Areas of Particular Concern. The Council recognizes that organized recreational boating and sailboat racing activities are concentrated in these particular areas, which are therefore important to sustaining Rhode Island's recreation and tourism economy.

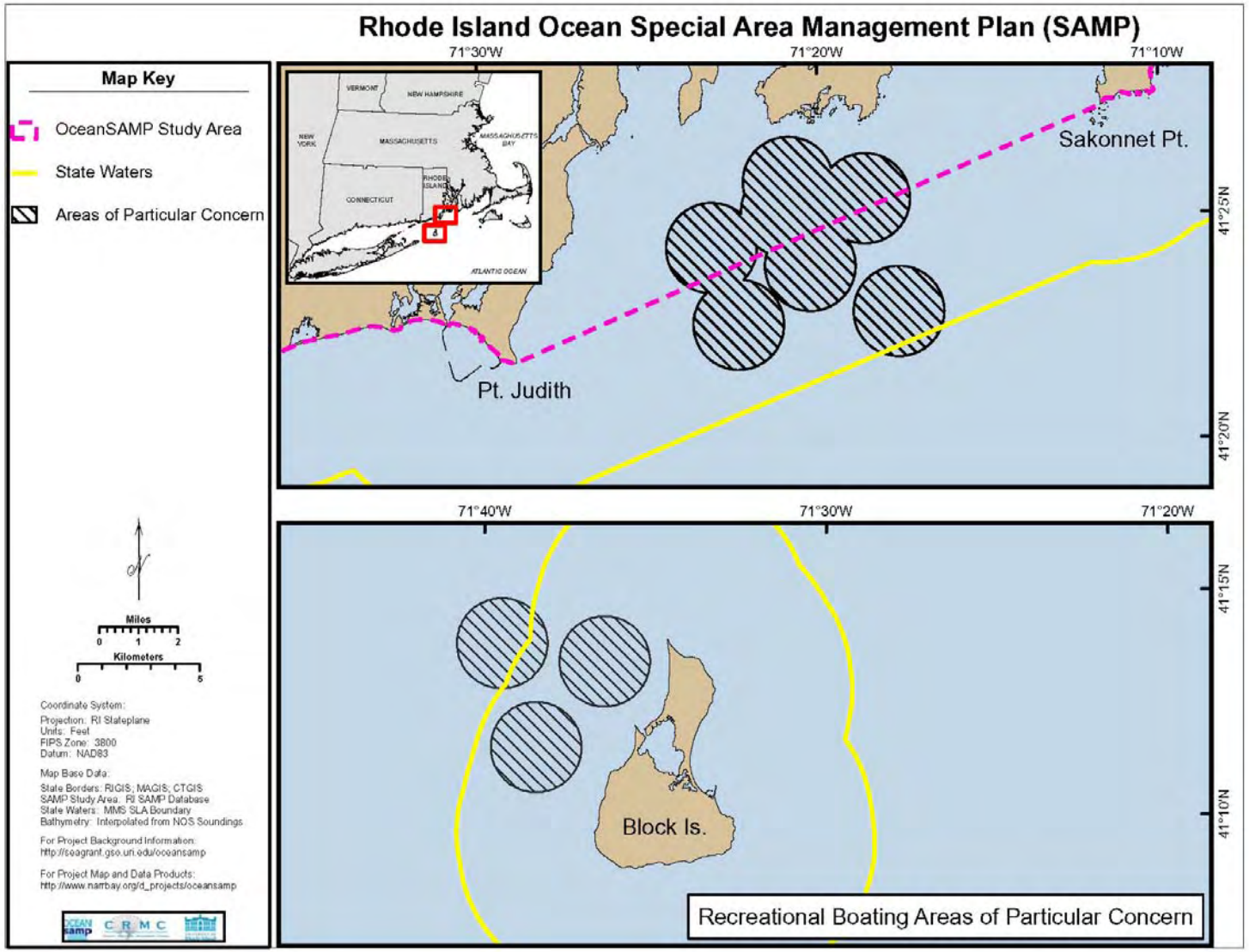


Figure 11.6. Recreational boating areas designated as Areas of Particular Concern in state waters.

vii. Naval Fleet Submarine Transit Lanes, as described in Chapter 7, Marine Transportation, Navigation, and Infrastructure section 720.7, are designated as Areas of Particular Concern.

viii. Other Areas of Particular Concern may be identified during the pre-application review by state and federal agencies as areas of importance.

4. Developers proposing projects for within the Renewable Energy Zone as described in section 1160.1.2 shall adhere to the requirements outlined in 1160.2 regarding Areas of Particular Concern in state waters, including any Areas of Particular Concern that overlap the Renewable Energy Zone (see Figure 11.7).

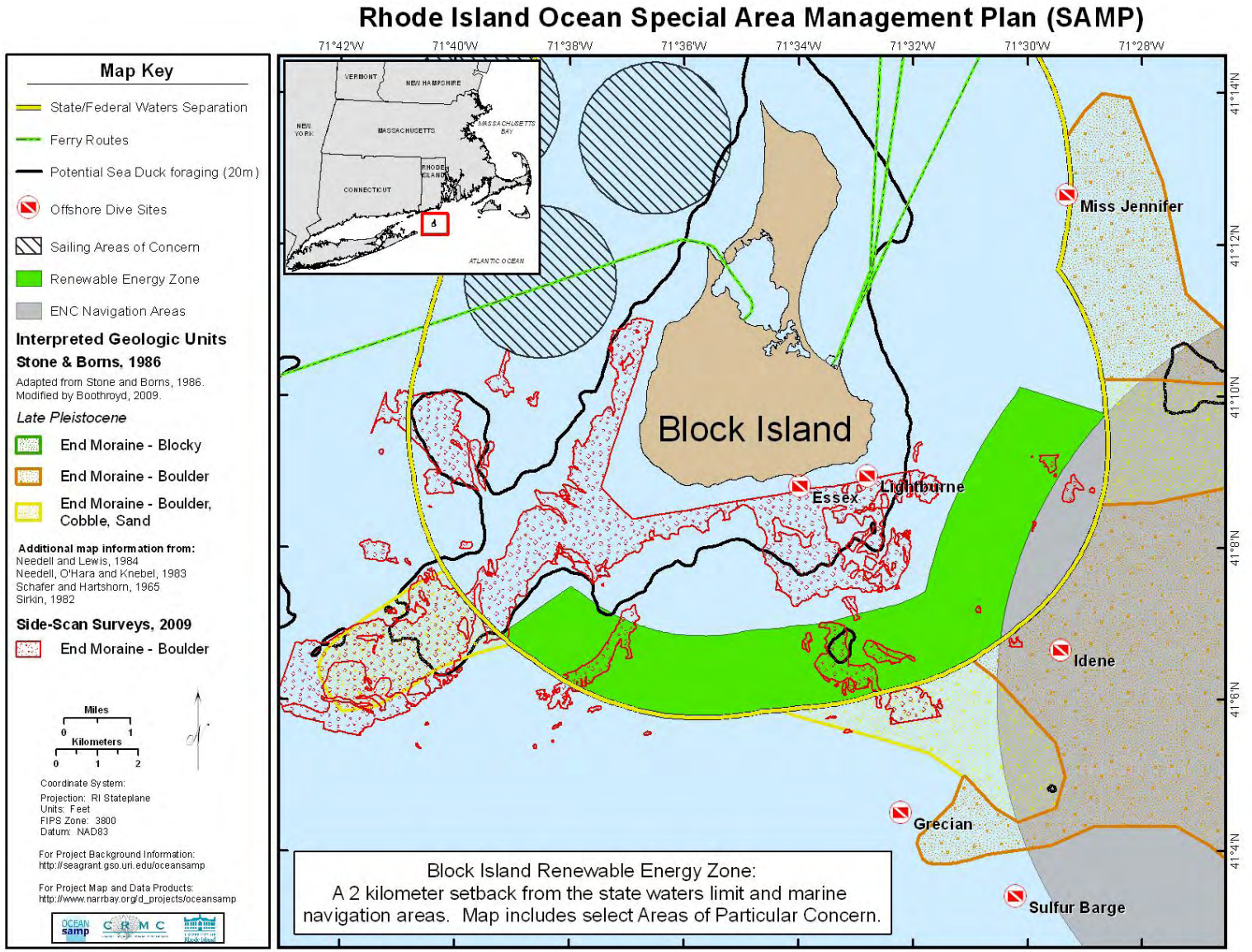


Figure 11.7. Areas of Particular Concern overlapping the Renewable Energy Zone in state waters.

