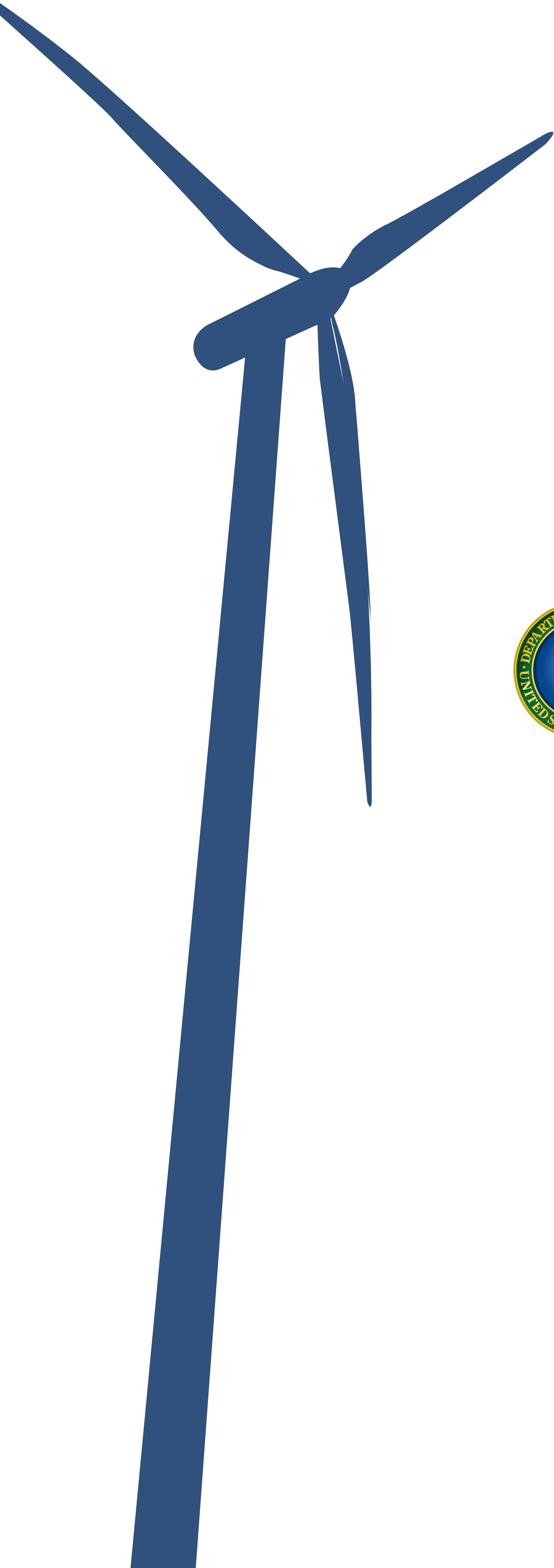

MAINE
Deepwater Offshore Wind Report

Funded by:

U.S. DEPARTMENT OF ENERGY

Rockefeller Brothers Fund

Authored by:

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Updated September, 2012

THE UNIVERSITY OF MAINE

Offshore Wind Feasibility Study

Compiled by: University of Maine and James W. Sewall Company

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Acknowledgments

The University of Maine (UMaine), James W. Sewall Company (Sewall) and all authors and contributors to this study would like to thank the following persons and organizations for their contributions to the overall development and success of this report:

- Senator Susan Collins
- Members of Maine's Congressional Delegation
- Secretary Steven Chu
- Governor John Baldacci
- Members of Governor Baldacci's Offshore Energy Task Force
- The Late Matthew Simmons
- Robert West and the Ocean Energy Institute
- Ms. Karin Tilberg
- Chris Hart, United States Department of Energy
- Bangor Hydro Electric Company
- Bath Iron Works
- Central Maine Power Company
- Cianbro Corporation
- Rockefeller Brothers Fund

In particular, the UMaine and Sewall would like to acknowledge and thank the staff and executive leadership at Statoil ASA for their collaboration, cooperation, and offshore experience in helping frame the content of the study.

Finally, UMaine would like to acknowledge the support of the United States Department of Energy, which provided funding for completion of this study.

Executive Summary

This report consists of the compilation and preliminary analysis of relevant data on the Gulf of Maine, to provide important information for parties seeking to respond to the RFP titled: ***Request for Proposals for Long-Term Contracts for Deep-Water Offshore Wind Energy Pilot Projects and Tidal Energy Demonstration Projects,*** released September 1, 2010 by the Maine Public Utilities Commission (PUC). As directed by the Maine Legislature under ***An Act To Implement the Recommendations of the Governor's Ocean Energy Task Force***[1], the RFP calls for bidders to propose the sale of renewable energy produced by a deep-water offshore wind energy pilot project that employs one or more floating turbines in the Gulf of Maine (GoM) at a location 300 feet (91 m) or greater in depth no less than ten (10) nautical miles (nmi) from any land area; or a tidal energy demonstration project that uses tidal action as a source of electrical power and that: (1) has a total installed generating capacity of 5 megawatts or less; and (2) is proposed for the primary purpose of testing tidal energy generation technology. As specified in the Act, the PUC may authorize one or more long-term contracts for an aggregate total of no more than 30 megawatts of installed capacity and associated renewable energy and renewable energy credits (RECs) from deep-water offshore wind energy pilot projects or tidal energy demonstration projects, as long as no more than 5 megawatts of the total is supplied by tidal energy demonstration projects. With initial responses due May 1, 2011, the PUC is calling for respondents who have "...experience relevant to tidal power or the offshore wind energy industry, as applicable, including, in the case of a deep-water offshore wind energy pilot project proposal, experience relevant to the construction and operation of floating wind turbines, and have the potential to construct a deep-water offshore wind energy project 100 megawatts or greater in capacity in the future to provide electric consumers in Maine with project-generated power at reduced rates."[2]

In evaluating the potential for the initial development of an up to 30 Megawatt (MW) floating offshore wind project and larger commercial-scale (100 MW and larger) project in federal waters off the coast of Maine, the following criteria are considered:

[1] Public Law, Chapter 615, LD 1810, 124th Maine State Legislature

[2] RFP, Section 2.1 D.

- Met-ocean conditions/Wind Resource –Mean annual wind speeds of at least eight meters per second (8 m/s) or Class 6 winds or better at 50 meters (m) elevation based on wind resource estimates from the United States Department of Energy (DOE) National Renewable Energy Laboratory (NREL)
- Bathymetry – As stated in the RFP, the minimum depth requirement is 300 ft (91 m). There is no maximum depth requirement set forth in the RFP.
- Distance to coastline – As stated in the RFP, the minimum distance to coastline is no less than ten (10) nmi from any land area.
- Environmental resource impacts – The primary environmental resources of concern for offshore wind projects include migratory birds, bats, and threatened and endangered marine species (e.g., North Atlantic right whales). For subsea cable route and nearshore construction, assembly and wet storage areas, impacts to coastal wildlife (including coastal seabird nesting areas), essential fish habitat areas, and coastal threatened and endangered species (e.g., Atlantic salmon and Atlantic sturgeon [proposed-not listed yet]) are also important considerations. Care should be taken to select areas that avoid marine sanctuaries and minimize potential impacts to critical habitat areas.
- Distance to grid interconnection – Minimizing the distance to grid interconnection is particularly important to managing the overall development and construction costs of an offshore wind project. The key findings of an interconnection study regarding distance to grid interconnection points and related subsea cable route include:
  - Fifteen (15) existing substations have been located along the southern coast and mid-coast areas with the capacity to support an offshore wind farm of up to 30 MW. Based on data currently available, it appears the best and most flexible interconnection points are located within the Bath, Wiscasset, Boothbay and Rockland areas
  - Potential subsea cable routes have been identified that will limit the cable length to less than 45 kilometers (km). Dominant conditions on Maine's Inner Continental Shelf (ICS), namely bedrock and mud, do not appear to support easy or cost-effective trenching. It may be possible to plan a cable route in trenchable materials using information currently available; however, additional studies are needed on the muddy areas of the ICS to see if indeed those areas could support the trenching of cables.
- Constructability and supply chain availability – Mid-coast Maine and the Penobscot Bay area have adequate facilities and capabilities to support early stage development of a floating offshore wind farm, including (1) suitable assembly and wet storage areas, with existing port infrastructure and potential industrial waterfront availability; (2) large, medium and small crane, barge and support vessels; (3) local resources for equipment and supplies; (4) local contractors and construction firms experienced with offshore construction and onshore wind

power projects; (5) maritime skills and shipbuilding heritage including experience building complex naval vessels and repairing steel ferries and barges; (6) support industries, such as marine steel fabrication and composite materials manufacturing; and (7) ready access to railways, road and interstate systems, and airports for supply chain accessibility and transportation.

Evaluation and Development of Floating Platform Designs by the University of Maine

Under funding from DOE, the University of Maine (UMaine) has undertaken a multi-year program focused on the development and testing of floating offshore wind energy platforms. As part of this program, UMaine has led a thorough evaluation of more than fourteen different platform technologies submitted by designers from around the world. Starting in 2011, the first of these platform concepts will be designed at an intermediate (approximately 1/3) scale to carry a 100 kW turbine. This first intermediate-scale platform will be fabricated and deployed into UMaine's Deepwater Wind Test Site off Monhegan Island in July 2012, for a period of approximately three to four months. Performance data will be gathered during this deployment, and will be used to refine the design for potential full-scale development. UMaine is currently developing plans to build and deploy additional intermediate-scale platforms in 2013 and 2014, to evaluate multiple platform technologies, validate numerical models, and study the interaction of the platforms with the environment.

Critical Issues

The listed threatened and endangered marine species in the GoM include Atlantic salmon and the North Atlantic right whale. The Atlantic sturgeon has been proposed for listing as a threatened species. The critical habitat for Atlantic salmon is designated to include all perennial rivers, streams, and estuaries connected to the marine environment. On September 16, 2009, a petition was filed with National Marine Fisheries Service (NMFS) requesting that the critical feeding and calving habitat area for the North Atlantic right whale be expanded to include state and federal waters off the coast of every state along the eastern seaboard from Maine to Florida. The petition focused on the New England coast in particular, requesting that all waters north of Cape Cod out to 200 nmi be designated as critical habitat. The critical habitat for Atlantic sturgeon include watersheds ranging from the Maine/Canada border and extending southward to include all associated watersheds draining into the GoM and wherever these fish occur in coastal bays, estuaries and the marine environment. Atlantic sturgeon has been documented in the Penobscot, Kennebec, Androscoggin, Sheepscot, Saco, Piscataqua, and Merrimack Rivers.

In order to proceed with the permitting process, it is recommended to prepare an extended biological assessment and habitat conservation plan for the proposed project area to (1) evaluate the effects of the project on the co-located species and (2) identify reasonable and prudent alternatives regarding impacts on wildlife and habitats such that the project can proceed. Likewise, it is recommended to provide an Incidental Take Statement consistent with Endangered Species Act provisions or to apply for an "Incidental Take Permit" through United States Fish & Wildlife Service (USFWS) or NMFS depending on the species of concern.

Permitting Considerations

The key permitting regulations for offshore wind project development in the GoM are summarized in Table 8-2 in Section 8.0 of this report. The critical path for state and federal permitting of a <30 MW floating offshore wind project in federal waters is anticipated to be the Outer Continental Shelf (OCS) leasing and permitting process through the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service (MMS). The State of Maine is in consultation with BOEMRE to develop the Maine Deepwater Wind Energy Pilot Project, which would implement a streamlined, three-year process for environmental review of an advanced, deepwater wind energy pilot project, including lease issuance and approval of project-specific assessment plans. The other major state (e.g., Site Law) and federal (e.g., United States Army Corps of Engineers (USACE) Section 404/Section 10) permits are anticipated to require six (6) to 18 months for permit review and approval. As part of the development of the required permit applications, a minimum of two seasons (spring and fall), and likely four seasons, of bird and bat monitoring will be required. Conservatively, the time required to perform these studies, additional required surveys, and prepare the necessary permit applications is estimated to be at least two years. Therefore, prospective developers should expect an approximately five-year permitting process from the start of necessary environmental studies and surveys (two (2) years) to permit issuance (an additional three (3) years beyond studies and surveys under streamlined permitting).

The other major component of an offshore wind project, the subsea cable route to shore and the land-based transmission line to the electric grid interconnection point, will require state (e.g., Site Law) and federal permitting (e.g., USACE Section 404/Section 10). This permit will be particularly focused on impacts to coastal marshland, mudflats, and coastal and freshwater wetlands. As offshore wind energy is regarded as "new" technology in the United States, the USACE permits will be treated and reviewed as a joint application for an Individual Permit. These permits typically require six (6) to 12 months for review; however, the permit application review process may take as long as 18 months depending on the number of comments and additional monitoring or investigation requests from the resource agencies.

The primary environmental stakeholders for offshore wind projects in the GoM include commercial fishermen (mobile-gear and fixed-gear), environmental non-governmental organizations, and coastal residents. In addition, tourism operators, coastal land trusts, and island electric cooperative representatives can also play important roles in supporting or opposing a proposed project.

Early communication and outreach to these stakeholders will be an important component of the permitting process.

Additional Surveys

The following additional surveys will likely be necessary to support design and permitting of a < 30 Megawatt (MW) floating offshore wind project:

Physical and geophysical investigations

- **Desktop studies** - synthesis of known anthropogenic and natural features of relevant importance, including (but not limited to) shipwrecks, fault lines, anticipated sediment types, historical feature migration, historical bathymetry, and the geological history of the area;
- **Topographic and boundary surveys** of the subsea cable connection to shore and along the transmission line route to the interconnection substation;
- **Multi-beam hydrographic survey** of the project area and subsea cable route for the detection of items on the seafloor and an accurate depiction of bathymetric changes;
- **Sidescan sonar** to detect objects on the seafloor that may impact anchor locations or subsea cable routes;
- **Sub-surface profiling** for detecting layers of different materials within the seabed, as well as the possibility of detecting erratics or other features that may make cable trenching difficult;
- **Sediment quality** testing at proposed anchoring locations and along the planned cable route for contaminants and heavy metals that may create environmental challenges;
- **Archaeological searches** including magnetometers and drop-cameras are recommended to detect any archaeological or cultural artifacts that require protection under local regulations;
- **Geotechnical testing** of shallow sediment cores is recommended to characterize the bottom substrate and the type and depth of surficial sediments. Testing should include conventional soil properties such as grain size, gradations and shear strengths, as well as testing such as strain rate effects, permeability (sands/silt), shell content, plasticity, compressibility and relative density for evaluation of trenchability.

Coastal engineering studies

- **Wind:** Site-specific measurements using a traditional anemometer supplemented with Light Ranging and Detection (LiDAR) or Sonic Detection and Ranging (SODAR)

- **Waves:** A full wave climate should be developed. Extreme value analysis and risk-based approaches should be employed to select representative events for further analysis and wave transformation. The measurement of waves near the detailed study areas through repurposing of inactive Gulf of Maine Ocean Observing System (GoMOOS) buoys is recommended to calibrate wave models to the local conditions. It is also recommended that the wave climate near the cable-landing site be determined for use in sediment transport modeling efforts.
- **Water levels**: A desktop study of recorded water levels near the planned cable route is recommended. Where recorded water levels are not available, it is recommended to have fixed measured values for at least 30 days to establish local tidal constituents. Water level events captured in observational data will help to understand the surge and setup conditions associated with the local passage of severe weather and storms, particularly Nor'easters. The understanding of the water level and its variability can be used in the calibration of hydrodynamic models.
- **Currents**: Tidal currents, wave-induced currents, and synoptic currents are important in the GoM. It is recommended that existing hydrodynamic models for the GoM be leveraged and the resolution improved near the project area, or new models be developed to gain a full understanding of the currents throughout the study area. Current measurements for calibration of the model(s) are highly recommended. A resolution sufficient to identify areas of strong or focused currents along the cable route should be employed.
- **Sediment transport**: A study of the baseline sediment transport conditions across the entire planned cable route is recommended. This includes identifications of dynamic features (ridges and shoals), as well as an assessment of longshore sediment transport and shoreline change near the cable landing area. Any areas that are particularly susceptible to scour can also be identified and appropriate measures recommended.

Environmental studies

- **Desktop studies**: Synthesis of known information on terrestrial, avian and marine resources including data from the Offshore Wind Energy Geographic Information System (OWEGIS), the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS) observational buoy network, ongoing regional environmental monitoring efforts, marine research universities and institutes, state and federal resources, and Maine Wind Industry Initiative (MWII) member organizations;
- **Delineation of natural resources** in the project area including freshwater wetlands, vernal pools, coastal wetlands, coastal marshland and essential fish habitat (EFH) areas in the vicinity of the construction/assembly area and along the subsea cable and transmission line route. As part of the identification of

these resources, a Biological Assessment of potential impacts to federally-listed species and assessment of impacts to EFH-managed species should be completed;

- **Direct physical interaction – birds/bats**: As noted, radar ranges of less than or equal to two kilometers (≤ 2 km) are needed to resolve individual passerines, and the need for a fixed or floating platform for radar will make pre-deployment data problematic to obtain. One adaptive management approach would be to use surveillance radar to detect and avoid flyways of large flocks, followed by studies after turbine deployment that mount radar units directly on the turbine platforms to evaluate individual bird trajectories and behaviors;
- **Habitat modification**: In terms of pelagic habitat modification, a before-after, control-impact (BACI) design is recommended to evaluate the impact of floating offshore wind platforms on pelagic fishes. Two sampling approaches should be used concurrently – one based on mobile acoustic surveys with biological verification and the other based on continuous stationary acoustic monitoring. The system may also be able to monitor marine mammal use of the area, depending on system configuration, sampling rate, frequencies, beam angles, etc.;
- **Upwelling studies** including an upstream buoy and a downstream buoy to achieve time resolution, with glider observations taken at the onset of stratification, at peak stratification in summer and during the fall decay of stratification;
- **Macrofaunal effects**: Recommended sampling design would employ BACI methodology on four stations, with two stations located at random within the anchor footprint, one 500 m upstream in the Maine Coastal Current of the closest anchor and one 500 m downstream with an approximate minimum of three cores or grabs from each of the four stations;
- **Acoustic effects**: Using a BACI design, continuous stationary (active and passive) acoustic monitoring can be deployed in control and test sites at various distances to examine patterns in fish distributions as functions of environmental conditions (e.g., wind speed) and ambient noise levels; and
- **Electromagnetic Field effects**: A better ability to determine the need for and to design appropriate electromagnetic field (EMF) effect studies is anticipated after the Pacific Northwest National Laboratory (PNNL) completes additional current studies on animal sensitivity across a range of species. Possible electromagnetic field studies include field observations via remotely operated vehicles (ROVs) on American lobster behavior.

1.0 Introduction

This report consists of a preliminary study of the feasibility of developing an up to 30 MW "stepping stone" floating offshore wind project and larger commercial-scale (100 – 300 MW) in federal waters off the coast of Maine. It provides key information to developers to help prepare successful bids in response to the Maine Public Utilities Commission (PUC) Request for Proposals (RFP) titled ***Request for Proposals for Long-Term Contracts for Deep-Water Offshore Wind Energy Pilot Projects and Tidal Energy Demonstration Projects***. The RFP was issued in September 1, 2010 with proposals due in May 1, 2011. The University of Maine *Advanced Structures and Composites Center* (AEWC) led the effort to obtain and collect this information in order to facilitate the preparation of successful proposals to the Maine PUC. Funding to collect this information was received primarily from the Department of Energy (DOE), with significant contributions in kind from the University of Maine (UMaine). UMaine is committed to providing additional technical support leading to the most cost-effective floating designs, while minimizing risk, environment impact, and impact on other human activities.