1160.3 Prohibitions and Areas Designated for Preservation

1. Areas Designated for Preservation are designated in the Ocean SAMP area in state waters for the purpose of preserving them for their ecological value.[6] Areas Designated for Preservation were identified by reviewing habitat and other ecological data and findings that have resulted from the Ocean SAMP process. Areas Designated for Preservation are afforded additional protection than Areas of Particular Concern (see section 1160.2) because of scientific evidence indicating that Large-Scale Offshore Development in these areas may result in significant habitat loss. The areas described in Section 1160.3 are designated as Areas Designated for Preservation. The Council shall prohibit any Large-Scale Offshore Development, mining and extraction of minerals, or other development that has been found to be in conflict with the intent and purpose of an Area Designated for Preservation. Underwater cables are exempt from this prohibition. Areas designated for preservation include:

    i. Ocean SAMP sea duck foraging habitat in water depths less than or equal to 20 meters [65.6 feet] (as shown in Figure 11.8) are designated as Areas Designated for Preservation due to their ecological value and the significant role these foraging habitats play to avian species, and existing evidence suggesting the potential for permanent habitat loss as a result of offshore wind energy development. The current research regarding sea duck foraging areas indicates that this habitat is depth limited and generally contained within the 20 meter depth contour. It is likely there are discreet areas within this region that are prime feeding areas, however at present there is no long-term data set that would allow this determination. Thus, the entire area within the 20 meter contour is being protected as an Area Designated for Preservation until further research allows the Council and other agencies to make a more refined determination.

[6] Areas Designated for Preservation are identified in the federal Coastal Zone Management Act and associated CFRs; see 15 CFR 923.22.

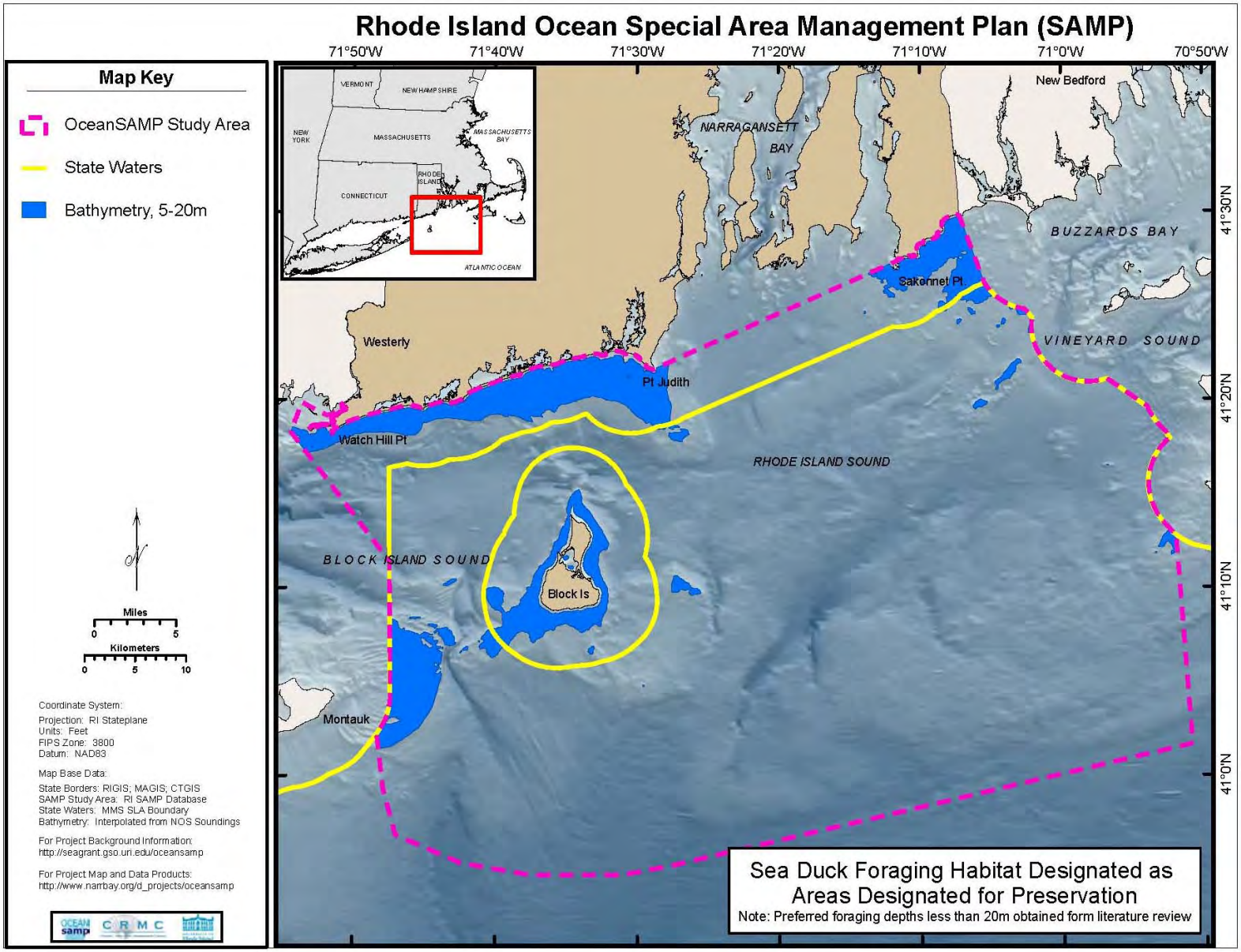


Figure 11.8. Sea duck foraging habitat designated as Areas Designated for Preservation in state waters.

2. The mining and extraction of minerals, including sand and gravel, from tidal waters and salt ponds is prohibited. This prohibition does not apply to dredging for navigation purposes, channel maintenance, habitat restoration, or beach replenishment for public purposes.

3. The Council shall prohibit any Offshore Development in areas identified as Critical Habitat under the Endangered Species Act.

4. Dredged material disposal, as defined in RICRMP Section 300.9 and subject to the regulations of RICRMP Section 300.9, is further limited in the Ocean SAMP area by the prohibition of dredged material disposal in the following Areas of Particular Concern as defined in section 1160.2: historic shipwrecks, archaeological, or historic sites; offshore dive sites; navigation, military, and infrastructure areas; and moraines. Beneficial reuse may be allowed in Areas Designated for Preservation, whereas all other dredged material disposal is prohibited in those areas. All disposal of dredged material will be conducted in accordance with the U.S. EPA and U.S. Army Corps of Engineers' manual, *Evaluation of Dredged Material Proposed for Ocean Disposal*.

Section 1160.4. Other Areas

1. Large-scale projects or other development which is found to be a hazard to commercial navigation shall avoid areas of high intensity commercial marine traffic in state waters. Avoidance shall be the primary goal of these areas. Areas of High Intensity Commercial Marine Traffic are defined as having 50 or more vessel counts within a 1 km by 1 km grid, as shown in Figure 11.9.

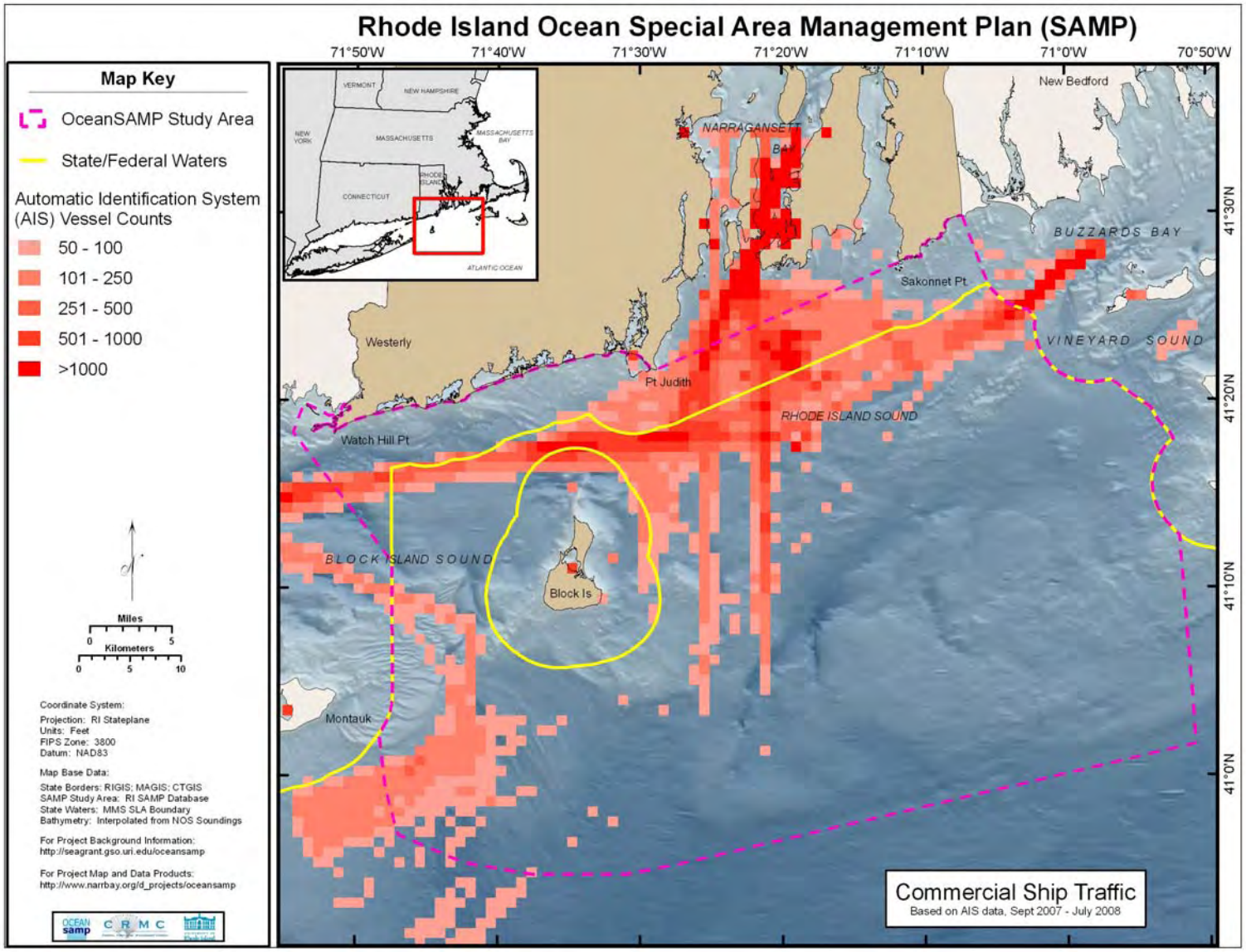


Figure 11.9. Areas of high intensity commercial ship traffic in state waters.

1160.5 Application Requirements

1. For the purposes of this document, the phrase "'necessary data and information'" shall refer to the necessary data and information required for federal consistency reviews for purposes of starting the Coastal Zone Management Act (CZMA) 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R. part 930, subpart E, pursuant to 15 C.F.R. § 930.58(a)(2). Any necessary data and information shall be provided before the 6-month CZMA review period begins for a proposed project. It should be noted that other federal and state agencies may require other types of data or information as part of their review processes.

2. For the purposes of this document, the following terms shall be defined as:

   i. A **Site Assessment Plan** (SAP) is defined as a pre-application plan that describes the activities and studies the applicant plans to perform for the characterization of the project site**.**
   ii. A **Construction and Operations Plan** (COP) is defined as a plan that describes the applicant's construction, operations, and conceptual decommissioning plans for a proposed facility, including the applicant's project easement area.
   iii. A **Certified Verification Agent** (CVA) is defined as an independent third-party agent that shall use good engineering judgment and practices in conducting an independent assessment of the design, fabrication and installation of the facility. The CVA should have licensed and qualified Professional Engineers on staff.

3. Prior to construction, the following sections shall be considered necessary data and information and shall be required by the Council:

   i. **Site Assessment Plan –** A SAP is a pre-application plan that describes the activities and studies (e.g. installation of meteorological towers, meteorological buoys) the applicant plans to perform for the characterization of the project site**. Within the Renewable Energy Zone, if an applicant applies within 2 years of CRMC's adoption of the Ocean Special Area Management Plan they may elect to combine the SAP and Construction and Operation Plan (COP) phase, but only within the renewable energy zone and only for 2 years after the adoption date. If an applicant elects to combine these two phases all requirements shall still be met.** The SAP shall describe how the applicant shall conduct the resource assessment (e.g., meteorological and oceanographic data collection) or technology testing activities. The applicant shall receive the approval of the SAP by the Council. For projects within Type 4E waters (depicted in Figure 11.1), pre-construction data requirements may incorporate data generated by the Ocean SAMP provided the data was collected within 2 years of the date of application, or where the Ocean SAMP data is determined to be current enough to meet the requirements of the Council in coordination with the Joint Agency Working Group. The applicant shall reference information and data discussed in the Ocean SAMP (including appendices and technical reports) in their SAP.
      i. The applicant's SAP shall include data from:
         1. Physical characterization surveys (e.g., geological and geophysical surveys or hazards surveys); and

2. Baseline environmental surveys (e.g., biological or archaeological surveys).

ii. The SAP shall demonstrate that the applicant has planned and is prepared to conduct the proposed site assessment activities in a manner that conforms to the applicant's responsibilities listed above in section 1160.1.5 and:
    1. Conforms to all applicable laws, regulations;
    2. Is safe;
    3. Does not unreasonably interfere with other existing uses of the state waters,
    4. Does not cause undue harm or damage to natural resources; life (including human and wildlife);the marine, coastal, or human environment; or sites, structures, or direct harm to objects of historical or archaeological significance;
    5. Uses best available and safest technology;
    6. Uses best management practices; and
    7. Uses properly trained personnel.

iii. The applicant shall also demonstrate that the site assessment activities shall collect the necessary data and information required for the applicant's COP, as described below in section 1160.5.3 (ii).

iv. The applicant's SAP shall include the information described in Table 11.1, as applicable.

Table 11.1. Contents of a Site Assessment Plan.

Project information:	**Including:**
(1) Contact information	The name, address, e-mail address, and phone number of an authorized representative.
(2) The site assessment or technology testing concept.	A discussion of the objectives; description of the proposed activities, including the technology to be used; and proposed schedule from start to completion.
(4) Stipulations and compliance.	A description of the measures the applicant took, or shall take, to satisfy the conditions of any permit stipulations related to the applicant's proposed activities.
(5) A location.	The surface location and water depth for all proposed and existing structures, facilities, and appurtenances located both offshore and onshore.
(6) General structural and project design, fabrication, and installation.	Information for each type of facility associated with the applicant's project.
(7) Deployment activities.	A description of the safety, prevention, and environmental protection features or measures that the applicant will use.
(8) The applicant's proposed measures for avoiding, minimizing, reducing, eliminating, and monitoring environmental impacts.	A description of the measures the applicant shall take to avoid or minimize adverse effects and any potential incidental take, before the applicant conducts activities on the project site, and how the applicant shall mitigate environmental impacts from proposed

	activities, including a description of the measures to be used.
(9) Reference information.	Any document or published sources that the applicant cites as part of the plan. The applicant shall reference information and data discussed in the Ocean SAMP (including appendices and technical reports), other plans referenced in the Ocean SAMP, and other plans previously submitted by the applicant or that are otherwise readily available to the Council.
(10) Decommissioning and site clearance procedures.	A discussion of methodologies.
(11) Air quality information.	Information required for the Clean Air Act (42 U.S.C. 7409) and implementing regulations
(12) A listing of all Federal, State, and local authorizations or approvals required to conduct site assessment activities on the project site.	A statement indicating whether such authorization or approval has been applied for or obtained.
(13) A list of agencies or persons with whom the applicant has communicated, or will communicate, regarding potential impacts associated with the proposed activities.	Contact information and issues discussed.
(14) Financial assurance information.	Statements attesting that the activities and facilities proposed in the applicant's SAP are or shall be covered by an appropriate performance bond or other Council approved security.
(15) Other information.	Additional information as requested by the Council in coordination with the Joint Agency Working Group

v. The applicant's SAP shall provide the results of geophysical and geological surveys, hazards surveys, archaeological surveys (as required by the Council in coordination with the Joint Agency Working Group), and biological surveys outlined in Table 11.2 (with the supporting data) in the applicant's SAP:

Table 11.2. Necessary data and information to be provided in the Site Assessment Plan.

Information.	**Report contents.**	**Including.**
(1) Geotechnical.	Reports from the geotechnical survey with supporting data.	A description of all relevant seabed and engineering information to allow for the design of the foundation of that facility. The applicant shall provide information to depths below which the underlying conditions shall not influence the integrity or performance of the structure. This could include a series of sampling locations (borings and *in situ* tests) as well as laboratory testing of soil samples.
(2) Shallow hazards.	The results from the shallow hazards survey with supporting	A description of information sufficient to determine the presence of the following

	data, if required.	features and their likely effects on the proposed facility, including: (i) Shallow faults; (ii) Gas seeps or shallow gas; (iii) Slump blocks or slump sediments; (iv) Hydrates; and (v) Ice scour of seabed sediments.
(3) Archaeological resources.	The results from the archaeological survey with supporting data, if required.	(i) A description of the results and data from the archaeological survey; (ii) A description of the historic and prehistoric archaeological resources, as required by the National Historic Preservation Act and Antiquities Act (16 U.S.C. 470 et. seq.), as amended, the Rhode Island Historical Preservation Act and Antiquities Act and Sections 220 and 330 of the RICRMP, as applicable; (iii) For more information on the archeological surveys and assessments required see Section 440.
(4) Geological survey.	The results from the geological survey with supporting data.	A report that describes the results of a geological survey that includes descriptions of: (i) Seismic activity at the proposed site; (ii) Fault zones; (iii) The possibility and effects of seabed subsidence; and (iv) The extent and geometry of faulting attenuation effects of geologic conditions near the site.
(5) Biological survey.	The results from the biological survey with supporting data.	A description of the results of a biological survey, including descriptions of the presence of live bottoms; hard bottoms; topographic features; and surveys of other marine resources such as fish populations (including migratory populations) not targeted by commercial or recreational fishing, marine mammals, sea turtles, and sea birds.