This report includes (1) a summary of available information on the physical characteristics and wind and wave resources in the Gulf of Maine (GoM); (2) a study of potential electric grid interconnection points and offshore electric cabling requirements; (3) an evaluation of permitting requirements, potential environmental impacts and stakeholder considerations; (4) a summary of available construction and assembly resources in Maine; and (5) a summary of economic and policy implications. Section 8 also includes a detailed summary of findings, critical issues for project development, and permitting considerations.

1.1 MAINE DEEPWATER OFFSHORE WIND PLAN – A NATIONAL ELECTRIFICATION MODEL

As recommended by the Maine Ocean Energy Task Force, supported by the Maine Legislature, and announced in the State of the State Address on January 21, 2010, Maine plans to construct a five (5) Gigawatt (GW), $20 Billion network of floating offshore wind farms, 20 – 50 miles offshore. This is part of an electrification strategy to reduce Maine's dangerous reliance on fossil fuels for heating and transportation, and to contribute to the renewable energy needs of the Northeast United States. Maine is the most reliant state on heating oil in the United States, with 80% of Maine families using it to heat their homes. More than residents of any other state, Mainers are exposed to and are negatively impacted by the increasing costs of gasoline and heating oil.

Maine has one of the best offshore wind resources in the United States, with156 GW of capacity within 50 nautical miles (nmi) (Schwartz et al., 2010). On the East Coast, Maine has the deepest waters near its shores, approximately 200 ft deep at three (3) nmi. Of Maine's 156 GW offshore wind resource, 80% resides in waters deeper than 200 feet (ft) (Schwartz et al., 2010). With Maine's plans to construct five (5) GW of deepwater offshore wind, its extensive maritime industry infrastructure, and its proximity to large northeast region energy markets, UMaine was selected in October 2009 through a DOE competition to lead a 35-member university-industry consortium, *DeepCwind*, focused on deepwater offshore wind research and development (See Section 1.2).

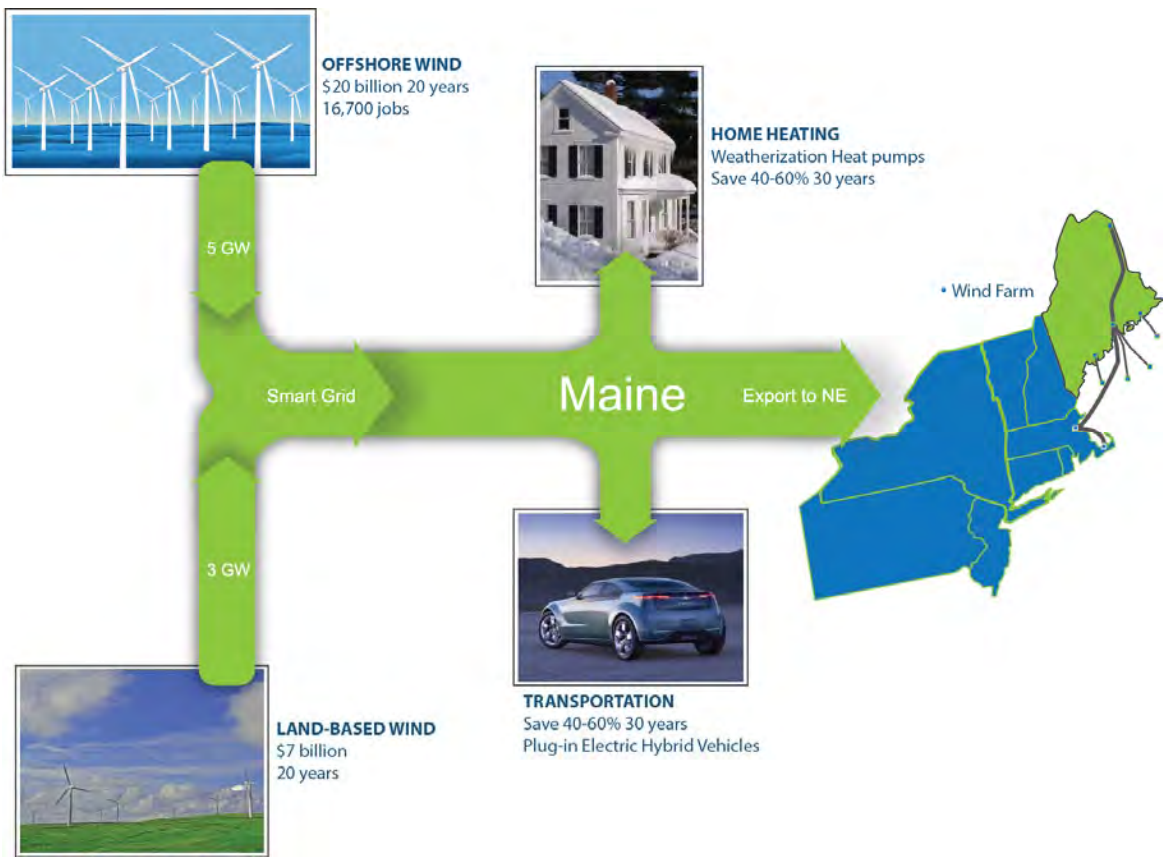


Figure 1-1: The Maine Plan - A National Electrification Model

In addition to five (5) GW of offshore wind development, the Maine Plan envisions the development of a smart grid to address the intermittency of wind, and for gradual conversion to home heating using electricity and to transportation to using electric vehicles (See Figure 1-1). This conversion may save the average Maine family thousands of dollars annually in energy costs by the end of this decade.

Figure 1-2 shows the potential growth in energy cost for the average Maine family as a portion of the total family budget. With the average Maine family using approximately 800 – 1,000 gallons of heating oil annually, the home heating bill is nearly $4,000 per year at $4 – $4.50 per gallon heating oil. At the same price for gasoline, the average Maine family pays approximately $5,000 per year in transportation costs. Including electricity costs (approximately $800 – $1,000 per year per family); energy costs for the Maine family would be approximately $10,000 per year, meaning 20% of the annual Maine family income of $40,000 – $45,000 would be needed to cover energy costs. Offshore wind generated electricity, coupled with electric heat pumps or electric thermal storage units, and enhanced-range electric vehicles, can reduce energy costs well below this level in the next two decades, and help provide a hedge against escalating liquid fossil fuel prices.

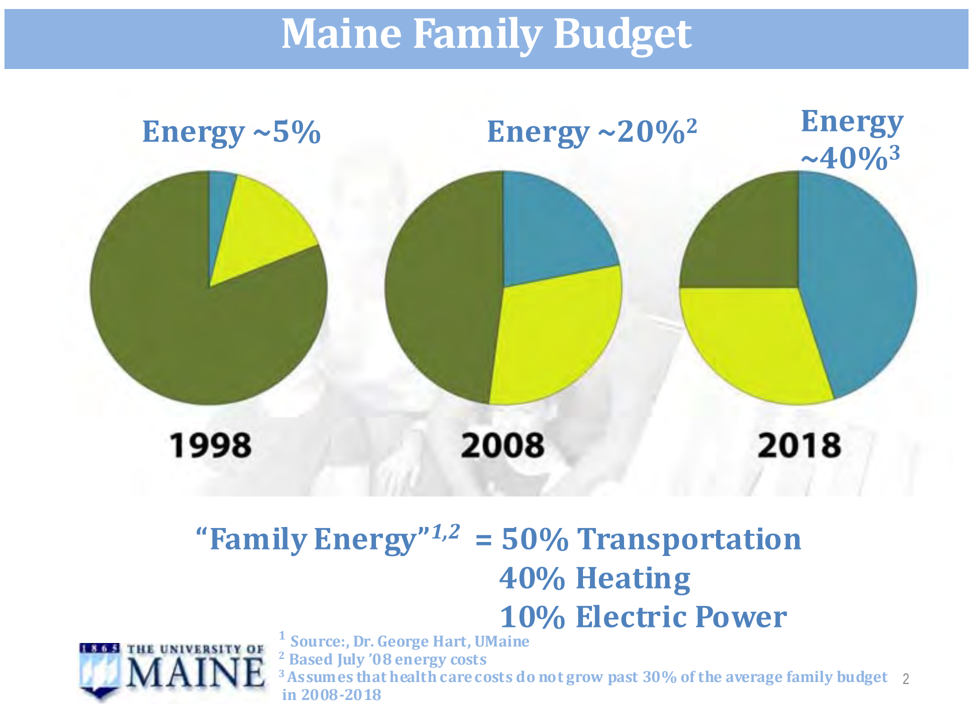


Figure 1-2: Maine Family Energy Costs - Transportation, Heating, and Electricity

Besides reducing the impact of rising prices of gasoline and heating oil, the five (5) GW, $20 Billion Maine Deepwater Plan is estimated to create 7,000 – 15,000 jobs needed to design, build, construct, operate and maintain this vast infrastructure. The number of jobs created will depend on the degree of success in developing the supply chain within the State of Maine. Approximately twice the state budget,

$5 Billion, leaves Maine every year in fossil fuel costs. Keeping just 20% of these dollars in Maine over time by developing Maine's renewable energy sector would mean an additional $1 Billion per year would available to add to the Maine economy, further creating local jobs.

Beyond the Maine interest, floating deepwater wind farms placed 20 nmi or greater offshore can play a critical role in reaching the DOE 20% by 2030 goal, as their related viewshed issues diminish, which have delayed or prevented some nearshore United States projects. In addition, their strategic offshore location can place energy generation closer to the demand of major United States population centers on both the East and West coasts. Likewise, they allow access to a more powerful Class 6 and 7 wind resource; and over time, they reduce wind energy costs by reducing transmission costs from remote land sites, and by simplifying deployment and maintenance logistics. Deepwater wind is the dominant United States ocean energy resource, representing a capacity of nearly 3,000 GW, compared to a United States electricity generation capacity of nearly 1,000 GW.

1.2 UMAINE *DEEPCWIND* PROGRAM AVAILABLE TO HELP DEVELOPERS SELECT FLOATING TECHNOLOGY

The UMaine-led 35-member *DeepCwind* Consortium, funded by DOE in October 2009, focuses on the development of floating offshore wind farm technologies, with an ambitious but achievable goal of reaching eight to ten cents per Kilowatt-hour (8 - 10 cents/kWh) by 2020 at the grid connection point.

The *DeepCwind* Consortium is currently working with DOE's National Renewable Energy Laboratory (NREL) and others to verify coupled aeroelastic hydrodynamic models for floating wind turbines. In April 2011, three 1:50 scale models of different floating wind turbine foundation designs will be tested in a wind-wave basin, and data will be used to refine and validate computational tools. This is the first test of its kind in the world and will utilize fully operational scale wind turbines with pitching blades and different control algorithms.

DeepCwind has also conducted a review of 14 floating foundation designs, as part of an RFP sponsored by the consortium in 2010. A Blue Ribbon Panel (BRP) consisting of personnel from UMaine, NREL, DOE, and representatives from three industry leaders in each of: the offshore sector, heavy manufacturing sector, and heavy construction sector, reviewed and assigned scores to the 14 proposals. The BRP narrowed the field down to seven (7), and used a value-risk evaluation methodology to score and rank the top designs.

The BRP unanimously agreed that there were multiple high-value designs received, and agreed that testing more than one of the leading designs at 1:3 scale would be critical in furthering floating wind turbine technology and allowing model validation across different platform configurations. The University of Maine plans to deploy the leading design at the 1:3 scale in July 2012 off Monhegan Island, and additional designs at the 1:3 scale in July 2013. Data from these tests will be available to help select and optimize the most cost-effective design concept. Optimized designs tested at the 1:3 scale will be available by 2014.

1.3 MAINE DEEPWATER OFFSHORE WIND PLAN

The purpose of this introduction is to put the Maine PUC RFP within the context of the overall Maine Plan for deepwater offshore wind development, and other supporting activities currently ongoing within the State. It is important for developers to understand the overall objectives in Maine, the level of careful planning that the State and UMaine have undertaken for the program to succeed, and the level of support that will be available to them as they embark on a program in Maine. It is telling that two offshore wind bills were passed by the Maine Legislature in 2010 nearly unanimously. It is also telling that Maine voters in June 2010 supported a bond proposal that provided $11 Million for offshore wind research and development (R&D), and this was the highest-ranked bond among many that the voters could select on the ballot.

The PUC RFP is an integral part of a carefully-designed, "walk-before-you-run" plan to deploy five (5) GW of deepwater floating offshore wind, cost effectively 20 – 50 miles off the coast of Maine by 2030**. It is the goal of UMaine and *DeepCwind* to develop floating technology to compete economically ($/kWh) with other forms of energy without subsidies by 2020 and beyond.**

The overall 20-year implementation plan is shown in Figure 1-3, which includes the following five (5) carefully integrated phases:

- Phase 1, ends 2012 – Initial Model validation (Research and Development (R & D)); develop & validate robust design and modeling tools.
- Phase 2, ends 2015 – Design optimization (R & D); develop optimum designs for floating turbines, continue model validation.
- Phase 3, ends 2016 – 25 Megawatt (MW) stepping-stone farm; start with one (1) full-size turbine, then build rest of pilot
- Phase 4, ends 2020 – Expand the 25 MW stepping-stone farm into a 500 – 1,000 MW commercial farm
- Phase 5, ends 2030 – Build a number of 500 – 1000 MW farms reaching five (5) GW by 2030, add Transmission and Distribution (T & D) system

The Maine PUC RFP represents Phase 3 leading to Phase 4 of the plan in Figure 1-3. To the majority of developers, the unknowns of floating offshore wind are many and maybe daunting. However, the 20-year implementation plan is designed to reduce risk, as developers can take advantage of Phases 1 and 2 of the plan, which are currently being conducted by UMaine and its *DeepCwind* R & D partners.

A developer is not expected to have all the answers regarding which floating foundation design to use, or what electricity costs to bid, in time for the May 2011 PUC deadline. Instead, the developer needs to present a plan of how they would get this information, taking advantage of Phases 1 and 2 of the program that are currently ongoing. By the time, a developer signs a contract with the Maine PUC (possibly 2012), the developer has five (5) years to complete the 25 MW farm.

By 2014, UMaine's *DeepCwind* Consortium will have robust modeling tools, validated through 1:50 scale tank testing and approximately 1:3 scale platform testing at the UMaine's deepwater demonstration site off of Monhegan Island. This R&D effort will produce at least one – and possibly more - optimized designs. UMaine is available to work with developers in preparing a proposal to the Maine PUC. This will allow developers to take advantage of the extensive *DeepCwind* Consortium's R&D efforts, the related DOE and state funding, and will significantly reduce technical risks.

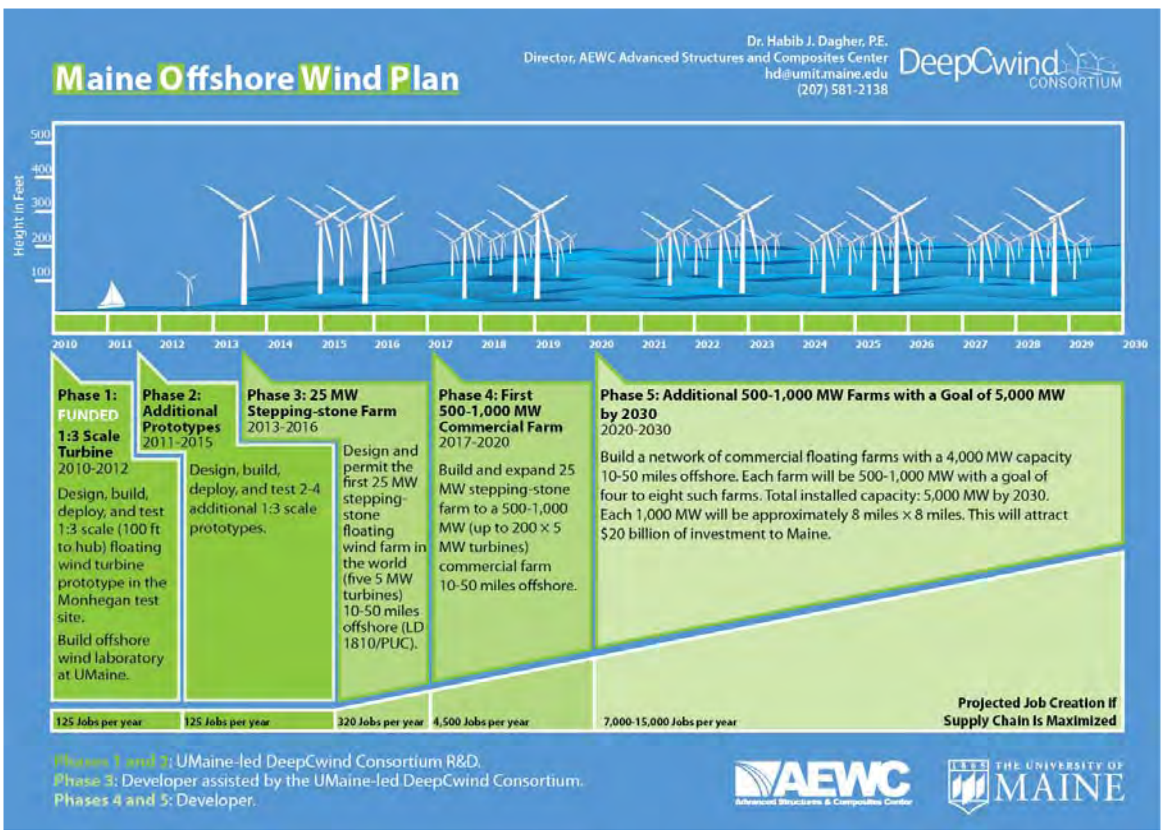


Figure 1-3: A Five-Phase, 20-Year Plan for Deepwater Deployment off Maine's Coast

2.0 Regional Analysis Criteria

One of the first tasks in evaluating the potential development of offshore renewable deepwater wind energy is to establish criteria that would aid in the evaluation and selection of feasible locations for project development. As part of this feasibility study, a regional analysis and evaluation of the potential for developing up to a 30 MW floating offshore wind project in the Gulf of Maine (GoM) was conducted using a set of six (6) screening criteria based on the Maine PUC RFP requirements and general permitting requirements for offshore wind projects. The selected screening criteria included met-ocean data (e.g., wind, waves, and currents), bathymetric data, environmental resource impacts, distance to mainland, distance to grid interconnection and constructability/supply chain. A description of each criterion follows and the key criteria are depicted in Figure 2-1.

2.1 MET-OCEAN CONDITIONS

Met-ocean conditions include information regarding wind, currents and waves. Areas of interest for project development must have a mean annual wind speed of over 8 meters per second (m/s) to ensure commercial viability for offshore wind project development (see Figure 2-1). Wave and current information must be available for areas of interest to provide necessary data for design of floating offshore platforms and other structures. Data required for review of areas of interest include extreme wave measurements, wind and wave measurements, average wind speed data, and oceanic currents at varying depths. For a detailed description of these data and other met-ocean information used in this study, see Section 3.1.