(6) Fish and Fisheries Survey	The results from the fish and fisheries survey with supporting data.	A report that describes the results of: (i) A biological assessment of commercially and recreationally targeted species. This assessment shall assess the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site. (ii) An assessment of commercial and recreational fisheries effort, landings, and landings value. Assessment shall focus on the proposed project area and alternatives across all four seasons of the year must. Assessment may use existing fisheries monitoring data but shall be supplemented by interviews with commercial and recreational fishermen. (iii) For more information on these assessments see Section 1160.9.3.

vi. The applicant shall submit a SAP that describes those resources, conditions, and activities listed in Table 11.3 that could be affected by the applicant's proposed activities, or that could affect the activities proposed in the applicant's SAP, including but not limited to:

Table 11.3. Resource data and uses that shall be described in the Site Assessment Plan.

Type of information	**Including:**
(1) Hazard information.	Meteorology, oceanography, sediment transport, geology, and shallow geological or manmade hazards.
(2) Water quality.	Turbidity and total suspended solids from construction.
(3) Biological resources.	Benthic communities, marine mammals, sea turtles, coastal and marine birds, fish and shellfish (not targeted by commercial or recreational fishing), plankton, seagrasses, and plant life.
(4) Threatened or endangered species.	As required by the Endangered Species Act (ESA) of 1973 (16. U.S.C. 1531 *et seq.*).
(5) Sensitive biological resources or habitats.	Essential fish habitat, refuges, preserves, Areas of Particular Concern, Areas Designated for Preservation, sanctuaries, rookeries, hard bottom habitat, and calving grounds; barrier islands, beaches, dunes, and wetlands.

(6) Archaeological and visual resources.	As required by the National Historic Preservation Act and Antiquities Act (16 U.S.C. 470 *et seq.*), as amended, the Rhode Island Historical Preservation Act and Antiquities Act and Sections 220 and 330 of the RICRMP, as applicable.
(7) Social and economic resources.	Employment, existing offshore and coastal infrastructure (including major sources of supplies, services, energy, and water), land use, subsistence resources and harvest practices, recreation, minority and lower income groups, and viewshed.
(8) Fisheries resources and uses	Commercially and recreationally targeted species, recreational and commercial fishing (including fishing seasons, location, and type), commercial and recreational fishing activities, effort, landings, and landings value.
(8) Coastal and marine uses.	Military activities, vessel traffic, and energy and non-energy mineral exploration or development.

vii. The Council shall review the applicant's SAP in coordination with the Joint Agency Working Group to determine if it contains the information necessary to conduct technical and environmental reviews and shall notify the applicant if the SAP lacks any necessary information.

viii. As appropriate, the Council shall coordinate and consult with relevant Federal and State agencies, and affected Indian tribes.

ix. Any Large-Scale Offshore Development, as defined above in section 1160.1.1, shall require a pre-application meeting between the FAB, the applicant, and the Council staff to discuss potential fishery-related impacts, such as, but not limited to, project location, construction schedules, alternative locations, and project minimization. During the pre-application meeting for a Large-Scale Offshore Development, the FAB can also identify areas of high fishing activity or habitat edges to be considered during the review process.

x. During the review process, the Council may request additional information if it is determined that the information provided is not sufficient to complete the review and approval process.

xi. Once the SAP is approved by the Council the applicant may begin conducting the activities approved in the SAP.

xii. Reporting requirements of the applicant under an approved SAP:

a. Following the approval of a SAP, the applicant shall notify the Council in writing within 30 days of completing installation activities of any temporary measuring devices approved by the Council.

b. The applicant shall prepare and submit to the Council a report semi-annually. The first report shall be due 6 months after work on the SAP begins; subsequent reports shall be submitted every 6 month thereafter until the SAP period is complete. The report shall summarize the applicant's site assessment activities and the results of those activities.

c. The Council reserves the right to require additional environmental and technical studies, if it is found there is a critical area lacking or missing information.

xiii. The applicant shall seek the Council's approval before conducting any activities not described in the approved SAP, describing in detail the type of activities the applicant proposes to conduct and the rationale for these activities. The Council shall determine whether the activities proposed are authorized by the applicant's existing SAP or require a revision to the applicant's SAP. The Council may request additional information from the applicant, if necessary, to make this determination.

xiv. The Council shall periodically review the activities conducted under an approved SAP. The frequency and extent of the review shall be based on the significance of any changes in available information and on onshore or offshore conditions affecting, or affected by, the activities conducted under the applicant's SAP. If the review indicates that the SAP should be revised to meet the requirements of this part, the Council shall require the applicant to submit the needed revisions.

xv. The applicant may keep approved facilities (such as meteorological towers) installed during the SAP period in place during the time that the Council reviews the applicant's COP for approval. Note: Structures in state waters shall require separate authorizations outside the SAP process.

xvi. The applicant is not required to initiate the decommissioning process for facilities that are authorized to remain in place under the applicant's approved COP. If, following the technical and environmental review of the applicant's submitted COP, the Council determines that such facilities may not remain in place the applicant shall initiate the decommissioning process.

ii. Construction and Operations Plan (COP) - The COP describes the applicant's construction, operations, and conceptual decommissioning plans for the proposed facility, including the applicant's project easement area.

a. The applicant's COP shall describe all planned facilities that the applicant shall construct and use for the applicant's project, including onshore and support facilities and all anticipated project easements.

b. The applicant's COP shall describe all proposed activities including the applicant's proposed construction activities, commercial operations, and conceptual decommissioning plans for all planned facilities, including onshore and support facilities.

c. The applicant shall receive the Council's approval of the COP before the applicant can begin any of the approved activities on the applicant's project site, lease or easement.

d. The COP shall demonstrate that the applicant has planned and is prepared to conduct the proposed activities in a manner that:

1. Conforms to all applicable laws, implementing regulations.
2. Is safe;
3. Does not unreasonably interfere with other uses of state waters;
4. Does not cause undue harm or damage to natural resources; life (including human and wildlife); the marine, coastal, or human

environment; or direct impact to sites, structures, or objects of historical or archaeological significance;

5. Uses best available and safest technology;
6. Uses best management practices; and
7. Uses properly trained personnel.

e. The applicant's COP shall include the following project-specific information, as applicable.

Table 11.4. Contents of the Construction and Operations Plan.

Project information:	**Including:**
(1.) Contact information	The name, address, e-mail address, and phone number of an authorized representative.
(2.) Designation of operator, if applicable.	
(3.) The construction and operation concept	A discussion of the objectives, description of the proposed activities, tentative schedule from start to completion, and plans for phased development.
(4.) A location.	The surface location and water depth for all proposed and existing structures, facilities, and appurtenances located both offshore and onshore, including all anchor/mooring data.
(5.) General structural and project design, fabrication, and installation.	Information for each type of structure associated with the project and, unless the Council provides otherwise, how the applicant shall use a CVA to review and verify each stage of the project.
(6.) All cables and pipelines, including cables on project easements.	Location, design and installation methods, testing, maintenance, repair, safety devices, exterior corrosion protection, inspections, and decommissioning. The applicant shall prior to construction also include location of all cable crossings and appropriate clearance from the owners of existing cables.
(7.) A description of the deployment activities.	Safety, prevention, and environmental protection features or measures that the applicant shall use.
(8.) A list of solid and liquid wastes generated.	Disposal methods and locations.
(9.) A list of chemical products used (if stored volume exceeds Environmental Protection Agency (EPA) Reportable Quantities).	A list of chemical products used; the volume stored on location; their treatment, discharge, or disposal methods used; and the name and location of the onshore waste receiving, treatment, and/or disposal facility. A description of how these products would be brought onsite, the number of transfers that may take place, and the quantity that shall be transferred each time.
(10.) Decommissioning and site clearance procedures.	A discussion of general concepts and methodologies.
(11.) A list of all Federal, State, and local authorizations, approvals, or permits that are required to conduct the proposed activities, including commercial operations.	A list of all Federal, State, and local authorizations, approvals, or permits that are required to conduct the proposed activities, including commercial operations. In addition, a statement indicating whether the applicant has applied for or obtained such authorizations, approvals, or permits.
(12.) The applicant's proposed measures for avoiding, minimizing, reducing, eliminating, and monitoring environmental impacts.	A description of the measures the applicant shall take to avoid or minimize adverse effects and any potential incidental take before conducting activities on the project site, and how the applicant shall minimize environmental impacts from proposed activities, including a description of the measures.

(13.) Information the applicant incorporates by reference.	A list of the documents referenced and the actual document if requested.
(14.) A list of agencies and persons with whom the applicant has communicated, or with whom the applicant shall communicate, regarding potential impacts associated with the proposed activities.	Contact information, issues discussed and the actual document if requested
(15.) Reference.	Contact information.
(16.) Financial assurance.	Statements attesting that the activities and facilities proposed in the applicant's COP are or shall be covered by an appropriate bond or security, as required by section 1160.7.2.
(17.) CVA nominations	CVA nominations for reports required.
(18.) Construction schedule.	A reasonable schedule of construction activity showing significant milestones leading to the commencement of commercial operations.
(19.) Air quality information.	Information required for the Clean Air Act (42 U.S.C. 7409) and implementing regulations.
(20.) Other information.	Additional information as required by the Council.

f. The applicant's COP shall include the following information and surveys for the proposed site(s) of the applicant's facility or facilities:

Table 11.5. Necessary data and information to be provided in the Construction and Operations Plan.

Information:	**Report contents:**	**Including:**
(1.) Shallow hazards.	The results of the shallow hazards survey with supporting data, if required.	Information sufficient to determine the presence of the following features and their likely effects on the proposed facility, including: (i) Shallow faults; (ii) Gas seeps or shallow gas; (iii) Slump blocks or slump sediments; (iv) Hydrates; or (v) Ice scour of seabed sediments.
(2.) Geological survey relevant to the siting and design of the facility.	The results of the geological survey with supporting data.	Assessment of: (i) Seismic activity at the proposed site; (ii) Fault zones; (iii) The possibility and effects of seabed subsidence; and (iv) The extent and geometry of faulting attenuation effects of geologic conditions near the site.

(3.) Biological survey.	The results of the biological survey with supporting data.	A description of the results of biological surveys used to determine the presence of live bottoms, hard bottoms, and topographic features, and surveys of other marine resources such as fish populations (including migratory populations) not targeted by commercial or recreational fishing, marine mammals, sea turtles, and sea birds.
(4.) Fish and fisheries survey.	The results from the fish and fisheries survey with supporting data.	A report that describes the results of: (i) A biological assessment of commercially and recreationally targeted species. This assessment shall assess the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site. (ii) An assessment of commercial and recreational fisheries effort, landings, and landings value. Assessment shall focus on the proposed project area and alternatives across all four seasons of the year must. Assessment may use existing fisheries monitoring data but shall be supplemented by interviews with commercial and recreational fishermen. (iii) For more information on these assessments see Section 1160.9.3.

(5.) Geotechnical survey.	The results of any sediment testing program with supporting data, the various field and laboratory tests employed, and the applicability of these methods as they pertain to the quality of the samples, the type of sediment, and the anticipated design application. The applicant shall explain how the engineering properties of each sediment stratum affect the design of the facility. In the explanation, the applicant shall describe the uncertainties inherent in the overall testing program, and the reliability and applicability of each method.	(i) The results of a testing program used to investigate the stratigraphic and engineering properties of the sediment that may affect the foundations or anchoring systems of the proposed facility. (ii) The results of adequate *in situ* testing, boring, and sampling at each foundation location, to examine all important sediment and rock strata to determine its strength classification, deformation properties, and dynamic characteristics. A minimum of one boring shall be taken per turbine planned, and the boring shall be taken within 50 feet of the final location of the turbine. (iii) The results of a minimum of one deep boring (with soil sampling and testing) at each edge of the project area and within the project area as needed to determine the vertical and lateral variation in seabed conditions and to provide the relevant geotechnical data required for design.
(6.) Archaeological and visual resources, if required.	The results of the archaeological resource survey with supporting data.	A description of the historic and prehistoric archaeological resources, as required by the National Historic Preservation Act and Antiquities Act (16 U.S.C. 470 et. seq.), as amended, the Rhode Island Historical Preservation Act and Antiquities Act and Sections 220 and 330 of the RICRMP, as applicable.
(7.) Overall site investigation.	An overall site investigation report for the proposed facility that integrates the findings of the shallow hazards surveys and geologic surveys, and, if required, the subsurface surveys with supporting data.	An analysis of the potential for: (i) Scouring of the seabed; (ii) Hydraulic instability; (iii) The occurrence of sand waves; (iv) Instability of slopes at the facility location; (v) Liquefaction, or possible reduction of sediment strength due to increased pore pressures; (vi) Cyclic loading; (vii) Lateral loading; (viii) Dynamic loading; (ix) Settlements and displacements; (x) Plastic deformation and formation collapse mechanisms; and (xi) Sediment reactions on the facility foundations or anchoring systems.

g. The applicant's COP shall describe those resources, conditions, and activities listed in Table 11.6 that could be affected by the applicant's

proposed activities, or that could affect the activities proposed in the applicant's COP, including:

Table 11.6. Resources, conditions and activities that shall be described in the Construction and Operations Plan.

Type of Information:	**Including:**
(1.) Hazard information and sea level rise.	Meteorology, oceanography, sediment transport, geology, and shallow geological or manmade hazards. Provide an analysis of historic and project (medium and high) rates of sea level rise and shall at minimum assess the risks for each alternative on public safety and environmental impacts resulting from the project (see Chapter 3, section 350.2 for more information).
(2.) Water quality and circulation.	Turbidity and total suspended solids from construction. Modeling of circulation and stratification to ensure that water flow patterns and velocities are not altered in ways that would lead to major ecosystem change.
(3.) Biological resources.	Benthic communities, marine mammals, sea turtles, coastal and marine birds, fish and shellfish not targeted by commercial or recreational fishing, plankton, seagrasses, and plant life.
(4.) Threatened or endangered species.	As defined by the ESA (16 U.S.C. 1531 *et seq.*)
(5.) Sensitive biological resources or habitats.	Essential fish habitat, refuges, preserves, Areas of Particular Concern, sanctuaries, rookeries, hard bottom habitat, barrier islands, beaches, dunes, and wetlands.
(6.) Fisheries resources and uses	Commercially and recreationally targeted species, recreational and commercial fishing (including fishing seasons, location, and type), commercial and recreational fishing activities, effort, landings, and landings value.
(6.) Archaeological resources.	As required by the NHPA (16 U.S.C. 470 *et seq.*), as amended.
(7.) Social and economic resources.	As determined by the Council in coordination with the Joint Agency Working Group.
(8.) Coastal and marine uses.	Military activities, vessel traffic, and energy and non-energy mineral exploration or development.

h. The applicant shall submit an oil spill response plan per the Oil Pollution Act of 1990, 33 USC 2701 *et seq*.
i. The applicant shall submit the applicant's Safety Management System, the contents of which are described below:
    1. How the applicant plans to ensure the safety of personnel or anyone on or near the facility;
    2. Remote monitoring, control and shut down capabilities;
    3. Emergency response procedures;
    4. Fire suppression equipment (if needed);
    5. How and when the safety management system shall be implemented and tested; and
    6. How the applicant shall ensure personnel who operate the facility are properly trained.

j. The Council shall review the applicant's COP and the information provided to determine if it contains all the required information necessary to conduct the project's technical and environmental reviews. The Council shall notify the applicant if the applicant's COP lacks any necessary information.
k. As appropriate, the Council shall coordinate and consult with relevant Federal, State, and local agencies, the FAB and affected Indian tribes.
l. During the review process, the Council may request additional information if it is determined that the information provided is not sufficient to complete the review and approval process. If the applicant fails to provide the requested information, the Council may disapprove the applicant's COP.
m. Upon completion of the technical and environmental reviews and other reviews required, the Council may approve, disapprove, or approve with modifications the applicant's COP.
n. In the applicant's COP, the applicant may request development of the project area in phases. In support of the applicant's request, the applicant shall provide details as to what portions of the site shall be initially developed for commercial operations and what portions of the site shall be reserved for subsequent phased development.
o. If the application and COP is approved, prior to construction the applicant shall submit to the Council for approval the documents listed below:
    1. **Facility Design Report**- The applicant's Facility Design Report provides specific details of the design of any facilities, including cables and pipelines, that are outlined in the applicant's approved SAP or COP. The applicant's Facility Design Report shall demonstrate that the applicant's design conforms to the applicant's responsibilities listed in section 1160.1.5. The applicant shall include the following items in the applicant's Facility Design Report:

Table 11.7. Contents of the Facility Design Report.

Required documents:	**Required contents:**	**Other requirements:**
(1.) Cover letter.	(i) Proposed facility designations; (ii)The type of facility	The applicant shall submit 4 paper copies and 1 electronic copy.
(2.) Location.	(i) Latitude and longitude coordinates, Universal Mercator grid-system coordinates, state plane coordinates in the Lambert or Transverse Mercator Projection System; (ii) These coordinates shall be based on the NAD (North American Datum) 83 datum plane coordinate system; and (iii) The location of any proposed project easement.	The applicant's plat shall be drawn to a scale of 1 inch equals 100 feet and include the coordinates of the project site, and boundary lines. The applicant shall submit 4 paper copy and 1 electronic copy.