Observations in the GoM consist of the Northeastern Regional Association of Coastal Observing Systems (NERACOOS) buoys, Gulf of Maine Ocean Observing System (GoMOOS) buoys, UMaine, Bowdoin, and University of New England (UNE) buoys, NOAA buoys and NOAA CMAN (land) stations, and Environment Canada buoys. Active NERACOOS and GoMOOS buoys are A01 (Massachusetts Bay), B01 (Western Maine Shelf), E01 (Central Maine Shelf), I01 (Eastern Maine Shelf), M01 (Jordan Basin), and N01 (Northeast Channel). Stations E02 and F01 are the UMaine DeepCwind and UMaine Penobscot Bay moorings. Bowdoin and UNE's moorings are respectively D02 (Lower Harpswell Sound) and C03 (East Saco Bay). NOAA buoys are given designated numbers as follows: 44005 (Gulf of Maine), 44007 (Portland), 44008 (Nantucket), 44011 (Georges Bank), 44013 (Boston), 44017 (Montauk Pt), 44018 (Cape Cod), 44020 (Nantucket Sound), and 44027 (Jonesport). NOAA CMAN (land) stations are given designated lettered names as follows: BUZM3 (Buzzards Bay), IOSN3 (Isle of Shoals), MDRM1 (Mt Desert Rock), MISM1 (Matinicus Rock), and PSBM1 (Eastport). Similar to the NOAA buoys, the Environment Canada buoys are given designated numbers and are as follows: 44258 (Halifax Harbor) and 44150 (LaHave Bank).

2.2 BATHYMETRY

As required by the RFP, offshore pilot project areas must have a minimum water depth of 300 ft (91 m). See Section 3.7 for a description of bathymetric data and resources used in this study. Bathymetric data for the GoM is depicted in Figure 2-1.

2.3 ENVIRONMENTAL RESOURCE IMPACTS

Selection of areas of interest for project development must include choosing sites that will avoid or minimize impacts on the environment, natural resources and human use activities. The process of assessing impacts must cover the offshore wind project area, the construction and assembly area, and the onshore aspects of the project. The following list includes relevant topics for area of interest impact assessment (see Section 5.0 for the impact assessment component of this study).

- Marine and onshore protected areas: federal or state designated areas
- Fisheries: Including lobster industry, commercial fishing, recreational fishing and other fisheries
- Benthic communities (corals): Including threatened and endangered species and fishery resources
- Demersal species: Including threatened and endangered species and fishery resources
- Pelagic species: Including threatened and endangered species and fishery resources
- Marine mammals: Including migratory species and threatened and endangered species
- Sea turtles: Including migratory species and threatened and endangered species
- Birds/bats: Including threatened and endangered species, migration routes, nesting and other important areas
- Visual impact: Including important tourism/recreational areas and neighboring communities
- Sound concerns: For people on the water or on nearby land masses

- Oceanographic effects: Including ecosystem-level impacts
- Communication: Including radars, microwave towers, etc.
- Ship traffic: Including commercial shipping lanes, short-distance freight and ferry routes
- Military activity/restricted areas: Including active military zones, unexploded ordnance areas, etc.
- Aviation: Including coastal airports
- Onshore land use conflicts: Including wetland and vernal pools fill impacts, as well as local zoning and land use permitting
- Cultural heritage/archaeology: Including shipwrecks, lighthouses, etc.

2.4 DISTANCE TO COASTLINE

As required by the Maine PUC RFP, proposed pilot projects must be a minimum of ten (10) nmi from any land area of the State of Maine, other than coastal wetlands or uninhabited islands. For the purposes of this report, this distance is measured from the mean lower low water (MLLW) datum. A ten (10) nmi offset from the coastline is depicted in Figure 2-1.

2.5 DISTANCE TO GRID INTERCONNECTION

Minimizing the distance to the electric grid interconnection, while still complying with requirements for distance to coastline, is particularly important to managing overall development costs. Greater distances translate into longer cable runs along the ocean floor and increased permitting and construction costs. Construction costs increase significantly the greater the distance from the grid interconnection due to increased diameter and lengths of cables and greater transit distances.

2.6 CONSTRUCTABILITY AND SUPPLY CHAIN

Construction and assembly of offshore wind project components (e.g. floating foundations and turbines) requires access to suitable construction facilities and equipment/material/trade supply chains in order for construction to be physically and economically feasible. These nearshore assembly areas need to be closely located to onshore facilities and must have ready access to navigable waters of sufficient depth connecting them to offshore wind project areas. Equipment and resources needed to meet constructability requirements are listed as follows:

- Contractors: Capable and experienced in offshore work, deepwater mooring installation, and subsea cables
- Trades people: Experienced welders, steel fabricators, pipe installers, etc.

- Machinists: Machining companies with wind turbine and energy component experience.
- Mooring systems: Mooring designers and manufacturers
- Cranes: Ranging from under 100 ton to 500 ton with offshore capabilities, onshore cranes available as well at shore facilities
- Barges: Capable of handling crane equipment and other construction activity, short lead time on rental vessels
- Support vessels: Tug boats capable of supporting barge vessels, crew vessels
- Shore support facilities: Dock yards, piers, launching capabilities, etc.
- Staging area: Available land for staging
- Harbor capacity and draft: Must be adequate to accommodate construction equipment, barges and support vessels
- Field office space: Temporary construction field office facilities with communications and office equipment
- Interior work/storage space: Available structures for interior construction work and storage
- Assembly area: Adequate marine assembly area
- Access to rail, highways and roads: Onshore facilities must be accessible by overland means of transport
- Proximity to local storage for components: There must be adequate facilities onshore to store component materials and parts. The local storage must have accessible dock facilities and allow for delivery of components to the assembly area in a timely fashion.

Development and construction of offshore wind projects requires a supply chain that is able to provide, at a minimum, the following in a timely fashion:

- Steel fabrications: Specifically for energy and/or maritime structural applications
- Composites: Access to manufacturing facilities with composite capabilities
- General: Construction materials, supplies and equipment for a complete and successful project.

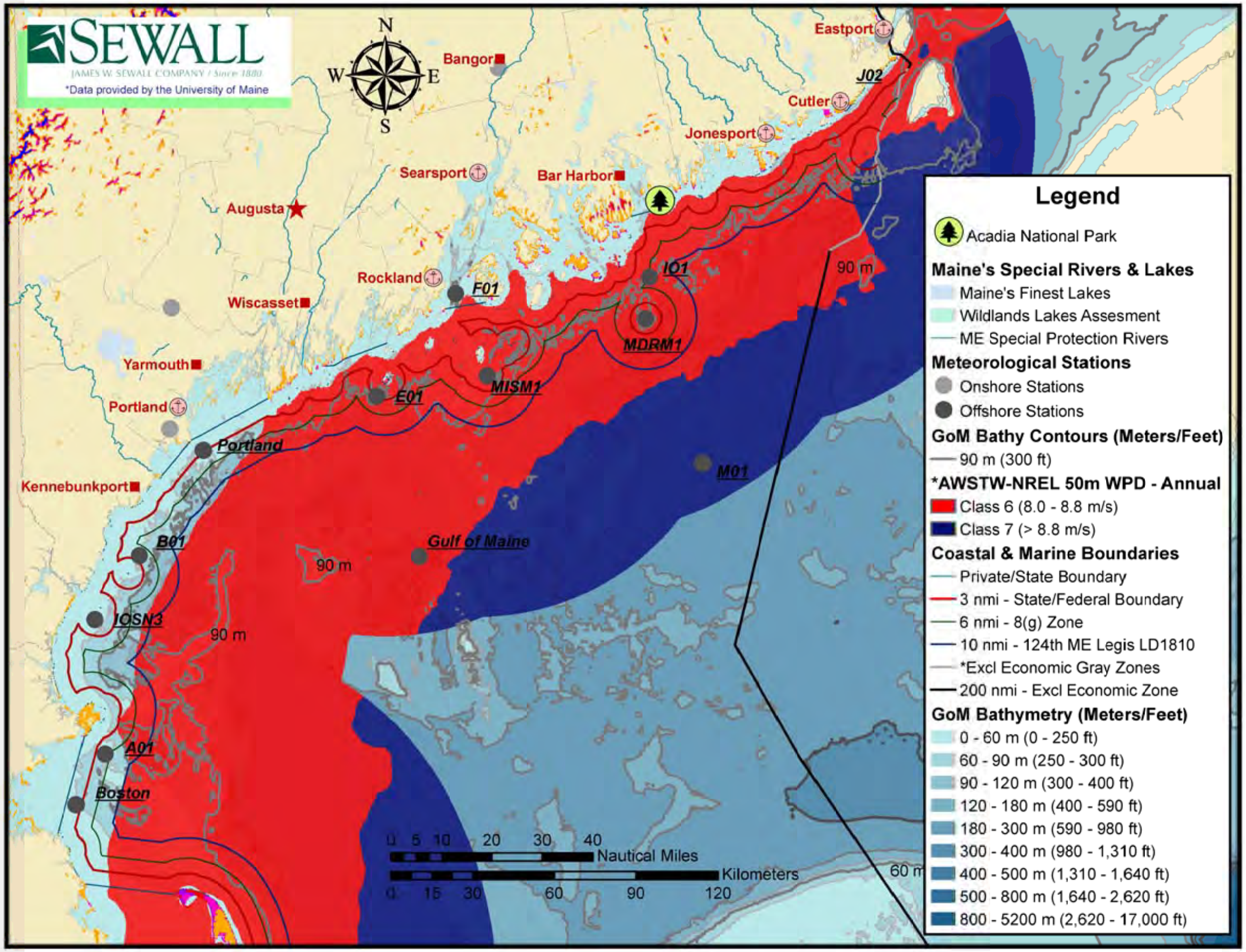


Figure 2-1: Screening criteria for offshore pilot project areas

3.0 Gulf of Maine Resource Information

3.1 MET-OCEAN CONDITIONS

This section summarizes the University of Maine's (UMaine's) analysis of met-ocean data gathered for the GoM. Figure 3-1 shows the location of all buoys and other instrumented sites in the GoM. Table 3-1 lists the sites analyzed as part of this study.

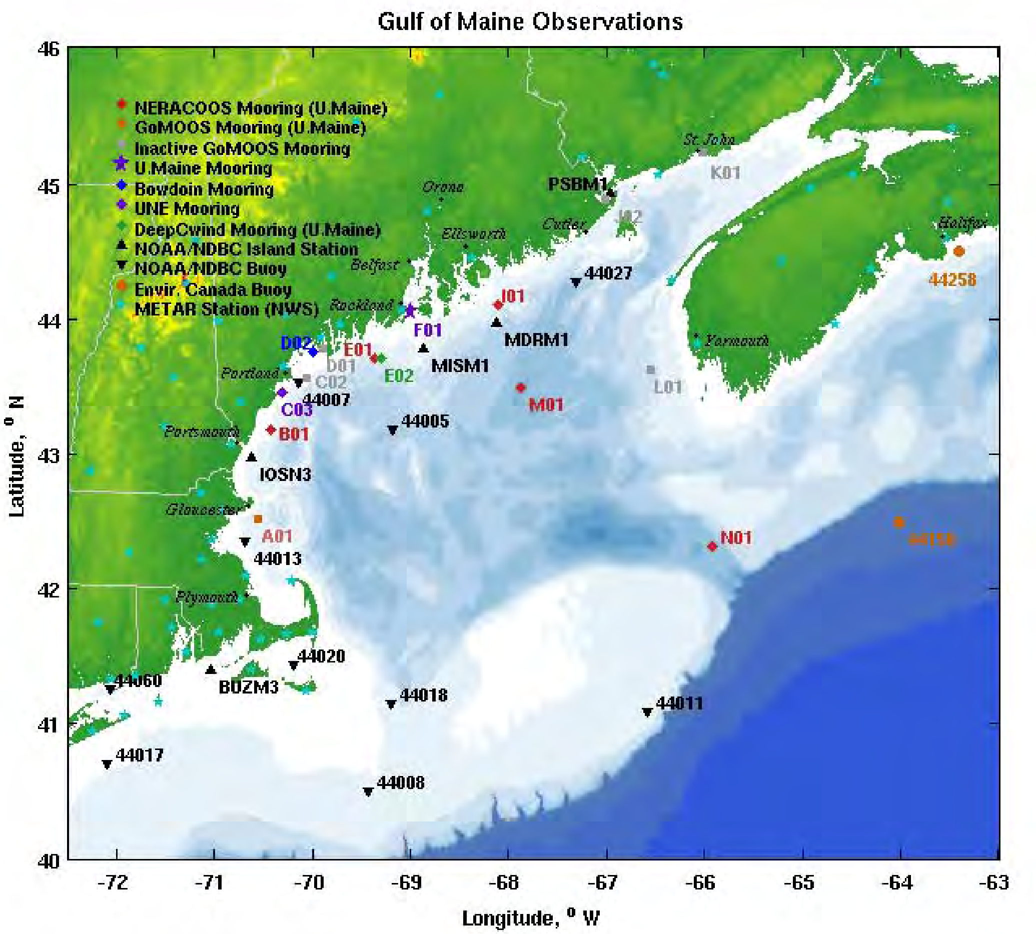


Figure 3-1: Observational buoy network in the Gulf of Maine

Observations in the GoM consist of the Northeastern Regional Association of Coastal Observing Systems (NERACOOS) buoys, Gulf of Maine Ocean Observing System

(GoMOOS) buoys, UMaine, Bowdoin, and University of New England (UNE) buoys, NOAA buoys and NOAA CMAN (land) stations, and Environment Canada buoys. Active NERACOOS and GoMOOS buoys are A01 (Massachusetts Bay), B01 (Western Maine Shelf), E01 (Central Maine Shelf), I01 (Eastern Maine Shelf), M01 (Jordan Basin), and N01 (Northeast Channel). Stations E02 and F01 are the UMaine DeepCwind and UMaine Penobscot Bay moorings. Bowdoin and UNE's moorings are respectively D02 (Lower Harpswell Sound) and C03 (East Saco Bay). NOAA buoys are given designated numbers as follows: 44005 (Gulf of Maine), 44007 (Portland), 44008 (Nantucket), 44011 (Georges Bank), 44013 (Boston), 44017 (Montauk Pt), 44018 (Cape Cod), 44020 (Nantucket Sound), and 44027 (Jonesport). NOAA CMAN (land) stations are given designated lettered names as follows: BUZM3 (Buzzards Bay), IOSN3 (Isle of Shoals), MDRM1 (Mt Desert Rock), MISM1 (Matinicus Rock), and PSBM1 (Eastport). In addition, Environment Canada buoys are given designated numbers and are as follows: 44258 (Halifax Harbor) and 44150 (LaHave Bank).

Table 3-1: Met-ocean data sites analyzed for the feasibility study

Name	Type	Latitude	Longitude	Location	Water Depth	# Years of Data
E01 Central Maine Shelf	NERACOOS Buoy	43°42.86'N	69°21.35'W	SSE of Port Clyde	100 m	9+
F01 Penobscot Bay	UMaine Buoy	44°3.25'N	68°59.87'W	Penobscot Bay	110 m	9+
44005 Gulf of Maine	NOAA Buoy	43°11.37'N	69°8.38'W	78NM East Of Portsmouth, NH	201 m	31+
44007 Portland	NOAA Buoy	43°31.88'N	70°8.65'W	12 NM Southeast of Portland, ME	24 m	27+
MISM1 Matinicus Rock	NOAA CMAN Station	43°47.0'N	68°51.3'W	Matinicus Rock, ME	0 m	25+

More information on the UMaine met-ocean buoys, data acquisition specifics, and data downloads is available at http://gyre.umeoce.maine.edu/buoyhome.php.

3.2 WIND DATA

UMaine has estimated the 8-minute average monthly and annual wind speeds at hub height using the data provided from the buoys in Table 3-1. Since the wind speeds were measured at reference heights different from the hub height, the wind speed was extrapolated to a hub height of 65 m using a power law approximation to the wind speed profile. Currently, there is no data available characterizing the surface to hub wind profile at these sites. The extrapolation was calculated using a power exponent of 0.14 as recommended in IEC 61400-3 Section 6.3, and changing this coefficient will have an effect on the reported wind speeds.

Please note that the exponent value used for the estimated wind speed is commonly used for grassy fields (originally from the 'Kansas' experiments of the late 1960s) and may over-estimate wind speeds. Table 3-2 illustrates other power exponents used in calculating wind speeds at elevation as a function of surface roughness.

Table 3-2: Surface roughness lengths (z_0) and the wind shear exponent (α) (after Manwell et al. 2002; Gipe, 2004; Wizelius, 2007)

Terrain	Surface Roughness Length z_0 (m)	Wind Shear Exponent α
Ice, Smooth mud (BN 0)	0.00001	0.07
Snow on flat ground (BN 1)	0.0001	0.09
Calm sea (BN 2)	0.0002	0.09
Blown sea (BN 3)	0.0005	0.10
Coast with onshore winds (BN 4)	0.001	0.11
Rough snow-covered surface (BN 5)	0.002	0.12
Cut grass – "*Average conditions*"	0.007	0.14
Short-grass prairie	0.02	0.16
Crops, tall-grass prairie	0.05	0.19
Hedges	0.085	0.21
Scattered trees and hedges	0.15	0.24
Trees, hedges, a few buildings	0.3	0.29
Suburbs	0.4	0.31
Woodlands	1	0.43

Note: Relative to a reference height of 10 m (33 ft)

Unlike the other data sources, the land based MISM1 data actually reports the two-minute (2-min) average wind speed instead of an eight-minute (8-min) average. This has been corrected to an eight-minute (8-min) wind speed for comparison following guidelines in ISO 19901-1:2005. Table 3-3 shows the estimated eight-minute (8-min) average monthly wind speeds estimated at 65-meter (m) hub height. Note that the land-based measurements were adjusted from the two-minute (2-min) average wind speed using the ISO 19901-1:2005 methodology.

Table 3-3: Estimated 8-minute average monthly wind speed (m/s) (estimated) at 65 m height

Calendar Month	E01 (m/s)	F01 (m/s)	NOAA 44005 (m/s)	NOAA 44007 (m/s)	MISM1 (Land based)	
					2-min. average (m/s)	8-min. average (m/s) (adj. per ISO 19901-1: 2005)
January	11.4	10.0	12.5	10.1	11.6	11.2
February	11.1	9.5	12.1	9.7	11.0	10.6
March	10.3	9.2	11.1	9.1	10.3	9.9
April	8.1	7.5	9.3	7.9	8.9	8.5
May	7.1	6.7	7.5	6.8	7.9	7.6
June	5.9	5.5	7.0	6.2	7.8	7.5
July	5.4	4.7	6.6	5.6	7.1	6.9
August	5.5	4.9	6.9	5.8	7.0	6.7
September	6.7	6.3	7.9	6.8	7.6	7.3
October	9.0	8.4	9.9	8.5	9.5	9.2
November	10.5	9.5	11.0	9.4	10.8	10.4
December	11.9	10.2	12.4	10.2	11.5	11.1
Annual Avg.	**8.6**	**7.7**	**9.5**	**8.0**	**9.3**	**8.9**
Wind Measurement Height (m)	**4 m**	**4 m**	**5 m**	**5 m**	**22.6 m**	

3.3 WAVE DATA

UMaine examined the monthly average maximum significant wave heights and estimated the extreme significant wave heights for different return periods for the selected sites. Table 3-4 shows the calculated average monthly maximum significant wave heights. These values were obtained by taking the maximum significant wave height seen during a given month for each year and then taking the average.

Table 3-4: Average monthly maximum significant wave heights (m)

Month	E01 (m)	F01 (m)	NOAA 44005 (m)	NOAA 44007 (m)
January	4.6	2.6	5.8	4.2
February	5.0	2.7	5.9	4.3
March	4.8	2.4	5.3	4.0
April	4.8	2.5	4.6	3.9
May	3.7	2.1	3.6	2.9
June	2.9	1.6	3.3	2.3
July	2.3	1.3	2.6	1.8
August	2.2	1.2	3.0	2.2
September	2.9	1.6	3.8	2.6
October	5.1	2.7	4.8	3.7
November	5.8	3.1	5.2	4.1
December	5.8	2.9	6.4	4.7
Average	**4.2**	**2.2**	**4.5**	**3.4**

Table 3-5 lists the extreme significant wave heights at the buoys for different return periods. Extreme significant wave heights were estimated following IEC 61400-3 and ISO 19901-1: 2005 using the historical method. IEC 61400-3 states that maximum individual wave heights may be estimated as 1.86 times the extreme significant wave height assuming a Rayleigh distribution of wave heights and a three-hour (3-hr) storm.

Table 3-5: Extreme significant wave heights (m) and return periods (years)

Return Period (years)	E01 (m)	F01 (m)	NOAA 44005 (m)	NOAA 44007 (m)
1	7.1	3.5	7.4	6.0
5	8.3	4.2	8.9	7.3
10	8.8	4.5	9.6	7.9
25	9.5	4.9	10.5	8.7
50	10.0	5.2	11.1	9.3
100	10.5	5.5	11.8	9.9
500	11.6	6.3	13.3	11.3

Figure 3-2 shows the graph and data used to make the predictions of extreme wave heights using a Gumbel distribution for Buoy E01. The analysis for the other sites is included in Section 3.6.

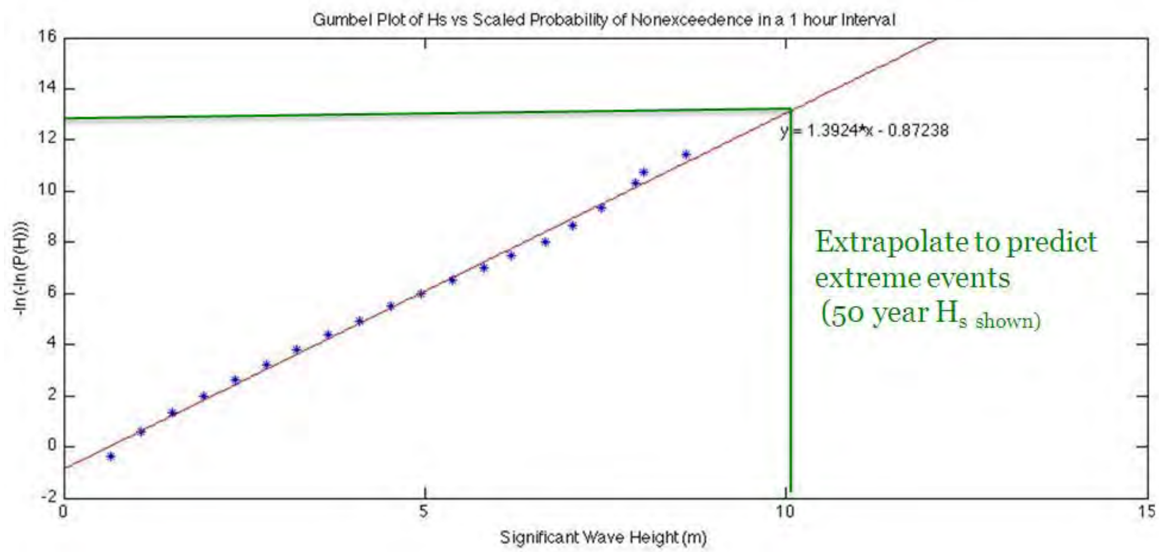


Figure 3-2: Example prediction of extreme significant wave heights (H_s) for Buoy E01 using a Gumbel distribution

3.4 MARINE GROWTH

Anecdotal evidence from the UMaine Physical Oceanography Group (PhOG) and two published studies were found as part of this research on the subject of marine growth. However, the information is not complete for an assessment for marine offshore structures. PhOG provided several pictures illustrating biological fouling of their buoys. Figure 3-3 to Figure 3-6 show some of the fouling and winter icing at the buoys. The general observations from the collection of these figures are as follows:

> *"The spring bloom (very active period of marine growth) usually starts in March or April of each year and then slows down by September/October (growth limited by light, temps, and nutrients). Buoys deployed in the fall and recovered in late winter/early spring typically do not have much growth. However, buoys deployed in the spring and recovered in the fall can have a large amount of fouling (approximately 6" has been seen). The type and amount varies by location and year, depending on currents, nutrients, light, etc."*

Figure 3-3: Buoy E01 summer bio-fouling (September 2006)

Figure 3-4: Buoy E01 summer bio-fouling close-up (September 2006)

Figure 3-5: Buoy E01 winter ice build-up (January 2004)

Figure 3-6: Buoy F01 early spring bio-fouling (April 2008)

UMaine also reviewed available scientific literature on the subject of marine fouling in the GoM. Two studies were found and the locations of the studies are shown in Figure 3-7.

The first study was completed at Pemaquid Point, Maine, in 1989 by Ojeda and Dearborn. The Pemaquid Point study reported that crustaceans, mollusks, and polychaetes were the most prominent, while green sea urchins (*Strongylocentrotus droebachiensis*) and horse mussels (*Modiolus modiolus*) were consistently the most important species in terms of biomass and density. Northern red chitons (*Tonicella rubra*), daisy brittle stars (*Ophiopholis aculeata*), Polychaetes, Northern sea stars (*Asterias vulgaris*), and limpets (*Tectura testudinalis*) were some of the most abundant macroinvertebrate taxa in the area. Various species of barnacles, worms, crustaceans, crabs, mollusks, shrimp, hydroids, bryozoa, and plants, including (*coralline*) algae, and kelp also make up a majority of the permanent marine life population (Ojeda and Dearborn, 1989).

In another study completed at Lamoine, Maine, in 1946 by Fuller et al., quantitative measurements were taken of marine growth on submerged panels. The results of this study for some of the species are summarized in Table 3-6. The thicknesses of the marine growth were not measured. Instead, the number of species per square foot was recorded. Copies of the two journal articles referenced above are included in Appendix A.1 (Section 10.1.1).

Table 3-6: Attachment density of three common sedentary marine organisms at Lamoine, Maine, from 2 June – 25 September 1944 (Fuller et al., 1946)

Blue mussels (Mytilus edulis)			Barnacles (Balanus balanoides)			Worms (Spirorbis spirorbis)		
Depth (ft)	Dates	# organisms/ sq. ft/week	Depth (ft)	Dates	# organisms/ sq. ft./week	Depth (ft)	Dates	# organisms/ sq. ft./week
3	6/18 to 7/9	80	3	6/25 to 8/4	340	15	6/2 to 6/18	0.5
3	7/9 to 8/4	20000	15	6/25 to 7/23	500	15	6/18 to 7/9	12
3	8/20 to 9/3	2000	30	7/9 to 8/4	13400	15	7/9 to 8/4	0 – crowded out by Mytilus
3	9/3 to 9/17	130	NA			15	8/4 to 9/3	575

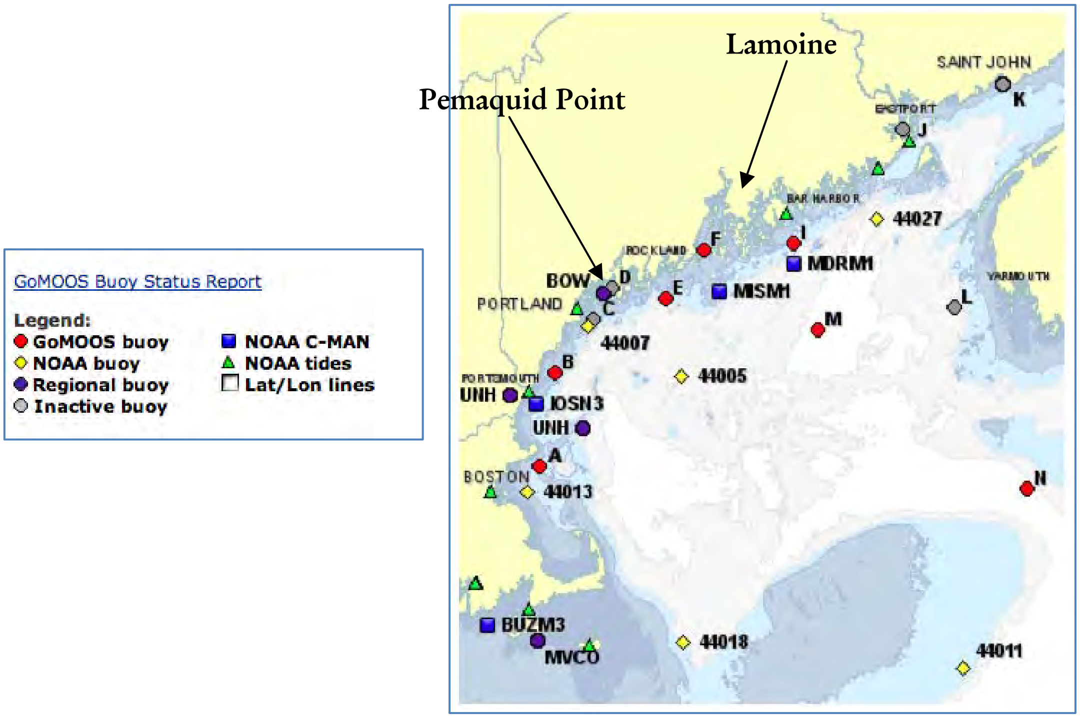


Figure 3-7: Locations of studies of marine growth in the Gulf of Maine

3.5 ICING

The following paragraphs summarize information obtained with regards to icing of marine structures in the GoM. No quantitative data for ice accumulation on offshore structures was found. The majority of the research found is for vessels and thus may predict larger ice thicknesses as compared to a non-moving floating platform.

The American Society of Civil Engineers (ASCE) "Minimum Design Loads for Buildings and Other Structures: ASCE 7-05" publishes design ice thicknesses for the United States. Following Figure 10-2 on p. 104 of this manual for the GoM, the 50-year mean recurrence interval for uniform ice thickness due to freezing rain with concurrent 3-second gust speeds is reported as 25.4 mm. ASCE notes, "ice thickness on structures in exposed locations at elevations higher than the surrounding terrain and in valleys and gorges may exceed the mapped values," so the data provided by ASCE may not be completely accurate for our site. ASCE offers an alternative way to determine the 50-year ice thickness and concurrent wind speed, which involves using local meteorological data that is based on the same recurrence interval. This alternative procedure was completed as part of this study.

According to Godshall (1980), the probability of ice accumulating on the exposed, outer layers of ships at sea depends on the "formation of spray" as well as the temperature of the air and sea. The formation of spray is "dependent on direction of ship travel with respect to direction of wave travel and wave height." Godshall considered wind speed (related to wave height), and air and sea-surface temperature in estimating icing potential. Because ice accretion rate is also dependent on the shape of the surface, Godshall's estimates "refer to general icing conditions over a ship." Godshall's map is divided into one-degree squares of latitude and longitude. Table 3-7 reports values for a location near Buoy E01 in the GoM.

Table 3-7: Superstructure icing potential frequency (percent) at 43° – 44° N, 69° – 70° W, (Godshall, 1980)

Month	Light (1-3 cm/24 hr)	Moderate (4-6 cm/24 hr)	Severe (7-14 cm/24 hr)	Very Severe (≥ 15 cm/24 hr)
November	0	0	0	0
December	14.7	0.7	0	0
January	12.9	2.4	0	0
February	14.3	2.1	1.4	0
March	9.1	0	0	0
April	0.8	0	0	0

Note, no icing potential is expected during the other months of the year; all values are percentages.

NOAA researchers developed a general formula to predict vessel icing at near-freezing sea surface temperatures in Alaskan waters (Overland, 1990). The icing rate depends on the following: wind speed (V_a [m/s]), air temperature (T_a [°C]), sea (surface) temperature (T_s [°C]), and freezing point of seawater (T_f [°C]) with a predictor (PR) given as follows:

$$PR = \frac{V_a\left(T_f - T_a\right)}{1 + 0.4\left(T_s - T_f\right)}$$

The icing rate can be determined using Table 3-8.

Table 3-8: Ice accumulation for vessels (Overland et al., 1986)

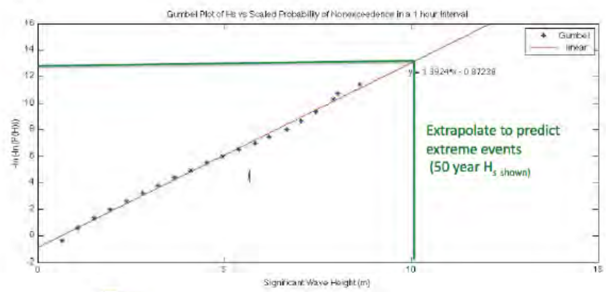
PR (m-°C/s)	< 20.6	20.6 < PR < 45.2	PR > 45.2	PR > 70.0
Description	light	moderate	heavy	extreme
Ice Accumulation (cm/hr)	< 0.7	0.7-2.0	>2.0	NA

3.6 EXTREME VALUE ANALYSIS OF WAVE DATA

Extreme wave height predictions for each of the buoy locations are summarized in Table 3-9 to Table 3-12.

Table 3-9: Extreme wave height prediction for Buoy E01

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method



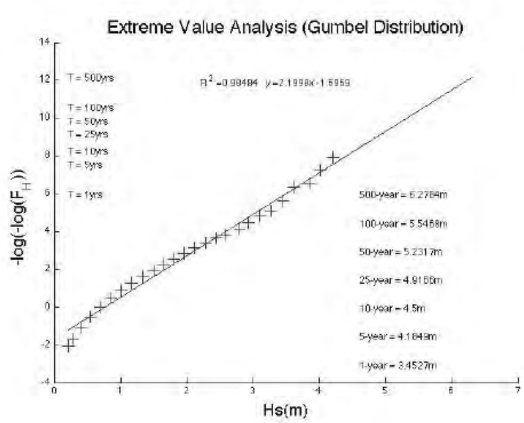
H_{max} =1.86xH_s (m)

"X" year wave	Probability of Non-occurrence in one year	Sig. Wave Height, H_s (m)	Max Individual Wave Height (1.86*H_s) (m)
1	37.0%	7.1	13.2
5	80.0%	8.3	15.4
10	90.0%	8.8	16.4
25	96.0%	9.5	17.7
50	98.0%	10.0	18.6
100	99.0%	10.5	19.5
500	99.8%	11.6	21.6

Compares very well with study by:
Panchang, V.G, Pearce, B.R., and Puri K.K. "Hindcast estimates of extreme wave conditions in the Gulf of Maine". Applied Ocean Research, 1990, Vol. 12, No.1 p. 43.

Table 3-10: Extreme wave height prediction for Buoy F01

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method

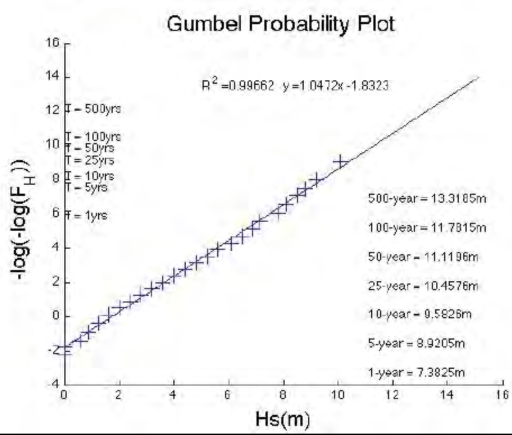


"X" Year Wave	Probability of Occurrence in One Year	Sig. Wave Height, H_s (m)	Max Individual Wave Height (1.86*H_s) (m)
1	37.0%	3.5	6.4
5	80.0%	4.2	7.8
10	90.0%	4.5	8.4
25	96.0%	4.9	9.1
50	98.0%	5.2	9.7
100	99.0%	5.5	10.3
500	99.8%	6.3	11.7

H_{max} =1.86xH_s (m)

Table 3-11: Extreme wave height prediction for NDBC Buoy 44005

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method

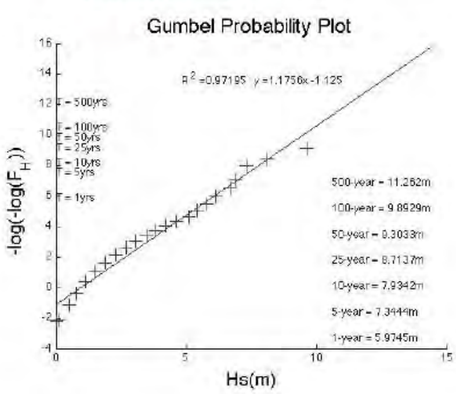


"X" Year Wave	Probability of Occurrence in One Year	Sig. Wave Height, H_s (m)	Max Individual Wave Height ($1.86*H_s$) (m)
1	63.0%	7.4	13.7
5	20.0%	8.9	16.6
10	10.0%	9.6	17.8
25	4.0%	10.5	19.5
50	2.0%	11.1	20.7
100	1.0%	11.8	21.9
500	0.2%	13.3	24.8

$H_{max} = 1.86xH_s$ (m)

Table 3-12: Extreme wave height prediction for NDBC Buoy 44007

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method



"X" Year Wave	Probability of Occurrence in One Year	Sig. Wave Height, H_s (m)	Max Individual Wave Height ($1.86*H_s$) (m)
1	63.0%	6.0	11.1
5	20.0%	7.3	13.7
10	10.0%	7.9	14.8
25	4.0%	8.7	16.2
50	2.0%	9.3	17.3
100	1.0%	9.9	18.4
500	0.2%	11.3	20.9

$H_{max} = 1.86xH_s$ (m)

3.7 BATHYMETRY DATA

The bathymetry data used for this study includes ocean floor contours of the GoM, supplying essential information regarding the underwater topography and water depths. Bathymetry information for this study was obtained primarily from two sources: (1) Digital bathymetry contours for the GoM provided by the United States Geological Survey (USGS), Coastal and Marine Geology Program (CMGP), as part of their studies of the sea floor geology in the GoM and along the New England Shelf; and (2) a field hydrographic survey of a discrete portion of the GoM completed by James W. Sewall Company (Sewall). Descriptions of both data sources follow.

USGS Digital Bathymetry Contours (GOM15CTR): USGS bathymetry data is based on surveys and soundings from at least eight separate sources, supplying data at various resolutions. The resulting dataset is a compilation by Roworth and Signell (1998) of the highest resolution data available throughout the GoM, blended to produce an accurate representation of sea floor topography measured from consistent vertical and horizontal data. The geographic data spans from south of the Cape Cod region to Nova Scotia in the north. This bathymetry data from USGS is available as layers for Geographic Information System (GIS) software at 30-arcsecond (1 km) and 15-arcsecond (0.5 km) resolutions. The 15-arcsecond resolution data was used as the basis of this study due to its detail.