(3.) Front, Side, and Plan View drawings.	(i) Facility dimensions and orientation; (ii) Elevations relative to Mean Lower Low Water; and (iii) Pile sizes and penetration.	The applicant's drawing sizes shall not exceed 11" x 17". The applicant shall submit 4 paper copies and 1 electronic copy.
(4.) Complete set of structural drawings.	The approved for construction fabrication drawings should be submitted, including, e.g., (i) Cathodic protection systems; (ii) Jacket design; (iii) Pile foundations; (iv) Mooring and tethering systems; (v) Foundations and anchoring systems; and (vi) Associated cable and pipeline designs.	The applicant's drawing sizes shall not exceed 11" x 17". The applicant shall submit 4 paper copies and 1 electronic copy.
(5.) Summary of environmental data used for design.	A summary of the environmental data used in the design or analysis of the facility. Examples of relevant data include information on: (i) Extreme weather; (ii) Seafloor conditions; and (iii) Waves, wind, currents, tides, temperature, sea level rise projections, snow and ice effects, marine growth, and water depth.	The applicant shall submit 4 paper copies and 1 electronic copy. If the applicant submitted these data as part of the SAP or COP, the applicant may reference the plan.
(6.) Summary of the engineering design data.	(i) Loading information (e.g., live, dead, environmental); (ii) Structural information (e.g., design-life; material types; cathode protection systems; design criteria; fatigue life; jacket design; deck design; production component design; foundation pilings and templates, and mooring or tethering systems; fabrication or installation guidelines); (iii) Location of foundation boreholes and foundation piles; and (iv) Foundation information (e.g., soil stability, design criteria).	The applicant shall submit 4 paper copies and 1 electronic copy.
(7.) A complete set of design calculations.	Self-explanatory.	The applicant shall submit 4 paper copies and 1 electronic copy.
(8.) Project-specific studies used in the facility design or installation.	All studies pertinent to facility design or installation, (e.g., oceanographic and soil reports)	The applicant shall submit 4 paper copies and 1 electronic copy.
(9.) Description of the loads imposed on the facility.	(i) Loads imposed by jacket; (ii) Turbines; (iii) Transition pieces; (iv) Foundations, foundation pilings and templates, and anchoring systems; and (v) Mooring or tethering systems.	The applicant shall submit 4 paper copies and 1 electronic copy.

(10.) Geotechnical report.	A list of all data from borings and recommended design parameters.	The applicant shall submit 4 paper copies and 1 electronic copy.

a. For any floating facility, the applicant's design shall meet the requirements of the U.S. Coast Guard for structural integrity and stability (e.g., verification of center of gravity). The design shall also consider:
    i. Foundations, foundation pilings and templates, and anchoring systems; and
    ii. Mooring or tethering systems.
b. The applicant is required to use a Certified Verified Agent (CVA). The Facility Design Report shall include two paper copies of the following certification statement: ''The design of this structure has been certified by a Council approved CVA to be in accordance with accepted engineering practices and the approved SAP, or COP as appropriate. The certified design and as-built plans and specifications shall be on file at (given location).''

2. **Fabrication and Installation Report**- The applicant's Fabrication and Installation Report shall describe how the applicant's facilities shall be fabricated and installed in accordance with the design criteria identified in the Facility Design Report; the applicant's approved SAP or COP; and generally accepted industry standards and practices. The applicant's Fabrication and Installation Report shall demonstrate how the applicant's facilities shall be fabricated and installed in a manner that conforms to the applicant's responsibilities listed in section 1160.1.5. The applicant shall include the following items in the applicant's Fabrication and Installation Report:

Table 11.8. Contents of the Fabrication and Installation Report.

Required documents:	**Required contents:**	**Other requirements:**
(1.) Cover letter.	(i) Proposed facility designation,; (ii) Area, name, and block number; and (iii) The type of facility	The applicant shall submit 4 paper copies and 1 electronic copy.
(2.) Schedule.	Fabrication and installation.	The applicant shall submit 4 paper copies and 1 electronic copy.
(3.) Fabrication information.	The industry standards the applicant shall use to ensure the facilities are fabricated to the design criteria identified in the Facility Design Report.	The applicant shall submit 4 paper copies and 1 electronic copy.

(4.) Installation process information.	Details associated with the deployment activities, equipment, and materials, including offshore and onshore equipment and support, and anchoring and mooring permits.	The applicant shall submit 4 paper copies and 1 electronic copy.
(5.) Federal, State, and local permits (e.g., EPA, Army Corps of Engineers).	Either 1 copy of the permit or information on the status of the application.	The applicant shall submit 4 paper copies and 1 electronic copy.
(6.) Environmental information.	(i) Water discharge; (ii) Waste disposal; (iii) Vessel information; and (iv) Onshore waste receiving treatment or disposal facilities.	The applicant shall submit 4 paper copies and 1 electronic copy. If the applicant submitted these data as part of the SAP or COP, the applicant may reference the plan.
(7.) Project easement.	Design of any cables, pipelines, or facilities. Information on burial methods and vessels.	The applicant shall submit 4 paper copies and 1 electronic copy.

i. A CVA report shall include the following: a Fabrication and Installation Report which shall include four paper copies of the following certification statement: ‘‘The fabrication and installation of this structure has been certified by a Council approved CVA to be in accordance with accepted engineering practices and the approved SAP or COP as appropriate.”

p. Based on the Council’s environmental and technical reviews, if approved, the Council may specify terms and conditions to be incorporated into any approval the Council may issue. The applicant shall submit a certification of compliance annually (or another frequency as determined by the Council) with certain terms and conditions which may include:
   1. Summary reports that show compliance with the terms and conditions which require certification; and
   2. A statement identifying and describing any mitigation measures and monitoring methods, and their effectiveness. If the applicant identified measures that were not effective, then the applicant shall make recommendations for new mitigation measures or monitoring methods.

q. After the applicant’s COP, Facility Design Report, and Fabrication and Installation Report is approved, and the Council has issued a permit and lease for the project site, construction shall begin by the date given in the construction schedule included as a part of the approved COP, unless the Council approves a deviation from the applicant’s schedule.

r. The applicant shall seek approval from the Council in writing before conducting any activities not described in the applicant’s approved COP.

The application shall describe in detail the type of activities the applicant proposes to conduct. The Council shall determine whether the activities the applicant proposes are authorized by the applicant's existing COP or require a revision to the applicant's COP. The Council may request additional information from the applicant, if necessary, to make this determination.

s. The Council shall periodically review the activities conducted under an approved COP. The frequency and extent of the review shall be based on the significance of any changes in available information, and on onshore or offshore conditions affecting, or affected by, the activities conducted under the applicant's COP. If the review indicates that the COP should be revised, the Council may require the applicant to submit the needed revisions.

t. The applicant shall notify the Council, within 5 business days, any time the applicant ceases commercial operations, without an approved suspension, under the applicant's approved COP. If the applicant ceases commercial operations for an indefinite period which extends longer than 6 months, the Council may cancel the applicant's lease, and the applicant shall initiate the decommissioning process.

u. The applicant shall notify the Council in writing of the following events, within the time periods provided:
    1. No later than 10 days after commencing activities associated with the placement of facilities on the lease area under a Fabrication and Installation Report.
    2. No later than 10 days after completion of construction and installation activities under a Fabrication and Installation Report.
    3. At least 7 days before commencing commercial operations.

v. The applicant may commence commercial operations within 30 days after the CVA has submitted to the Council the final Fabrication and Installation Report.

w. The applicant shall submit a Project Modification and Repair Report to the Council, demonstrating that all major repairs and modifications to a project conform to accepted engineering practices.
        1. A major repair is a corrective action involving structural members affecting the structural integrity of a portion of or all the facility.
        2. A major modification is an alteration involving structural members affecting the structural integrity of a portion of or all the facility.
        3. The report must also identify the location of all records pertaining to the major repairs or major modifications.
        4. The Council may require the applicant to use a CVA for project modifications and repairs.