USGS bathymetry water depths are measured in meters from the mean sea level (MSL) datum. In a positive upward coordinate system, these depths are given as negative numbers from MSL. The bathymetry data ranges in depths from zero (0) meters (m) to 5,200 meters (m). The horizontal datum used is the World Geodetic System 1984 (WGS84). The data is presented in 1-meter vertical bins and is not to be used for navigation purposes. Figure 3-8 shows the 15-arcsecond grid bathymetry data for the GoM.

Hydrographic Survey: Sewall performed a field hydrographic survey to provide detail of the bathymetry at a critical depth location within Penobscot Bay. The area surveyed is along a shipping lane that has the potential to be used as tow out route for assembling turbine equipment. Available bathymetric data from USGS did not provide sufficient accuracy or resolution to evaluate the current channel depth and changes in channel morphology.

The survey took place on 18 – 19 August 2010 and was performed by Sewall professional surveyors and using a contracted vessel and captain. The area surveyed measures approximately 1.75 miles by 1.75 miles and is bounded generally between 43°58'00"N and 44°00'00"N, and 68°58'00"W and 69°00'00"W. The survey vessel was outfitted with a Trimble Pathfinder ProXH GPS receiver and Horizon DS50 digital depth sounder, both linked to a data collector, and measurements were taken each second. The vessel traveled in a methodical fashion, with roughly 200 ft between travel passes (see Figure 3-9). The resulting data was then adjusted for tidal fluctuations using a control survey of a known tidal benchmark (Rockland, Maine #8415490) during the same time as the vessel survey. See Table 3-13 for tidal statistics for the Rockland, Maine benchmark. A vertical datum of Mean Lower Low Water (MLLW) was used and depths are shown in meters. Geographic coordinates were recorded in decimal degrees, and then projected to UTM NAD83 coordinates, measured in meters. Depth measurements are accurate to ± 2%, which based on the depths measured in this survey, translates to accuracy of ± 1.2 to 2 meters (m).

Table 3-13: Tidal statistics for Rockland, Maine
(based on NOAA National Ocean Service benchmark tables)

TIDAL STATISTICS	Rockland (8415490)	
	(m)	(ft)
Highest Observed Water Level	4.319	14.17
Mean Higher High Water (MHHW)	3.223	10.57
Mean High Water (MHW)	3.100	10.17
North American Vertical Datum 1988 (NAVD88)	1.751	5.74
Mean Sea Level (MSL)	1.624	5.33
Mean Tide Level (MTL)	1.609	5.28
Mean Low Water (MLW)	0.119	0.39
Mean Lower Low Water (MLLW)	0	0
Lowest Observed Water Level	-0.795	-2.61

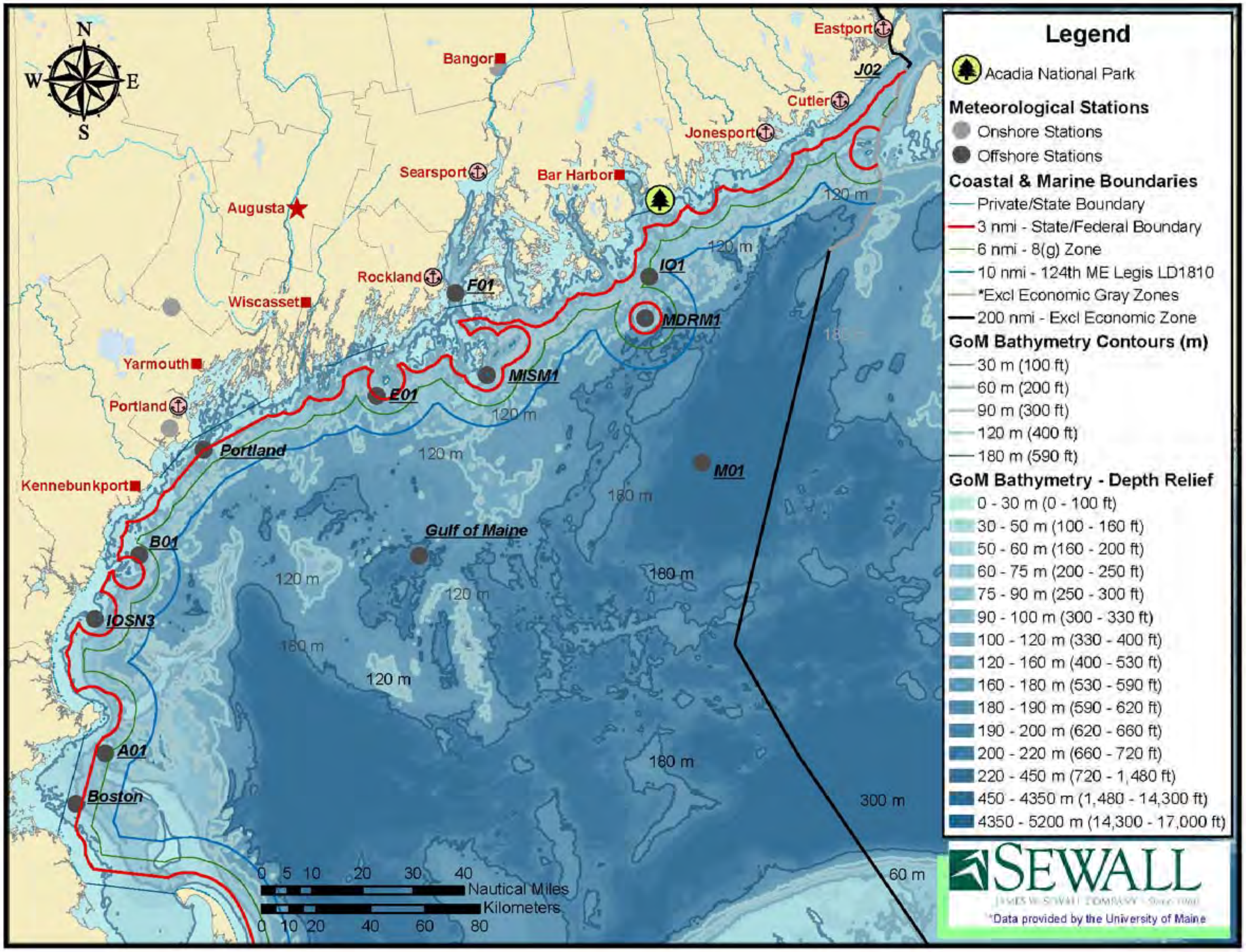


Figure 3-8: Gulf of Maine bathymetry and marine boundaries

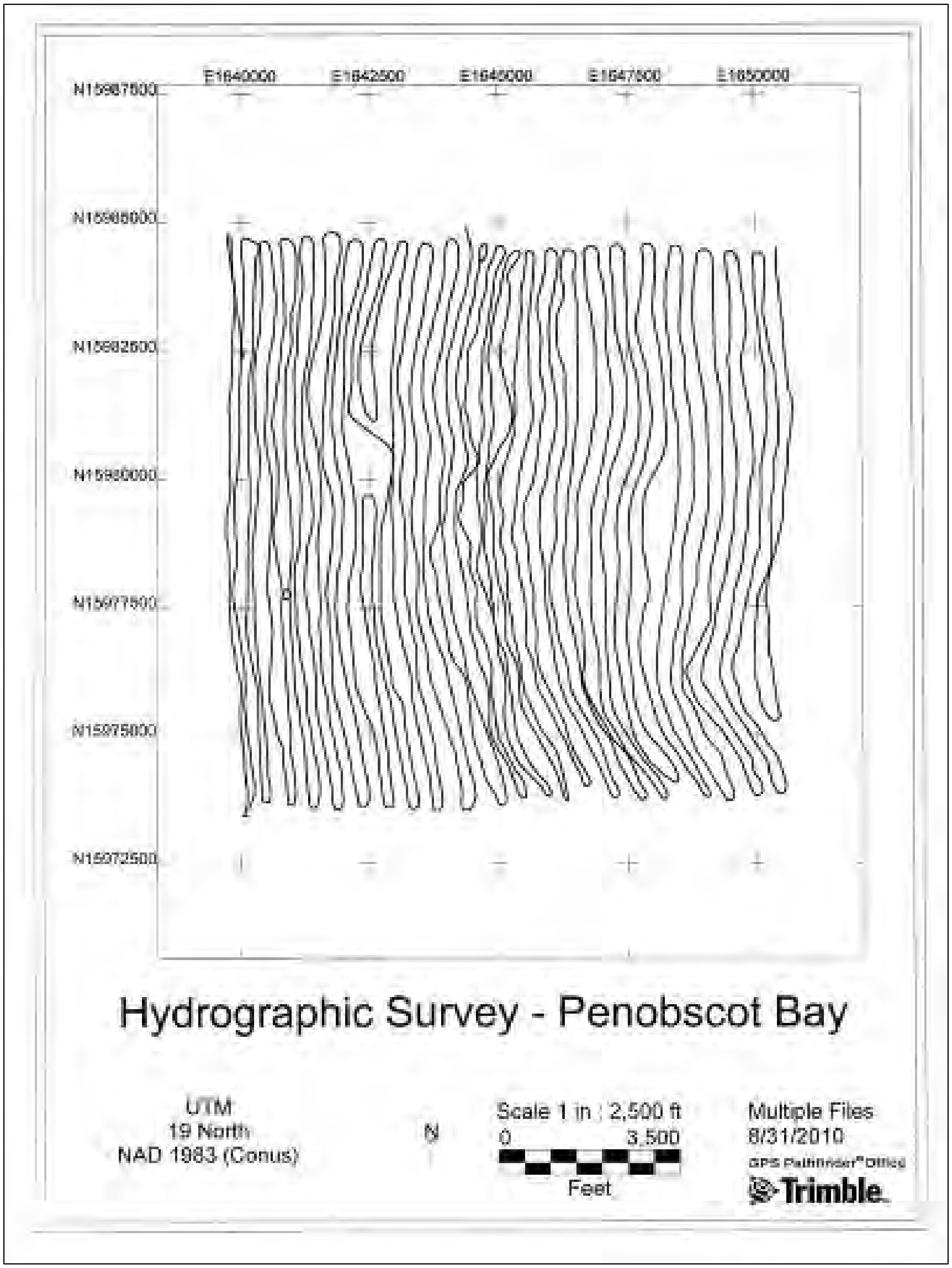


Figure 3-9: Hydrographic survey vessel track (August 2010)

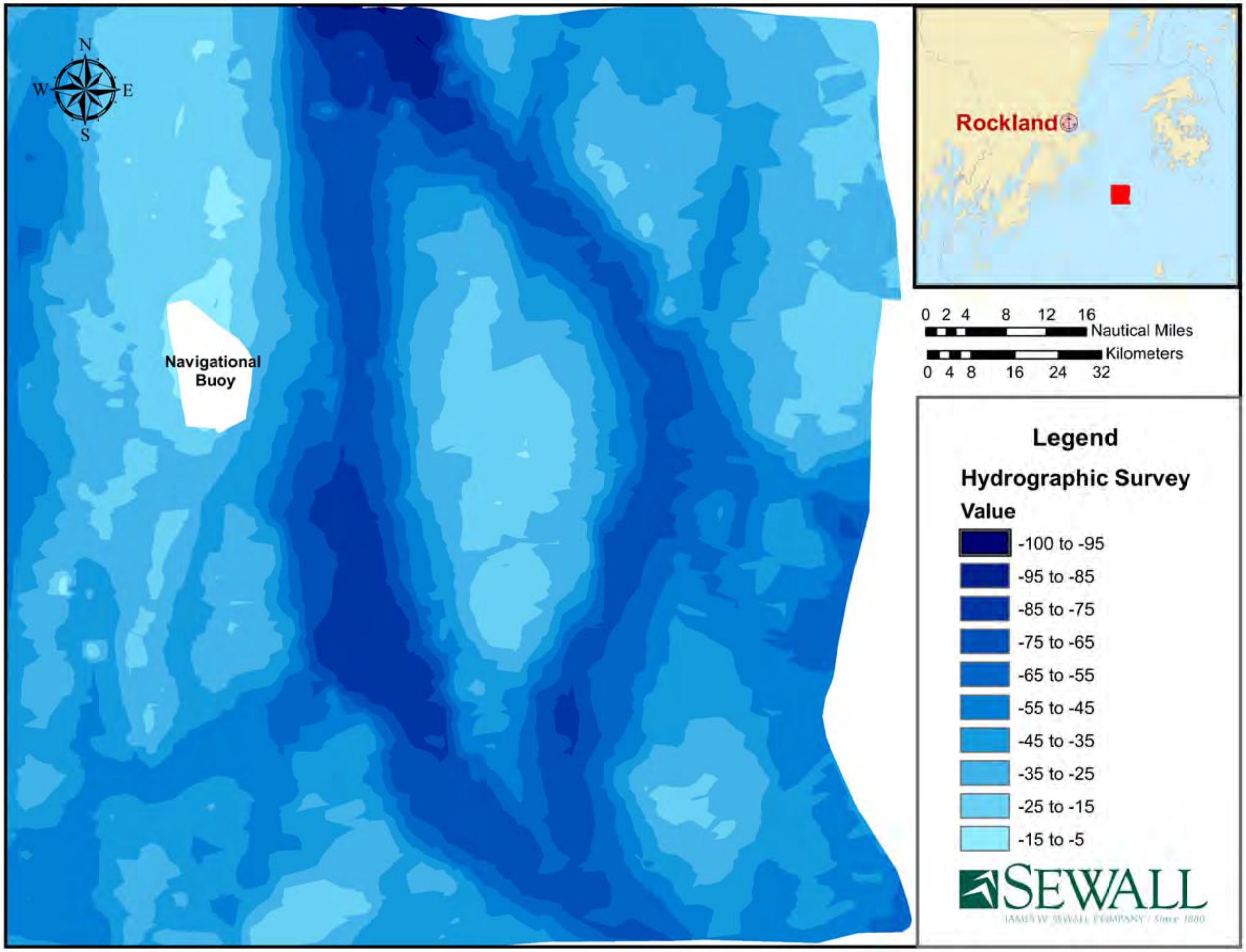


Figure 3-10: Measured depths (m) from August 2010 hydrographic survey

3.8 MARINE GEOLOGY OF THE MAINE INNER CONTINENTAL SHELF

The geology of the Maine inner continental shelf is controlled by three factors:

1) bedrock composition and structure;
2) glacial deposits; and
3) modern processes including changing sea level.

The bedrock consists of many distinct terrains of differing ages, compositions and structures (van Stall et al., 2009). These have undergone differential erosion for hundreds of millions of years so that rocks resistant to erosion (intrusive or "granitic" rocks) remain as islands, peninsulas and shoals, while those rocks more readily eroded underlie bays and deeper basins. As a rule, the topography of the coastal zone is a reasonable guide to what the adjacent seafloor is like (Kelley et al., 1998). Off the central coast, shoals continue seaward of the many peninsulas of the region with deeper basins seaward of estuaries. Shallow, highly irregular seafloor surrounds granitic islands, and paleo-fault zones are often linear bays or basins.

Glaciers sculptured weak rocks and accentuated their topographic/bathymetric expression. They also deposited material over the bedrock. The main glacial deposits include till and fine-grained glacial-marine sediments (i.e., glacial-marine mud). Till is a mixture of many rock types and sizes and occurs as patchy deposits of widely varying thickness (0-30 m) and in elongate moraines that once paralleled the ice margin (Kelley et al., 1998; 2008). Glacial-marine muddy sediment is the most common deposit in the GoM. It is often highly laminated with alternating mud and sand layers and is rock flour that blanketed the landscape seaward of melting glaciers.

Sea level changed profoundly because of deglaciation. As the ice melted back, its weight depressed the land and marine waters accompanied ice retreat and accommodated deposition of the glacial-marine muddy sediment. Once the ice melted, the land rebounded and the shoreline fell to -60 m depth around 12.5 ka (Kelley et al., 2010). Since then, sea level has risen at an irregular rate to the present time.

The changes in sea level allowed sediment deposition from rivers well out onto the present continental shelf (Kelley et al., 2003; Belknap et al., 2005). The passage of the shoreline across glacial deposits also led to their erosion and re-deposition of their sediment as beaches, tidal flats and other deposits. The time/depth interval between 11.5 ka and 7.5ka/ 25 m and 15 m (respectively) was one of very slow sea-level rise and, hence, relatively complete erosion of glacial sediment along with extensive deposition of the reworked sediment (Kelley et al., 2010). Abundant shallow water deposits also accumulated on the shelf at that time/depth and are occasionally associated with early human remains.

The surficial sediment distribution resulting from the complex bedrock and glacial history is very heterogeneous and complex. Kelley et al. (1998) suggested that on the basis of almost 2,000 bottom samples and more than 5,000 km of seismic reflection and side scan sonar profiles a simplified description of the shelf involves only 6 map units defined by bathymetry and surficial sediment. This is illustrated in Figure 3-11 for the inner continental shelf in central Maine.

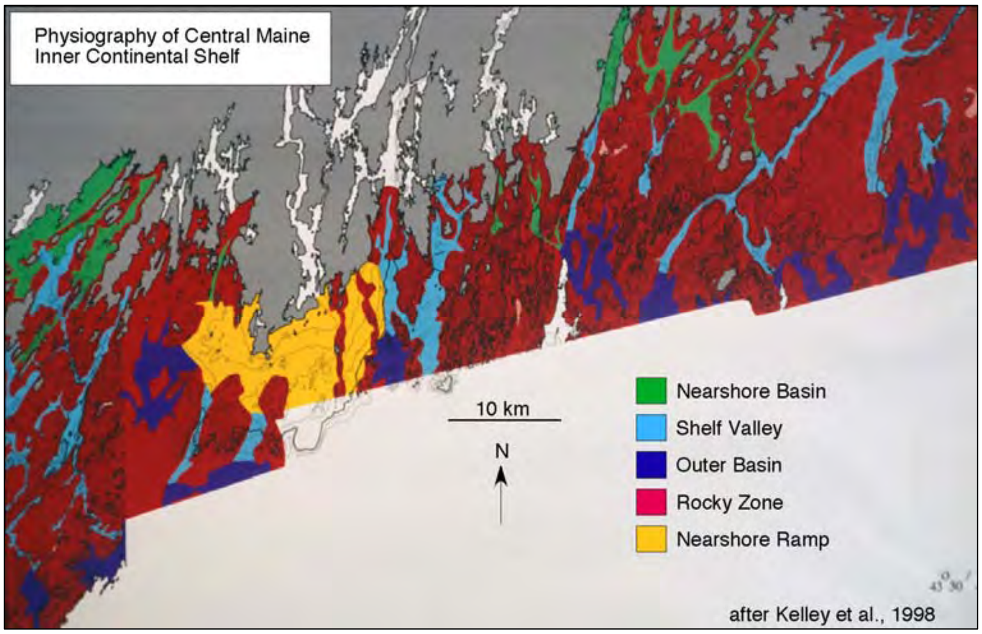


Figure 3-11: Central Maine inner continental shelf physical geology (after Kelley et al., 1998)

1. **Nearshore Ramps** occur seaward of large beaches and often represent the remains of deltas from a time of lower-than-present sea level. The seafloor is composed of well-sorted sand and gravel and bathymetric contours are widely spaced and subparallel to one another. Bedrock occurs randomly through these areas, which are largely in the southern half of Maine. The surficial sand deposit is wedge shaped, commonly thickening to as much as 5 m near land.
2. **Nearshore Basins** are muddy areas seaward of the numerous tidal flats and bluffs of glacial-marine sediment found north of Portland. The seafloor tends to be relatively flat and the mud deposits can be more than 50 m thick. Bedrock crops out within the basins and typically follows the trend of rock ridges on land.
3. **Rocky Zones** are generally shallow areas (< 50 m water depth) underlain by exposed bedrock or coarse-grained glacial deposits (moraines). They comprise almost 50% of the inner shelf and represent locations where younger sediment was eroded as sea level passed over the shelf twice (falling and then rising).