1160.6 Design, Fabrication and Installation Standards

1. **Certified Verification Agent-** The Certified Verification Agent (CVA) shall use good engineering judgment and practices in conducting an independent assessment of the design, fabrication and installation of the facility. The CVA shall certify in the Facility Design Report to the Council that the facility is designed to withstand the environmental and functional load conditions appropriate for the intended service life at the proposed location. The CVA is paid for by the applicant, but is approved and reports to the Council.
    i. The applicant shall use a CVA to review and certify the Facility Design Report, the Fabrication and Installation Report, and the Project Modifications and Repairs Report. The applicant shall use a CVA to:
        a. Ensure that the applicant's facilities are designed, fabricated, and installed in conformance with accepted engineering practices and the Facility Design Report and Fabrication and Installation Report;
        b. Ensure that repairs and major modifications are completed in conformance with accepted engineering practices; and
        c. Provide the Council immediate reports of all incidents that affect the design, fabrication, and installation of the project and its components.
    ii. **Nominating a CVA for Council approval-** The applicant shall nominate a CVA for the Council approval. The applicant shall specify whether the nomination is for the Facility Design Report, Fabrication and Installation Report, Modification and Repair Report, or for any combination of these.
        a. For each CVA that the applicant nominates, the applicant shall submit to the Council a list of documents they shall forward to the CVA and a qualification statement that includes the following:
            1. Previous experience in third-party verification or experience in the design, fabrication, installation, or major modification of offshore energy facilities;
            2. Technical capabilities of the individual or the primary staff for the specific project;
            3. Size and type of organization or corporation;
            4. In-house availability of, or access to, appropriate technology (including computer programs, hardware, and testing materials and equipment);
            5. Ability to perform the CVA functions for the specific project considering current commitments;
            6. Previous experience with the Council requirements and procedures, if any; and
            7. The level of work to be performed by the CVA.
    iii. Individuals or organizations acting as CVAs shall not function in any capacity that shall create a conflict of interest, or the appearance of a conflict of interest.
    iv. The verification shall be conducted by or under the direct supervision of registered professional engineers.
    v. The Council shall approve or disapprove the applicant's CVA prior to construction.
    vi. The applicant shall nominate a new CVA for the Council approval if the previously approved CVA:

a. Is no longer able to serve in a CVA capacity for the project; or
b. No longer meets the requirements for a CVA set forth in this subpart.

vii. The CVA shall conduct an independent assessment of all proposed:
a. Planning criteria;
b. Operational requirements;
c. Environmental loading data;
d. Load determinations;
e. Stress analyses;
f. Material designations;
g. Soil and foundation conditions;
h. Safety factors; and
i. Other pertinent parameters of the proposed design.

viii. For any floating facility, the CVA shall ensure that any requirements of the U.S. Coast Guard for structural integrity and stability (e.g., verification of center of gravity), have been met. The CVA shall also consider:
a. Foundations;
b. Foundation pilings and templates, and
c. Anchoring systems.

ix. The CVA shall do all of the following:
a. Use good engineering judgment and practice in conducting an independent assessment of the fabrication and installation activities;
b. Monitor the fabrication and installation of the facility;
c. Make periodic onsite inspections while fabrication is in progress and verify the items required by section 1160.1.1(xi.);
d. Make periodic onsite inspections while installation is in progress and satisfy the requirements of section 1160.1.1 (xii.); and
e. Certify in a report that project components are fabricated and installed in accordance with accepted engineering practices; the applicant's approved COP or SAP; and the Fabrication and Installation Report.
1. The report shall also identify the location of all records pertaining to fabrication and installation.
2. The applicant may commence commercial operations or other approved activities 30 days after the Council receives that certification report, unless the Council notifies the applicant within that time period of its objections to the certification report.

x. The CVA shall monitor the fabrication and installation of the facility to ensure that it has been built and installed according to the Facility Design Report and Fabrication and Installation Report.
a. If the CVA finds that fabrication and installation procedures have been changed or design specifications have been modified, the CVA shall inform the applicant and the Council.

xi. The CVA shall make periodic onsite inspections while fabrication is in progress and shall verify the following items, as appropriate:
a. Quality control by lessee (or grant holder) and builder;
b. Fabrication site facilities;
c. Material quality and identification methods;

d. Fabrication procedures specified in the Fabrication and Installation Report, and adherence to such procedures;
e. Welder and welding procedure qualification and identification;
f. Adherence to structural tolerances specified;
g. Nondestructive examination requirements and evaluation results of the specified examinations;
h. Destructive testing requirements and results;
i. Repair procedures;
j. Installation of corrosion protection systems and splash-zone protection;
k. Erection procedures to ensure that overstressing of structural members does not occur;
l. Alignment procedures;
m. Dimensional check of the overall structure, including any turrets, turret and- hull interfaces, any mooring line and chain and riser tensioning line segments; and
n. Status of quality-control records at various stages of fabrication.

xii. The CVA shall make periodic onsite inspections while installation is in progress and shall, as appropriate, verify, witness, survey, or check, the installation items required by this section. The CVA shall verify, as appropriate, all of the following:
a. Load out and initial flotation procedures;
b. Towing operation procedures to the specified location, and review the towing records;
c. Launching and upprighting activities;
d. Submergence activities;
e. Pile or anchor installations;
f. Installation of mooring and tethering systems;
g. Transition pieces, support structures, and component installations; and
h. Installation at the approved location according to the Facility Design Report and the Fabrication and Installation Report.

xiii. For a fixed or floating facility, the CVA shall verify that proper procedures were used during the following:
a. The loadout of the transition pieces and support structures, piles, or structures from each fabrication site; and
b. The actual installation of the facility or major modification and the related installation activities.

xiv. For a floating facility, the CVA shall verify that proper procedures were used during the following:
a. The loadout of the facility;
b. The installation of foundation pilings and templates, and anchoring systems.

xv. The CVA shall conduct an onsite survey of the facility after transportation to the approved location.

xvi. The CVA shall spot-check the equipment, procedures, and recordkeeping as necessary to determine compliance with the applicable documents incorporated by reference and the regulations under this part.

xvii. The CVA shall prepare and submit to the applicant and the Council all reports required by this subpart. The CVA shall also submit interim reports to the applicant and the Council, as requested by the Council. The CVA shall submit one electronic copy and four paper copies of each final report to the Council. In each report, the CVA shall:
   a. Give details of how, by whom, and when the CVA activities were conducted;
   b. Describe the CVA's activities during the verification process;
   c. Summarize the CVA's findings; and
   d. Provide any additional comments that the CVA deems necessary.

xviii. Until the Council releases the applicant's financial assurance under section 1160.7.2, the applicant shall compile, retain, and make available to the Council representatives, all of the following:
   a. The as-built drawings;
   b. The design assumptions and analyses;
   c. A summary of the fabrication and installation examination records;
   d. Results from the required inspections and assessments;
   e. Records of repairs not covered in the inspection report submitted.

xix. The applicant shall record and retain the original material test results of all primary structural materials during all stages of construction until the Council releases the applicant's financial assurance under section 1160.7.2. Primary material is material that, should it fail, would lead to a significant reduction in facility safety, structural reliability, or operating capabilities. Items such as steel brackets, deck stiffeners and secondary braces or beams would not generally be considered primary structural members (or materials).

xx. The applicant shall provide the Council with the location of these records in the certification statement.

xxi. The Council may hire its own CVA agent to review the work of the applicants CVA. The applicant shall be responsible for the cost of the Council's CVA. The Council's CVA shall perform those duties as assigned by the Council.

1160.7 Pre-Construction Standards

1. The Council may issue a permit for a period of up to 50 years to construct and operate an Offshore Development. A lease shall be issued at the start of the construction phase and payment shall commence at the end of the construction phase. Lease payments shall be due when the project becomes operational. Lease renewal shall be submitted 5 years before the end of the lease term. Council approval shall be required for any assignment or transfer of the permit or lease. This provision shall not apply to aquaculture permitting. Aquaculture permitting and leasing are governed by the provisions of Title 20 Chapter 10 of the General Laws of Rhode Island and Section 300.11 of the RICRMP.

2. Prior to construction, the assent holder shall post a Performance Bond sufficient to ensure removal of all structures at the end of the lease and restore the site. The Council shall review the bond amount initially and every 3 years thereafter to ensure the amount is sufficient.

3. Prior to construction, the assent holder shall show compliance with all federal and state agency requirements, which may include but are not limited to the requirements of the following agencies: the Rhode Island Coastal Resources Management Council, the Rhode Island Department of Environmental Management, the Rhode Island Energy Facilities Siting Board, the Rhode Island Historical Preservation and Heritage Commission, U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement, Army Corps of Engineers, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency.

4. The Council shall consult with the U.S. Coast Guard, the U.S. Navy, marine pilots, the Fishermen's Advisory Board as defined in section 1160.1.6, fishermen's organizations, and recreational boating organizations when scheduling offshore marine construction or dredging activities. Where it is determined that there is a significant conflict with season-limited commercial or recreational fishing activities, recreational boating activities or scheduled events, or other navigation uses, the Council shall modify or deny activities to minimize conflict with these uses.

5. The Council shall require the assent holder to provide for communication with commercial and recreational fishermen, mariners, and recreational boaters regarding offshore marine construction or dredging activities. Communication shall be facilitated through a project website and shall complement standard U.S. Coast Guard procedures such as Notices to Mariners for notifying mariners of obstructions to navigation.

6. For all Large-Scale Offshore Developments, underwater cables, and other development projects as determined by the Council, the assent holder shall designate and fund a third-party fisheries liaison. The fisheries liaison must be knowledgeable about fisheries and shall facilitate direct communication between commercial and recreational fishermen and the project developer. Commercial and recreational fishermen shall have regular contact with and direct access to the fisheries liaison throughout all stages of an offshore development (pre-construction; construction; operation; and decommissioning).