They are common seaward of peninsulas and surrounding islands, but occur in all depths of water. Bathymetric relief in excess of 5 m occurs commonly over short horizontal distances in Rocky Zones. Gravel is the most common sediment type in these areas.

4. **Shelf Valleys** are elongate bathymetric depressions that typically extend seaward from Nearshore Basins into the deeper GoM. Their origin is unclear, but they occur seaward of every embayment in Maine. They are sometimes filled in and only recognized on seismic reflection profiles, but often are steep-sided and possess up to 50 m of relief cut into bedrock in some places. They are commonly floored by sand and gravel.
5. **Outer Basins** occur seaward of the 40-m isobath and are relatively flat regions covered with mud. Many Shelf Valleys terminate in Outer Basins, which may represent the depositional sink of the Valley systems. Rock and gravel can occur in the Outer Basins, but mud is dominant in these quiet, deep water areas that experience little wave activity or erosion.
6. **Hard-Bottom Plains** (not shown in Figure 3-11) are only found in the most eastern part of the inner shelf, but they occur at all water depths. These are bathymetrically flat areas with gravel up to boulder size strewn across the seafloor. Their eroded appearance and occurrence near the opening of the Bay of Fundy suggest that tidal currents eroded and formed the Hard-Bottom Plains.

3.9 MARINE GEOHAZARDS

A geohazard is a geological state related to present or past geological conditions and/or processes that represent, or have the potential to develop, a situation leading to damage or uncontrolled risk (Offshore Geohazards, 2010). Offshore geohazards such as submarine landslides, gas build-up and earthquakes have the potential to impart unnecessary risk to offshore infrastructure if inadequately assessed, mitigated and managed. In the GoM, geologic features having the potential to result in geohazards are related to gassy seafloor sediments and earthquakes.

3.9.1 Seafloor Gas

A systematic side-scan sonar, seismic reflection, and bathymetric geophysical mapping program covering more than 1,900 square miles has identified biogenic natural gas in more than 120 square miles of the western GoM's nearshore, muddy embayments (typically less than 300 ft of water depth) and within the deep basins of the GoM (Rogers et al., 2006; Uchupi and Bolmer, 2008). Gas, where found offshore of Maine, is typically in thickly deposited modern mud and does not occur in quantities economical for energy capture. While the presence of gas is not fully understood, it is likely the result of decomposing organics deposited when sea level was much lower than present.

The presence of gas is not identifiable by imaging the seafloor or bathymetric data, however seismic reflection surveys and an experienced interpreter can identify if it is likely present or not. The one case where evidence of gas at the seafloor occurs is from pockmarks. Pockmarks are massive seafloor depressions associated with fluid (e.g., gas or water) escape (Figure 3-12). Where formed, pockmarks significantly alter the seabed and form fields of numerous (hundreds to thousands) hemispherical depressions that can be up to hundreds of meters in diameter and tens of meters deep (Rogers et al., 2006). Brothers et al. (2010) discuss hypotheses surrounding pockmark formation in the muddy embayments of Maine, and conclude they most likely form "episodically with changes in environmental conditions such as changes in ocean temperature, storm- or tsunami-related sea-level changes, or by physical vibration from earthquakes or other sources." Little evidence is reported for recent formation and activity.

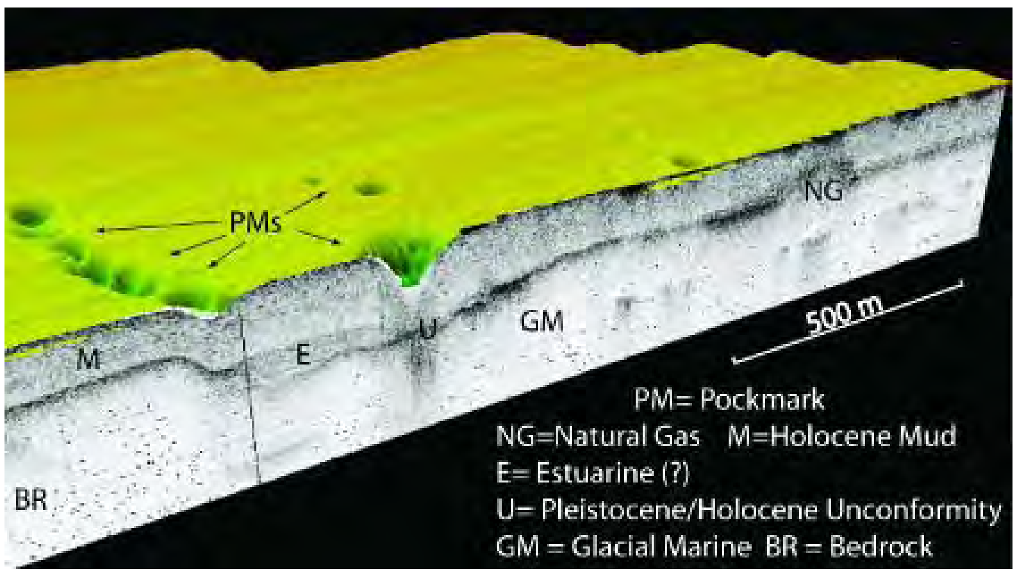


Figure 3-12: Combined bathymetric and seismic reflection data illustrating seafloor sediment layering and the pockmark surface features (Andrews et al., 2010)

Pockmarks have been observed regularly in regions surrounding gas deposits in Maine's inner continental shelf regions (Brothers et al., 2010). Regions where gassy sediment and pockmarks associated with gassy sediment have been identified are shown in Figure 3-13, which include Penobscot, Blue Hill and Passamaquoddy Bays as well as other locations.

Much of the existing offshore geohazards knowledge is for water depths less than 100 m, corresponding to the area of extensive study of Maine's inner continental shelf geology. This is shallower than most of the area relevant for floating offshore wind development. Small pockets of gassy sediments, likely from organic matter decomposition, have been identified as far offshore as southwest of Monhegan Island, more than ten (10) miles from the mainland.

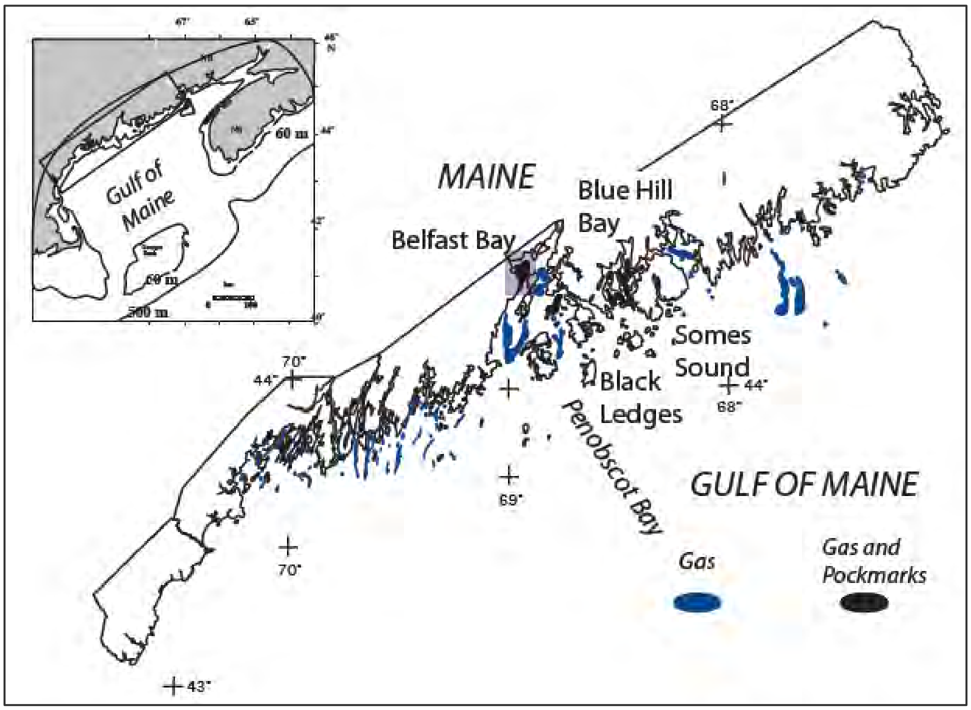


Figure 3-13: Maine shoreline with natural gas fields where gas only is shaded blue and black represents gas and pockmarks (Brothers et al., 2010, modified following Rogers et al., 2006)

What does the presence of gas mean for development? Marine sediments containing gas are often more compressible and have weaker strengths than non-gassy sediments, which is dependent on gas pressure and past and present sediment loading (Sills and Gonzalez, 2001). Gas also has the potential to migrate along the interface of structural elements in the seafloor, thereby compromising or eliminating their ability to withstand loading. Avoidance of gas is optimal. However, there are numerous examples in offshore oil and gas development of successful mitigation and management of the effects of seafloor gas at development sites upon discovery, both pre- and post-construction.

Identification of the presence of seafloor gas will be possible through geophysics surveys conducted as part of any routine site investigations required for offshore development. It is unlikely that deepwater development tens of miles from Maine's coast will encounter significant amounts of seafloor gas, due to the limited impact of sea level changes and low rates of organic material deposition. The most significant impact it is likely to have for development along the inner continental shelf relates to locating pipelines or cables. Pockmark fields have a highly variable seafloor, which may require meandering cable/pipe routes or leave lengths of cable/pipe unsupported.

3.9.2 Earthquakes

The Maine Geological Survey has cataloged most of the recorded earthquakes that have occurred between 1814 and 2002 (Berry and Loiselle, 2003). Additionally, earthquake monitoring in the New England states is performed by the Weston Observatory at Boston College, as well as the United States Geological Survey (USGS). In the last century, earthquakes with Richter scale magnitudes as great as 4.9 have occurred on land and offshore, with a recent 2006 event near Bar Harbor, Maine, with a Richter magnitude of 4.2.

Maine is located within the North American plate and experiences "intraplate" earthquakes, not plate boundary earthquakes like those that occur in California, which cannot be correlated with known faults. Generally, Maine earthquakes seem to break on a different fault every time, many of which are unmapped (Berry and Loiselle, 2003). Mapped faults in Maine have not been found to demonstrate recurring movement that leads to earthquakes. The impact of this geohazard is likely minimal. Routinely, offshore development projects include seismic risk analyses that would mitigate concern for this geohazard.

3.10 SURFICIAL SEDIMENTS

The uppermost layer of sediment along the ocean floor is referred to as surficial sediment, and provides critical information for any structure either resting on or embedded into the seabed, including anchoring systems. The surficial sediment data used in this study includes location, description and texture of samples that have been collected by numerous marine sampling programs. Textural and descriptive data may include grain-size analyses, silt or clay content, and lithology of rock samples encountered.

This feasibility study uses the following sources for surficial sediment information: USGS East Coast Sediment Texture Database; USGS Continental Margin Mapping (CONMAP) sediments grain size distribution for the United States East Coast Continental Margin; USGS BARNHARDT: Maine Inner Continental Shelf Sediment Data; and Maine Geological Survey (MGS) Surficial Geology of the Maine Inner Continental Shelf map series. These data sources are further described in the subsections below. A brief summary of the datasets may be found in Table 3-14.

Table 3-14: Surficial sediment dataset summary

Name	Description	Horizontal Datum	Vertical Datum	Accuracy
USGS East Coast Sediment Texture Database	Location of sediment samples throughout the world – mostly in Atlantic Continental Margin (US). Texture data available for some samples. GIS points layer.	NAD27, decimal degrees	Unadjusted water depth at time of sample, meters	Horizontal accuracy varies
USGS CONMAP	Maps of sediment classifications based on grain size distributions. GIS polygon layer.	NAD83, decimal degrees	NA, no elevation information	Boundaries inferred, use for general trends not small scale analysis
USGS BARNHARDT	Sediment sample data from the northwestern Gulf of Maine inner continental shelf. GIS points layer.	NAD27, decimal degrees	Water depth, meters	Horizontal accuracy varies from ±10 m to ±100 m
MGS Surficial Geology of the Maine Inner Continental Shelf	Map series showing generalized surficial geology areas along the Maine inner continental shelf. Digital static maps (pdf).	NAD27, decimal degrees	NOS Bathymetric Maps (datum not explicitly noted)	Horizontal accuracy varies from ±10 m to ±100 m

3.10.1 USGS East Coast Sediment Texture Database (ECSTB2005)

The USGS East Coast Sediment Texture Database (ECSTDB2005) includes information on the location, the description, and the texture regarding all sediment samples that were processed at the USGS Woods Hole Coastal and Marine Science Center (WHSC) Sediment Laboratory through November 2004. Samples are located from around the world, but are mostly concentrated in the Atlantic Continental Margin of the United States. This GIS data was derived from an Excel spreadsheet containing the accumulated results of surficial sediment analyses, and converted into a points layer for use in GIS software.

The horizontal datum is the North American Datum 1927 (NAD27), measured in decimal degrees; however due to different systems, datums and navigational equipment, positional accuracy of the samples in this dataset varies. Vertical depths of water overlying sediment samples are available for individual samples, measured in meters; depths have not been adjusted for tides and were measured at time of sampling. Top and bottom depths of the sample, measured from sea floor surface, are reported in centimeters.

3.10.2 USGS Continental Margin Mapping Sediment Grain-Size (CONMAPSG)

CONMAPSG is the USGS Continental Margin Mapping (CONMAP) program focusing on mapping sediment grain size distributions for the U.S. East Coast Continental Margin, analyzed at WHSC from 1962 to 2005, and is presented in a graphical form. Sediments were classified using the Wentworth (1929) grain-size scale and the Shepard (1954) scheme of sediment classification. Some grain-size categories were combined due to the paucity of some sediment textures, while empty regions of the maps indicate areas where data was insufficient to infer sediment type. Graphical data include broad-scale boundaries of sediment classifications, based on grain size distribution, for dominant sediments along the East Coast Continental Margin of the United States, extending from just south of Florida to Nova Scotia. The horizontal datum is the North American Datum 1983 (NAD83), measured in decimal degrees. There is no vertical data associated with this dataset. The data was published in 2005 in GIS shapefile format.

Maps depicted from this data should be used as a general overview of textural trends in sediment, as they do not accurately reflect small-scale sediment distributions or sea-floor variability. Boundaries between sediment types should be viewed as inferred and not absolute, as actual boundaries may be highly irregular or gradational. USGS also used bathymetric data to provide additional support for probable sediment type transitions.

3.10.3 USGS Maine Inner Continental Shelf Sediment Data (BARNHARDT)

Localized to the inner continental shelf in the northwestern GoM along the coast of the State of Maine, the BARNHARDT dataset is a compilation of data collected by UMaine, produced in connection with the Maine Geological Survey, and published by USGS in 2003. It consists of information for over 1,700 sediment samples, including grain size data, locations, and textural classifications. Data was used to create a points layer for use in GIS software.

The horizontal datum is NAD27, measured in decimal degrees. Horizontal positional accuracy of the data varies from +/-10 m to +/-100 m, due to the use of various navigation apparatuses, and is not differentiated on the individual sample locations. Water depths are recorded in meters for individual samples; however a vertical datum is not specified.

3.10.4 Maine Geological Survey Surficial Geology of the Maine Inner Continental Shelf

The surficial geology map series of the Maine inner continental shelf was produced by Maine Geological Survey (MGS) in 1996 (Barnhardt et al., 1996) and depicts generalized mapping of dominant surficial geology. Sediment sample locations and oceanic features, such as identified shipwrecks, are noted on the map series. The maps also include short descriptions of the sediment types and their general locations. This map set is complimented by The Seafloor Revealed (Kelley et al., 1998), a book that describes surveys and data analysis leading to the understanding of surficial and stratigraphic geology of the inner continental shelf of Maine. Copies of these maps may be found in Appendix A.3 (Section 10.1.2) or at the following web address: http://www.maine.gov/doc/nrimc/mgs/pubs/online/ics/ics.htm/ .

The maps are based on seismic reflection and side-scan sonar geophysical data, bottom samples, National Ocean Service (NOS) provisional bathymetric maps, published nautical charts. The maps are supplemented with bottom photographs and direct observations from submersibles. The map series are available publicly only as digital static maps. Basic bathymetric contours are shown on these maps, however it is noted that these contours may not be reliably accurate for navigation due to digitization methods and potential interpretation errors. Accurate bathymetry data used for this feasibility study is described in Section 3.7 of this report.

The maps use a horizontal datum of NAD27. Horizontal accuracy varies from +/-10 m to +/-100 m, due to differences of equipment and navigation. The vertical datum is based on NOS bathymetric maps and not explicitly noted.

3.11 OFFSHORE WIND ENERGY GEOGRAPHIC INFORMATION SYSTEM (OWEGIS) DATA STATUS AND UPDATES

The Offshore Wind Energy Geographic Information System (OWEGIS) was created and developed by Dr. Susan Elston at UMaine and was implemented and refined through a partnership between UMaine and Sewall. This partnership combined the scientific expertise and resource capabilities of UMaine with Sewall's understanding of state and federal permitting regulations, wind energy development, and Geographic Information System (GIS) expertise. This public-private collaboration produced a comprehensive, integrated ecosystem-based information system for use in siting, planning and permitting offshore wind energy in the GoM. OWEGIS was created with the intent to collect, analyze, and graphically display information to assist in planning, permitting, and development of offshore wind energy in the Gulf of Maine in a transparent manner. ***N.B.*** **The information contained in OWEGIS reflects the current state of knowledge and should not be considered the final authority on continuously evolving data, data sources, or on-going scientific studies; and, it does not reflect any position within or external to the University of Maine.**

Areas encompassed by the OWEGIS system include coastal and marine areas from Nantucket, Massachusetts to the Bay of Fundy. OWEGIS was used to leverage the power of GIS technology and geospatial data analysis for the purpose of resource assessment and site selection. The assessment and site selection process consisted of identifying key assessment criteria across various stakeholders in evaluating regions of interest for offshore wind development.

OWEGIS was designed to be a flexible geospatial database system that could easily accommodate continuously evolving spatial and temporal data as well as be easily modified to address stakeholder needs. The comprehensive multi-faceted OWEGIS information system currently has over 450 data layers derived from public and private sources, including traditional GIS data, discrete observational data, and value-added data. For clarity, these layers have been subdivided into five principle areas by theme: (1) physical characteristics/physical environment, (2) coastal restrictions and marine hazards, (3) human activity impacts, (4) infrastructure and commercial uses, and (5) legal, technical, and permitting boundaries. The human activity constraints are further subdivided into three equally important areas: (3a) coastal economic and extractive resource uses, (3b) cultural and aesthetic qualities, and (3c) ecological-environmental impacts and wildlife (see OWEGIS reference information in Appendix A.4). The guiding principle for selection of pertinent assessment criteria and data layers was identifying the key state and federal legislation affecting the use and management of submerged lands and the outer continental shelf (see Appendix A.4). Incorporation of this broad range of data into OWEGIS allows for a comprehensive evaluation of the potential impacts of a variety of human activities in and upon coastal and marine environments. This evaluation is critical to conservation planning efforts in line with traditional, new and expanding human uses, which will facilitate ecosystem sustainability.

OWEGIS information used in assisting the State and UMaine in the resource analysis of offshore wind energy in Maine is summarized in Table 3-15 below and can be found listed in the *UMoffshorewind energy_GIS_mar19.pdf* document at the Maine State Planning Office (SPO) website under the Ocean Energy Task Force – Environmental Issues subcommittee: http://www.maine.gov/spo/specialprojects/OETF.

An example of using OWEGIS as a public outreach and transparent siting tool is shown in Table 3-15 and was developed by the consensus of active participants during the public OETF subcommittee #1 meeting held on March 17, 2009. Researchers, developers, consultants, state agency personnel, and the interested public attended this subcommittee meeting to decide collaboratively how best to rate the individual layers of information in OWEGIS, critical data gaps, and criteria necessary for its use in the development of offshore wind projects in the GoM.

The outcome of the March 17, 2009, subcommittee meeting provides one approach to classifying complex overlapping multi-faceted data in a consistent fashion. For another approach to the same complex overlapping multi-faceted data, please see "The Creation of a Multidisciplinary, Criteria-Oriented Review and Selection Process for Deepwater Wind Test Facilities in Maine State Waters" developed by the State Planning Office (SPO). The resultant work of the SPO criteria review with non-proprietary data supplied by UMaine from OWEGIS is now part of the Maine Coastal Atlas.

Table 3-15 provides a brief description of the data collected and integrated into OWEGIS through March 2009. Additionally, it identifies data in various stages of acquisition and integration, as well as supplemental information necessary to improve OWEGIS.

Table 3-15: OWEGIS Data Content and Status (October 2008 to March 2009)

Gulf of Maine Offshore Wind Energy Development Initiative

1865 THE UNIVERSITY OF MAINE

Topic: ***Updated Content of the Gulf of Maine Offshore Wind Energy Geographic Information System (OWEGIS) – DRAFT****
Date: *April 22, 2009*
Authors: *Dr. Susan A. Elston, Dr. Melissa M. Landon, Dr. Habib J. Dagher (University of Maine), & Matthew E. Nixon (State Planning Office)*

The Offshore Wind Energy Geographic Information System (*OWEGIS*) was created with the intent to collect, analyze, and display graphical information to assist in planning, permitting, and the development of offshore wind energy in the Gulf of Maine. This document provides a brief description of the data collected and integrated into the Gulf of Maine *OWEGIS* to date. Additionally, it identifies data in various stages of acquisition and integration, as well as supplemental information necessary to improve *OWEGIS*. ***N.B.* This information reflects current state of knowledge and should not be considered the final authority on continuously evolving data, data sources, or on-going scientific studies.**

A. Rating Criteria for Offshore Wind Turbine Site Locations Minimizing Conflict – Weights by Filter Order & Geometry Type
Weights by Filter Order - Arabic Numerals: 1 – 3 respectively for first order filtering to third order filtering for siting considerations
1 – first order resource assessment filtering for siting considerations (e.g., physical criteria – winds, water depth, infrastructure, marine hazards)
2 – second order resource assessment filtering for siting considerations (e.g., additional physical criteria – land use, public planning information)
3 – third order resource assessment filtering for siting considerations (e.g., site specific conditions – local and regional feature assessment)

Weights by Geometry Type - Upper Case Letters: A – C for go/no go conditions, range conditions, site specific conditions
A – Go/No go conditions for siting (e.g., shipping channels or unexploded ordinances)
B – Range conditions (e.g., bathymetry, wind power class – technology dependent, etc.)
C – Site specific conditions (e.g., endangered/threatened/depleted species, shellfish industry, etc.)

Assessment Criteria for Offshore Wind Turbine Regions of Interest were divided into four general categories with "telescoping" as follows:

Resource Availability – Physical Characteristics (Level 1)
Human Activity Constraints – Coastal Economic & Extractive Resource Uses (Level 2)
Human Activity Constraints – Cultural & Aesthetic Features (Level 2)
Human Activity Constraints – Environmental Impacts & Wildlife (Level 2)
Industrial Needs – Infrastructure & Commercial Uses (Level 3)
Legal & Permitting Boundaries (Level 4)

Coastal economic & extractive resource uses, environmental impacts & wildlife, and cultural & aesthetic features are treated equal. OWEGIS layers were developed in reference to MMS' Proposed Rule 30 CFR Parts 250, 285, & 290 & the Multipurpose Marine Cadastre OCS Mapping Initiative.

Table 3-15 continued

B. OWEGIS Current Content

Items in gray indicate data in acquisition/integration and/or data sources that can only be viewed for proprietary reasons and/or have limited data sharing agreements. Items marked by * indicate data are multi-dimensional and are listed under more than one category.

PHYSICAL CHARACTERISTICS

1 Gulf of Maine Wind Resource

- 1 B Analysis/interpretation of comprehensive wind data collected from the Gulf of Maine buoy network by Dr. Susan A. Elston, including wind speeds and classes for elevations of 50 m and 100 m above mean sea level.
  - January 2009 analysis includes 11 data stations within 3 nautical miles and 13 stations within 6 nautical miles of the coast, with a total of 40 data stations within U.S. and International Atlantic Ocean waters.
  - An additional 16 verifiable sites will be included for subsequent analyses of the wind resource.
- 1 B U.S. DOE National Renewable Energy Laboratory (NREL)/AWS Truewind Gulf of Maine wind resource at 50 & 100m.
- 1 B LANDSAT satellite imagery for the Gulf of Maine from USGS Global Viewer (to be incorporated)
- 2 B/C Scatterometer winds providing spatial fields of wind vectors over the entire Gulf of Maine (consideration by Andy Thomas)
- 3 C Historical Atlantic hurricane tracks*

2 Bathymetry and Topography

- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 C Continental shelf survey (ICS) bottom photographs (older data – low resolution data)
- 1 C Integrated continental shelf surveys (ICS) surveys
- 1 C Seismic fault lines in the coastal zone and uplands*
- 2 B Geologic depth profiles of marine soils, bedrock, and gas deposits at discrete locations from Maine Geological Society survey tracks: locations shown in *OWEGIS*, with actual profiles available from UMaine Marine Geologists Joseph Kelley and Daniel Belknap.
- 2 B Gulf of Maine bathymetry (ocean depths)
- 2 B Maine 20 m topography (for assistance in characterizing on-shore wind resource)
- 2 B/C Coastal Navigation Charts (Resolution: 1:24,000 for Greater Portland; Bar Harbor; Casco Bay; 1:80,000 – 1:120,000 elsewhere in the Gulf of Maine Region)
- 2 C Surficial soils (low resolution data)
- 3 A Inter-continental shelf (ICS) surficial soils and methane gas locations from the Maine Geological Survey (data in acquisition)
- 3 C Inter-continental shelf bathymetric survey tracks and bathymetry from Maine Geological Survey

INFRASTRUCTURE & COMMERCIAL USES

3 Transportation Infrastructure

- 1 C Maine airports (*Maine airports showing a 5 nautical mile radius buffer zone around them*)
- 1 C Coastal airports (*Coastal Maine airports within 10 nautical miles of the coastline showing a 5 nautical mile radius buffer zone*)
- 1 C Heliports and Med-Flight/Life-Flight landing locations (data in acquisition)
- 1 C Air tours in Coastal Maine (Trenton, MDI/Acadia region)
- 1 C Alternative Fuel Stations (data in acquisition)*
- 1 C Navigable waterways (data in acquisition)*
- 1 C Army Corps of Engineers Ports (data in acquisition)*
- 2 C National Railway Network (data in acquisition)*
- 2 C Ferry routes
- 2 C Rail lines*

4 Utility and Development Infrastructure

- 1 C Electrical infrastructure (*power plants, substations, 115 kV and 345 kV transmission lines*) – current infrastructure
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – current infrastructure (proprietary)
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – approved plans (data requested)
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – submitted plans (data requested)
- 1 C Pipeline and cable infrastructure (data requested from management body)
- 1 C Military Bases and Installations (data in acquisition)
- 1 C Navigable waterways (data in acquisition)*
- 1 C Army Corps of Engineers Ports (data in acquisition)*
- 2 C National Railway Network (data in acquisition)*
- 2 C Rail lines*
- 2 C Hospitals

5 Coastal Restrictions & Marine Hazards

- 1 A Dragging prohibited zones
- 1 A Dumping and spoil grounds, explosives dumping grounds, areas of unexploded ordinance(s).
- 1 A Military zones
- 1 A Right whale restrictions (critical habitat, foaling grounds, recommended avoidance routes)
- 1 A Shipping lanes (harbor approach, traffic separation)
- 1 C Seismic fault lines in the coastal zone and uplands*
- 2 C Obstructions (movable physical hazards, buoys, etc.)

Table 3-15 continued

- 2 B Lobster and fish trap area* - general regions classified by NOAA Coast Survey – distinct data from local and regional information
- 2 B Coastal shellfish collection regions* - general regions classified by Maine – distinct data from local and regional information
- 2 B Worm crop harvest regions* - general regions classified suitable for harvesting – distinct data from local and regional information
- 3 C Historical Atlantic hurricane tracks*

CULTURAL & AESTHETIC FEATURES

6 **Native Lands and Cultural/Historical Features (including Landscapes & Seascapes)**

- 1 A National Park Service Data* (to be incorporated)
- 1 A State Park Data* (verify have most up-to-date version)
- 1 C Maine Coastal Island Registry*
- 1 C Fishing charter vessel and operations locations
- 1 C Maine portion of the Appalachian Trail
- 1 C Maine special protection rivers, Maine's Finest Lakes, Wildlands Lakes
- 1 C Maine Wind Jammer Association estimated use range (SPO)
- 1 C National Historic Register Sites (SPO)
- 1 C Native lands
- 1 C Whale watching charter vessel locations
- 2 C Sunken vessels, ship wrecks, light houses, and sea archeology sites

ENVIRONEMENTAL IMPACTS & WILDLIFE

7 **Habitat and Wildlife (Terrestrial, Coastal, and Marine)**

- 1 A/C Marine sanctuaries*
- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 B Bats – some digitally available migration route and tracking survey routes
- 1 B Breeding bird – locations/routes where surveys were conducted
- 1 B Environmental Vulnerability Index Maps (Maine Oil Spill Hazard Mitigation Maps)*
- 1 B Migratory marine mammals – sightings of threatened, endangered, and depleted species (dolphins: bottlenose, spinner; turtles: green, leatherback, loggerhead; whales: fin back, humpback, minke, sei, and northern right)
- 1 C Anadromous fish year-class counts of salmon per location
- 1 C Essential Aquatic Habitats (eelgrass, freshwater wetlands)
- 1 C Essential avian habitats (bald eagle nests; coastal seabird nesting; piping plover, least tern, roseate tern areas; inland waterfowl and wading bird areas)
- 1 B Maine and New Hampshire National Marine Fisheries Service Trawl Data
- 2 B National Marine Fisheries Service Trawl Data

- 2 B Northeast Resources
  - 2 B Essential fish habitat – as per the Code of Federal Regulations (50CFR 648.81)
  - 2 B New England Multispecies closures (year-round and seasonal closures for scallops and other species)
  - 2 B Gulf of Maine Dynamic Area Management Zones (DAMS) for Right Whales (yearly, seasonal, and real time closures)
  - 2 B Regulated mesh area (regulated fishing zones)

COASTAL ECONOMIC & EXTRACTIVE RESOURCE USES

8 **Coastal Economic Regions (Marine and Terrestrial)**

- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 B Environmental Vulnerability Index Maps (Maine Oil Spill Hazard Mitigation Maps)*
- 1 B Local and regional Lobster and fish trap areas* (data in acquisition)
- 1 B Local and regional Coastal shellfish collection regions* (data in acquisition)
- 1 B Local and regional Worm crop harvest regions* (data in acquisition)
- 2 B Lobster and fish trap area* - general regions classified by NOAA Coast Survey – distinct data from local and regional information
- 2 B Coastal shellfish collection regions* - general regions classified by Maine – distinct data from local and regional information
- 2 B Worm crop harvest regions* - general regions classified suitable for harvesting – distinct data from local and regional information

LEGAL & PERMITTING BOUNDARIES

9 **Boundaries/Municipalities/Population**

- 1 A National Park Service Data*
- 1 A State Park Data*
- 1 C Maine Coastal Island Registry*
- 1 A/C Marine sanctuaries*
- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 C Coastal state and federal marine boundaries (*private, state, federal "8(g)" revenue-sharing, territorial sea, contiguous zone, economic exclusive zone*)
- 1 C Outer Continental Shelf (OCS) Lease Blocks (data acquired, to be incorporated)
- 1 C State easements and right of way access (roads, transmission lines, pipelines, rail)
- 1 C State, New England States, and International boundaries
- 2 C Tax parcels (i.e., LURC vs. non-LURC divisions)
- 3 C 2000 Maine State Census Data
- 3 C Maine towns

Table 3-15 continued

C. Areas of *OWEGIS* Needing Further Development or Data Integration

- Supplemental migration routes and tracking survey data (digital GIS, tabulated, or proxy) for the following:
  - **ECON 1 B** Ground fish and fisheries resource zone information
  - **ENVR 1 B** Protected mammals (right whales, etc.) and/or delisted species
  - **ENVR 1 B** Updates to salmon essential habitat, newly designated closure areas for Atlantic Salmon fishing rights
  - **ENVR 1 B** Birds and Bats (tracking methods: radar, satellite, or radio-tagged)
- **CLTR 1 C** Additional Native population information regarding cultural/historical resources and wind power development
- **CLTR 2 C** Onshore historical or archeological sites (for permitting), recreational trails, additional recreational resources
- **ENVR 1 C** Areas of Special Significance
- **ENVR 1 B** Maine Seaweed and Kelp Harvesting Areas
- **ENVR 2 B** Land use change information – changes in land use with time over the last 20 and 50 years for development purposes
- **INFR 1 C** Additional power infrastructure information
- **INFR 1 C** Med-flight information and coastal hospitals with helicopter landing facilities
- **LEGL 1 A** Comprehensive Maine State permitting agencies and requirements for offshore energy development
- **LEGL 2 C** All relevant public and marine policy, management, and planning information
- Potential Additional Sources of New Information
  - **CLTR 2 C** Maine Island Trails Association
  - **ECON 1 C** Cobscook Bay Resource Center
  - **ECON 1 C** Penobscot East Resource Center
  - **ECON 1 B** Island Institute
  - **ENVR 1 C** University of Southern Maine Census on Marine Life
  - **ENVR 2 B** Northwest Atlantic Marine Alliance

D. Bibliography of digital information collected and integrated into *OWEGIS*

- Automated Wreck and Obstruction Information System (AWOIS)
- Bangor Hydro (BHE)
- Maine Department of Environmental Protection (ME-DEP)
- Environment Canada (envCanada)
- Federal Emergency Management Agency (FEMA)
- Federal Geographic Data Committee (FGDC)
- Island Institute
- Maine Department of Conservation (DoC)
- Maine Department of Marine Resources (DMR)
- Maine Office of GIS (MEgis)

4.0 Electric Grid Interconnection

A suitable grid interconnection site for a proposed offshore wind pilot project must be capable of handling 15 to 30 MW of wind generation at an interconnection voltage of 34.5 kV. The interconnection location must be relatively close to the coast line to minimize the overall distance between the interconnection point and the wind project, to minimize the length of the generator leader line and provide the most economic connection to the Maine Electric grid.

4.1 INTERCONNECTION LOCATIONS

A list of potential electrical interconnection locations was created by identifying all medium voltage (34.5 kV) and high voltage (115 kV) electric facilities within ten (10) miles of the Maine coastline. This process resulted in a compilation of 61 potential sites in Central Maine Power Company's (CMP) service territory and 18 potential sites in Bangor Hydro Electric Company's (BHE) service territory as follows in Table 4-1:

Table 4-1: Potential interconnection locations by County

CENTRAL MAINE POWER AREA	
York County	18
Cumberland County	20
Sagadahoc County	4
Lincoln County	7
Knox County	7
Waldo County	5

BANGOR HYDRO ELECTRIC AREA	
Hancock County	10
Washington County	8

Figure 4-1 shows a map of the potential interconnection locations in the Central Maine Power and the Bangor Hydro Electric service areas.

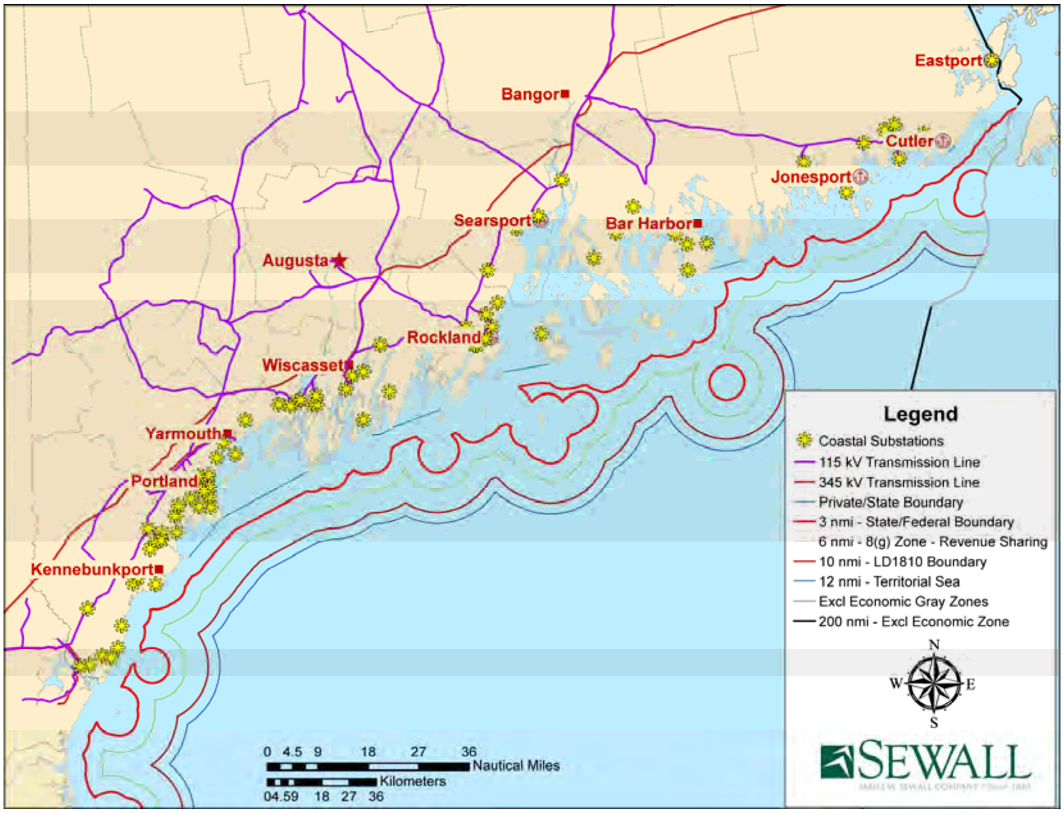


Figure 4-1: Potential interconnection locations in Central Maine Power and Bangor Hydro service areas

These interconnection sites were further evaluated based on their relative grid stiffness (ratio of available fault duty to project size), their general readiness to accept up to 30 MW of wind generation and their location relative to the proposed wind project areas of interest. Any interconnection site that offered a grid stiffness ratio of less than 5:1 was rejected as a viable site. Any interconnection site that could not accommodate the transmission of 30 MW over its existing transmission system was also rejected as a viable site. Finally, any interconnection site that was in excess of 60 km from a proposed wind project was rejected as a viable site. A second evaluation was conducted November 2010 to identify any additional interconnection sites that could accommodate a smaller 15 MW wind project.