7. Where possible, Offshore Developments should be designed in a configuration to minimize adverse impacts on other user groups, which include but are not limited to: recreational boaters and fishermen, commercial fishermen, commercial ship operators, or other vessel operators in the project area. Configurations which may minimize adverse impacts on vessel traffic include, but are not limited to, the incorporation of a traffic lane through a development to facilitate safe and direct navigation through, rather than around, an Offshore Development

8. Any assent holder of an approved Offshore Development shall work with the Council when designing the proposed facility to incorporate where possible mooring mechanisms to allow safe public use of the areas surrounding the installed turbine or other structure.

9. The facility shall be designed in a manner that minimizes adverse impacts to navigation. As part of its application package, the project applicant shall submit a navigation risk assessment under the U.S. Coast Guard's Navigation and Vessel Inspection Circular 02-

07, "Guidance on the Coast Guard's Roles and Responsibilities for Offshore Renewable Energy Installations."

10. Applications for projects proposed to be sited in state waters pursuant to the Ocean SAMP shall not have a significant impact on marine transportation, navigation, and existing infrastructure. Where the Council, in consultation with the U.S. Coast Guard, the U.S. Navy, NOAA, the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement, the U.S. Army Corps of Engineers, marine pilots, the R.I. Port Safety and Security Forums, or other entities, as applicable, determines that such an impact on marine transportation, navigation, and existing infrastructure is unacceptable, the Council shall require that the applicant modify the proposal or the Council shall deny the proposal. For the purposes of Marine Transportation Policies and Standards as summarized in Chapter 7, sections 770.1-770.2, impacts will be evaluated according to the same criteria used by the U.S. Coast Guard, as follows; these criteria shall not be construed to apply to any other Ocean SAMP chapters or policies:

    i. Negligible: No measurable impacts.
    ii. Minor: Adverse impacts to the affected activity could be avoided with proper mitigation; or impacts would not disrupt the normal or routine functions of the affected activity or community; or once the impacting agent is eliminated, the affected activity would return to a condition with no measurable effects from the proposed action without any mitigation.
    iii. Moderate: Impacts to the affected activity are unavoidable; and proper mitigation would reduce impacts substantially during the life of the proposed action; or the affected activity would have to adjust somewhat to account for disruptions due to impacts of the proposed action; or once the impacting agent is eliminated, the affected activity would return to a condition with no measurable effects from the proposed action if proper remedial action is taken.
    iv. Major: Impacts to the affected activity are unavoidable; proper mitigation would reduce impacts somewhat during the life of the proposed action; the affected activity would experience unavoidable disruptions to a degree beyond what is normally acceptable; and once the impacting agent is eliminated, the affected activity may retain measurable effects of the proposed action indefinitely, even if remedial action is taken.

11. Prior to construction, the Applicant shall provide a letter from the U.S. Coast Guard showing it meets all applicable U.S. Coast Guard standards.

1160.8 Standards for Construction Activities

1. The Assent Holder shall use the best available technology and techniques to minimize impacts to the natural resources and existing human uses in the project area.

2. The Council shall require the use of an environmental inspector to monitor construction activities. The environmental inspector shall be a private, third-party entity that is hired by the Assent Holder, but is approved and reports to the Council. The environmental inspector shall possess all appropriate qualifications as determined by the Council. This inspector service may be part of the CVA requirements.

3. Installation techniques for all construction activities should be chosen to minimize sediment disturbance. Jet plowing and horizontal directional drilling in nearshore areas shall be required in the installation of underwater transmission cables. Other technologies may be used provided the applicant can demonstrate they are as effective, or more effective, than these techniques in minimizing sediment disturbance.

4. All construction activities shall comply with the policies and standards outlined in the Rhode Island Coastal Resources Management Program (RICRMP), as well as the regulations of other relevant state and federal agencies.

5. The applicant shall conduct all activities on the applicant's permit under this part in a manner that conforms with the applicant's responsibilities in section 1160.1.5, and using:
    i. Trained personnel; and
    ii. Technologies, precautions, and techniques that shall not cause undue harm or damage to natural resources, including their physical, atmospheric, chemical and biological components.

6. The Assent Holder shall be required to use the best available technology and techniques to mitigate any associated adverse impacts of offshore renewable energy development.
    i. As required, the applicant shall submit to the Council:
        a. Measures designed to avoid or minimize adverse effects and any potential incidental take of endangered or threatened species as well as all marine mammals;
        b. Measures designed to avoid likely adverse modification or destruction of designated critical habitat of such endangered or threatened species; and
        c. The applicant's agreement to monitor for the incidental take of the species and adverse effects on the critical habitat, and provide the results of the monitoring to the Council as required; and

7. If the Assent Holder, the Assent Holder's subcontractors, or any agent acting on the Assent Holder's behalf discovers a potential archaeological resource while conducting construction activities, or any other activity related to the Assent Holder's project, the applicant shall:
    i. Immediately halt all seafloor disturbing activities within the area of the discovery;
    ii. Notify the Council of the discovery within 24 hours; and
    iii. Keep the location of the discovery confidential and not take any action that may adversely affect the archaeological resource until the Council has made an evaluation and instructed the applicant on how to proceed.
        a. The Council may require the Assent Holder to conduct additional investigations to determine if the resource is eligible for listing in the National Register of Historic Places under 36 CFR 60.4. The Council shall do this if:
            1. The site has been impacted by the Assent Holder's project activities; or

2. Impacts to the site or to the area of potential effect cannot be avoided.

b. If the Council incurs costs in protecting the resource, under section 110(g) of the NHPA, the Council may charge the applicant reasonable costs for carrying out preservation responsibilities.

8. Post construction, the Assent Holder shall provide a side scan sonar survey of the entire construction site to verify that there is no post construction debris left at the project site. These side-scan sonar survey results shall be filed with the Council within 90 days of the end of the construction period. The results of this side-scan survey shall be verified by a third-party reviewer, who shall be hired by the Assent Holder but who is pre-approved by and reports to the Council.

9. All pile-driving or drilling activities shall comply with any mandatory best management practices established by the Council in coordination with the Joint Agency Working Group and which are incorporated into the RICRMP.

10. The Council may require the Assent Holder to hire a CVA to perform periodic inspections of the structure(s) during the life of those structure(s). The CVA shall work for and be responsible to the council.

1160.9 Monitoring Requirements

1. The Council in coordination with the Joint Agency Working Group, as described in Section 1160.1.4, shall determine requirements for monitoring prior to, during, and post construction. Specific monitoring requirements shall be determined on a project-by-project basis and may include but are not limited to the monitoring of:
    i. Coastal processes and physical oceanography
    ii. Underwater noise
    iii. Benthic ecology
    iv. Avian species
    v. Marine mammals
    vi. Sea turtles
    vii. Fish and fish habitat
    viii. Commercial and recreational fishing
    ix. Recreation and tourism
    x. Marine transportation, navigation and existing infrastructure
    xi. Cultural and historic resources

2. The Council shall require where appropriate that project developers perform systematic observations of recreational boating intensity at the project area at least three times: pre-construction; during construction; and post-construction. Observations may be made while conducting other field work or aerial surveys and may include either visual surveys or analysis of aerial photography or video photography. The Council shall require where appropriate that observations capture both weekdays and weekends and reflect high-activity periods including the July 4th holiday weekend and the week in June when Block Island Race Week takes place.

The quantitative results of such observations, including raw boat counts and average number of vessels per day, will be provided to the Council.

3. The items listed below shall be required for all Offshore Developments:
    i. A biological assessment of commercially and recreationally targeted species shall be required within the project area for all Offshore Developments. This assessment shall assess the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. Such an assessment shall be performed at least four times: pre-construction (to assess baseline conditions); during construction; and at two different intervals during operation (i.e. 1 year after construction and then post-construction). At each time this assessment must capture all four seasons of the year. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site. The Council will not require this assessment for proposed projects within the Renewable Energy Zone that are proposed within 2 years of the adoption of the Ocean SAMP.
    ii. An assessment of commercial and recreational fisheries effort, landings, and landings value shall be required for all proposed Offshore Developments. Assessment shall focus on the proposed project area and alternatives. This assessment shall evaluate commercial and recreational fishing effort, landings, and landings value at three different stages: pre-construction (to assess baseline conditions); during construction; and during operation. At each stage, all four seasons of the year must be evaluated. Assessment may use existing fisheries monitoring data but shall be supplemented by interviews with commercial and recreational fishermen. Assessment shall address whether fishing effort, landings, and landings value has changed in comparison to baseline conditions. The Council will not require this assessment for proposed projects within the Renewable Energy Zone that are proposed within 2 years of the adoption of the Ocean SAMP.

4. The Council in coordination with the Joint Agency Working Group may also require facility and infrastructure monitoring requirements, that may include but are not limited to:
    i. Post construction monitoring including regular visual inspection of inner array cables and the primary export cable to ensure proper burial, foundation and substructure inspection.

Appendix I. Overview of Offshore Development Permitting Process in State Waters