For completing this interconnection study, four (4) areas of interest for offshore project development have been identified off the coast the Maine (see Figure 4-2). These sites run from the southern part of Maine off York Beach to the eastern part of coastal Maine near Machias Bay. These sites are identified as Areas 1 through 4 with Area No. 1 being the southernmost and Area No. 4 being the easternmost. Each area is characterized by a different range of interconnection locations and options.

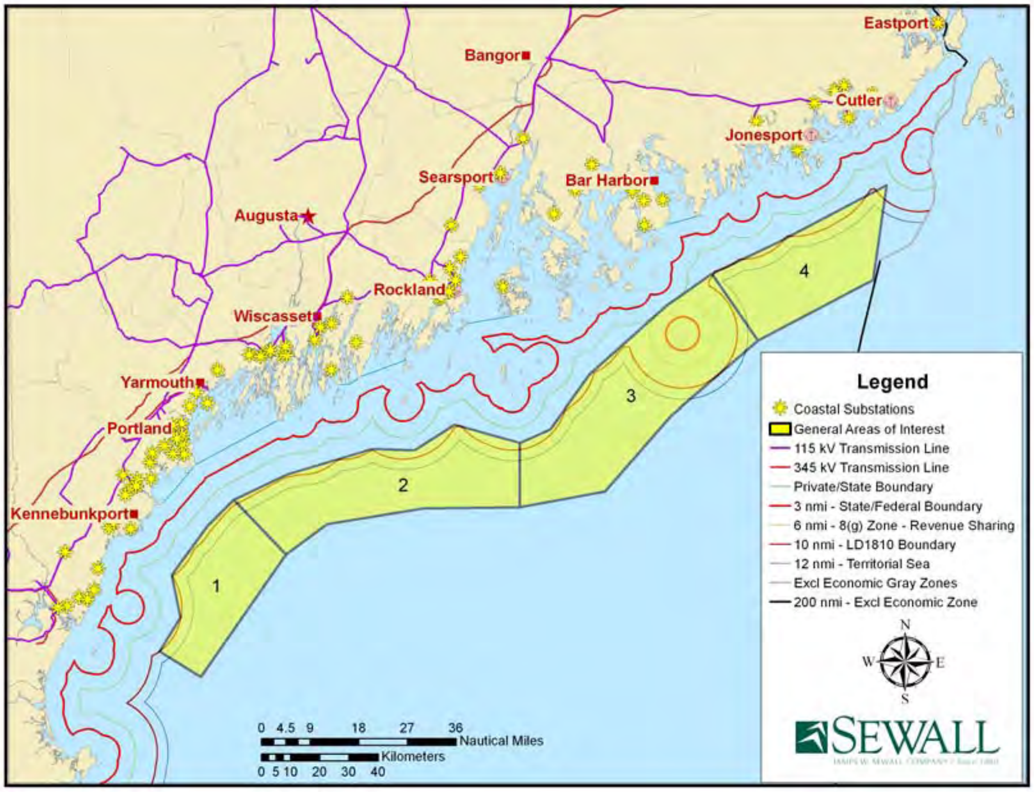


Figure 4-2: General areas of interest for offshore wind project development

Area No. 1 offers a generous range of interconnection opportunities that exist in York and Cumberland Counties. There are an assortment of good 34.5 kV and 115 kV interconnection locations in this vicinity with the best candidates listed in Table 4-2.

Table 4-2: Interconnection locations for Area No. 1 (Projects 30 MW or less)

OWNER	SUBSTATION NAME	VOLTAGE
CMP	York – 1	34.5 kV
CMP	York – 2	34.5 kV & 115 kV
CMP	York – 7	34.5 kV
CMP	York – 8	34.5kV
CMP	Cumberland – 1	34.5 kV & 115 kV
CMP	Cumberland – 5	115 kV
CMP	Cumberland – 8	34.5 kV & 115 kV
CMP	Cumberland – 10	34.5 kV & 115 kV
CMP	Cumberland – 11	34.5 kV
CMP	Cumberland – 15	115 kV

Table 4-3 lists additional interconnection locations for Area No. 1 for projects of 15 MW or less as determined by the November 2010 interconnection evaluation.

Table 4-3: Additional interconnection locations for Area No. 1 (15 MW or less)

OWNER	SUBSTATION NAME	VOLTAGE
CMP	York – 4	34.5 kV
CMP	York – 6	34.5 kV
CMP	York – 9	34.5 kV
CMP	York – 10	34.5kV
CMP	York-16	34.5 kV
CMP	Cumberland – 2	34.5 kV

Area No. 2 also offers a good range of interconnection opportunities that exist in Cumberland, Sagadahoc, Lincoln and Knox Counties. There are an assortment of 34.5 kV and 115 kV interconnection locations in this vicinity with the best candidates listed in Table 4-4.

Table 4-4: Interconnection locations for Area No. 2 (Projects 30 MW or less)

OWNER	SUBSTATION NAME	VOLTAGE
CMP	Cumberland – 1	34.5 kV & 115 kV
CMP	Cumberland – 5	115 kV
CMP	Cumberland – 8	34.5 kV & 115 kV
CMP	Cumberland – 10	34.5 kV & 115 kV
CMP	Cumberland – 11	34.5 kV
CMP	Cumberland – 15	115 kV
CMP	Lincoln – 3	115 kV
CMP	Lincoln – 4	34.5 kV & 115 kV
CMP	Lincoln – 7	34.5 kV
CMP	Sagadahoc -1	34.5 kV & 115 kV
CMP	Sagadahoc – 2	34.5 kV
Private	Knox – 1	34.5 kV & 115 kV

Table 4-5 lists additional interconnection locations for Area No. 2 for projects of 15 MW or less as determined by the November 2010 interconnection evaluation.

Table 4-5: Additional interconnection locations for Area No. 2 (15 MW or less)

OWNER	SUBSTATION NAME	VOLTAGE
CMP	Lincoln – 1	34.5 kV

Area No. 3 offers an extremely limited range of interconnection opportunities that exist in Knox and Hancock Counties. This area of interest is positioned off the barrier islands of Vinalhaven, Isle au Haut, Swans Island, Stonington, and Deer Isle. The electric systems in this area are very weak and largely consist of 15 kV distribution systems capable of handling less than ten (10) MW of load. There is a very limited selection of interconnection locations in this vicinity with the best candidates listed in Table 4-6.

Table 4-6: Potential interconnection locations for Area No. 3

OWNER	SUBSTATION NAME	VOLTAGE
Private	Knox – 1	34.5 kV & 115 kV
CMP	Knox – 4	34.5 kV & 115 kV
BHE	Hancock – 6	34.5 kV – less than 15 MW

No additional interconnection locations were determined for Area No. 3 from the November 2010 evaluation of a smaller 15 MW project.

Area No. 4 offers a limited range of interconnection opportunities that exist in Washington County. Due to the rural nature of this area, there is a limited selection of 34.5 kV and 115 kV interconnection locations in this vicinity with the best candidates listed in Table 4-7.

Table 4-7: Potential interconnection locations for Area No. 4

OWNER	SUBSTATION NAME	VOLTAGE
BHE	Washington – 1	34.5 kV– less than 25 MW
BHE	Washington – 2	34.5 kV – less than 15 MW
BHE	Washington – 3	34.5 kV – less than 15 MW
BHE	Washington – 4	34.5 kV – less than 15 MW
BHE	Washington – 7	34.5 kV
BHE	Washington – 8	34.5 kV & 115kV

These identified sites will require further specific load flow study analysis to verify that there would likely be no significant adverse impacts to the transmission system resulting from the interconnection of 15 to 30 MW of wind turbine generation. The following pre-feasibility study provides a cursory examination of these sites.

4.2 CONNECTION PRE-FEASBILITY STUDY/AVAILABLE CAPACITY

The primary objectives of this pre-feasibility study are to evaluate potential interconnection locations for 30 MW of offshore wind generation and to perform a cursory assessment as to whether the interconnection will have a significant adverse impact on the steady-state reliability of the Central Maine Power (CMP) Company 115 kV transmission and 34.5 kV sub-transmission systems. Note that stability conditions were not analyzed in as part of this study.

4.2.1 Study Area

Transmission System
The primary focus of this study is the 34.5 kV and 115 kV facilities located along the coastal region of CMP's service territory. The Project is assumed to be either interconnected directly into the 34.5 kV sub-transmission system or to the 115 kV transmission system via an additional 115/34.5 kV step-up transformer. The Project interconnection will also involve a significant, radial, submarine cable that will span the distance between the offshore collector system and the onshore interconnection point.

The substation facilities listed in Table 4-8 and identified in Figure 4-3 were evaluated in this study as possible locations for a 30 MW or less interconnection. In a similar manner, the substation facilities listed in Table 4-9 and identified in Figure 4-4 were evaluated for this study as possible locations for a 15 MW or less interconnection.

Table 4-8: Substation facilities evaluated in the pre-feasibility study for a 30 MW or less interconnection

SUBSTATION	VOLTAGE
CMP – Cumberland – 1	34.5 kV
CMP – Cumberland – 5	115kV
CMP – Cumberland – 8	115kV
CMP – Cumberland – 10	34.5 kV
CMP – Cumberland – 11	34.5 kV
CMP – Cumberland – 15	115kV
Private – Knox – 1	115kV
CMP – Knox – 4	34.5 kV
CMP – Lincoln – 3	115kV
CMP – Lincoln – 4	34.5 kV
CMP – Lincoln – 7	34.5 kV
CMP – Sagadahoc – 2	34.5 kV
CMP – York – 1	34.5 kV
CMP – York – 2	34.5 kV
CMP – York – 7	34.5 kV
CMP – York – 8	34.5 kV

Table 4-9: Substation facilities evaluated in the pre-feasibility study for a 15 MW or less interconnection

SUBSTATION	VOLTAGE
CMP – Cumberland – 2	34.5 kV
CMP – Lincoln – 1	34.5 kV
CMP – York – 4	34.5 kV
CMP – York – 6	34.5 kV
CMP – York – 9	34.5 kV
CMP – York – 10	34.5 kV
CMP – York – 16	34.5 kV

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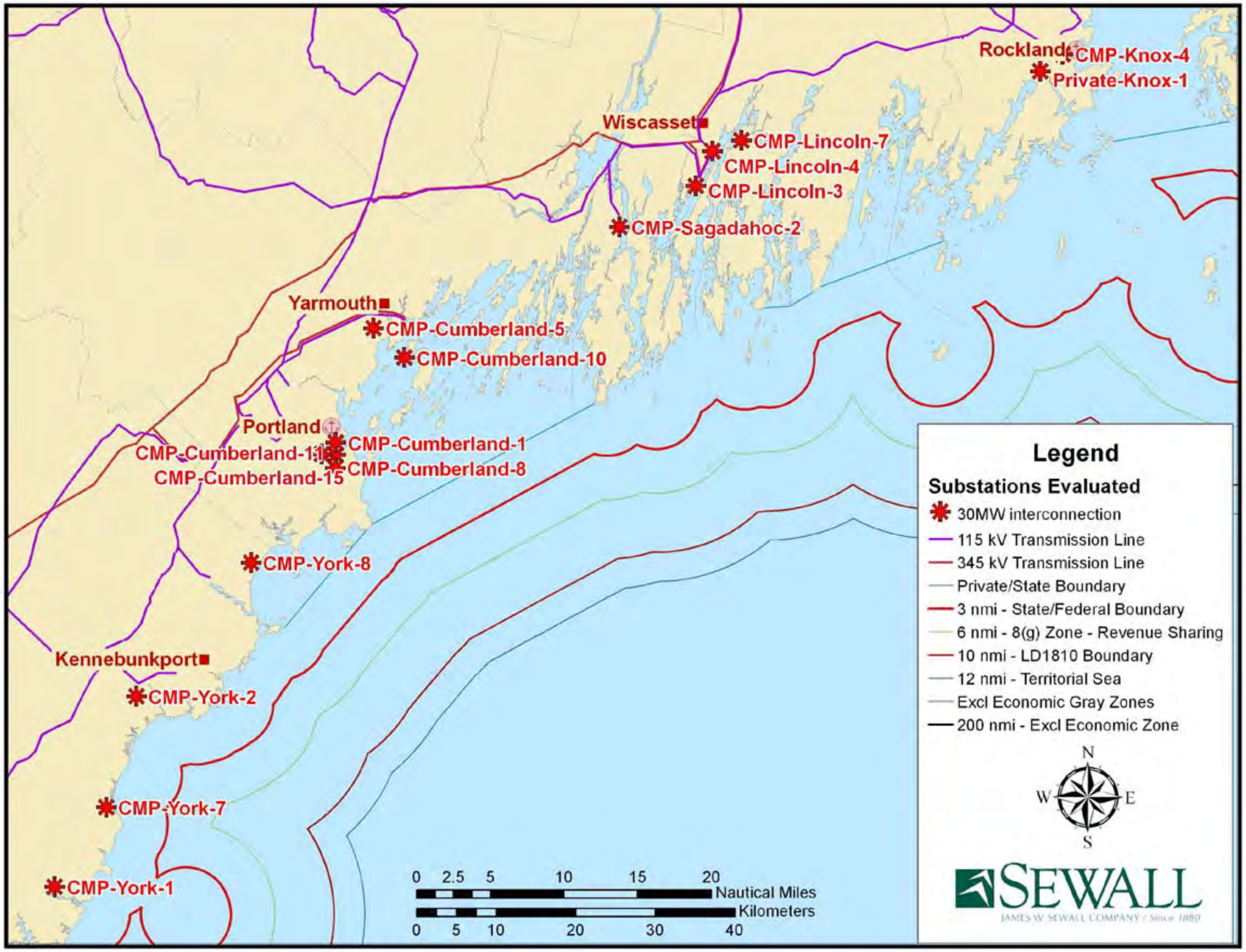

Figure 4-3: Connection pre-feasibility study substations (30 MW or less)

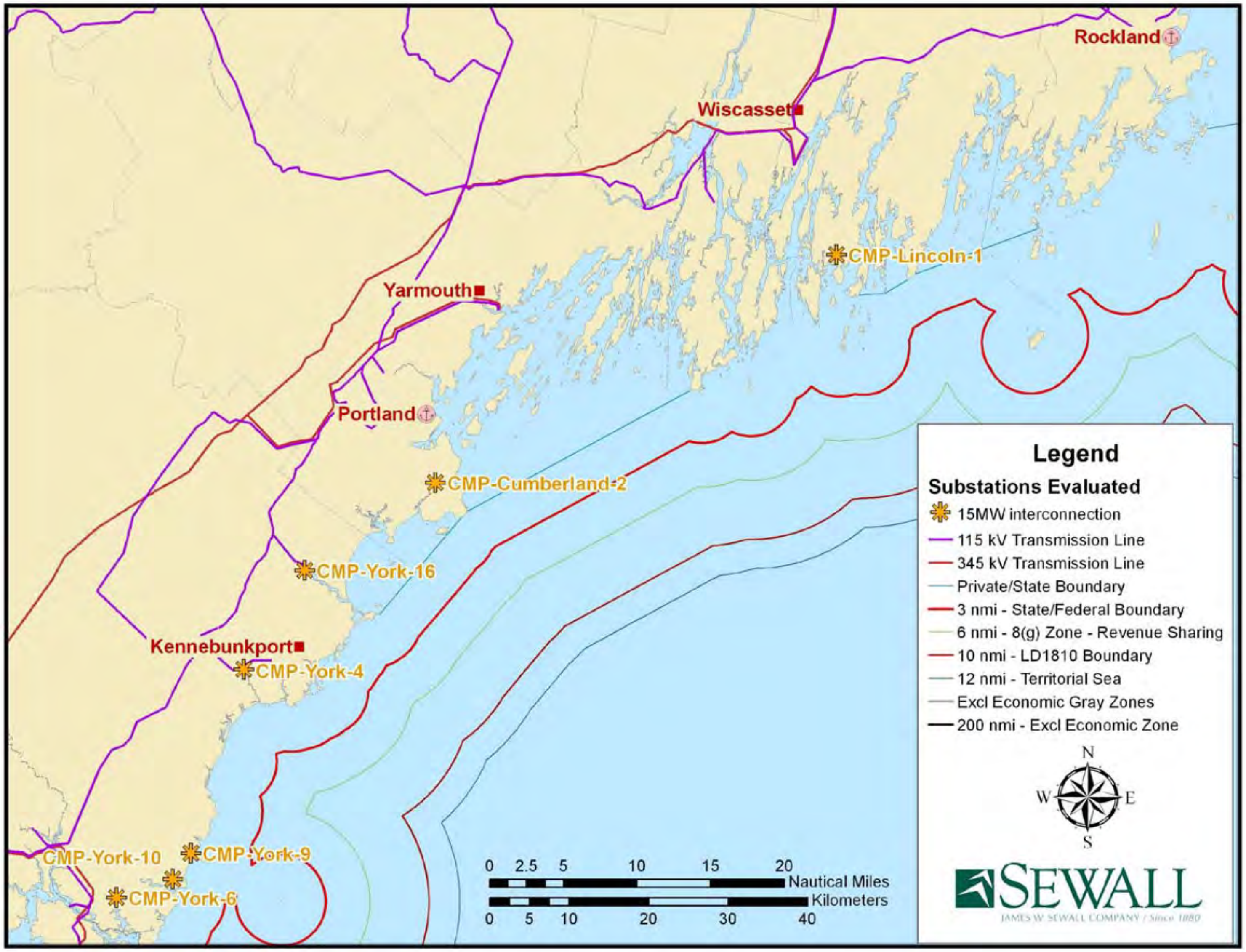

Figure 4-4: Connection pre-feasibility study substations (15 MW or less)

Base Case Development

The base case power flow for this study originated from CMP and included a model of CMP's 34.5 kV sub-transmission system. Steady-state analyses were conducted using a Summer peak 2010 load level.

Steady-state Analysis Methodology

The steady-state analysis was performed using the GE Power Systems PSLF load flow software package, Version 17. Steady-state thermal and voltage analyses initially examined system performance without the proposed Project in order to establish a baseline for comparison. System performance was then re-evaluated with the Project interconnected at the various interconnection sites listed above and compared with the previous baseline performance to demonstrate the impact of the Project on area transmission reliability. At each site, evaluations were conducted for the base system followed by first contingency (an outage of a transmission line or transformer).

Steady-state Voltage Limits

Table 4-10 identifies the voltage criteria used by CMP in the primary Study area for steady-state voltage assessment.

Table 4-10: Steady-state voltage criteria

VOLTAGE CLASS	ACCEPTABLE VOLTAGE RANGE	
	PRE-CONTINGENCY (NORMAL CONDITIONS)	POST-CONTINGENCY (EMERGENCY CONDITIONS)
115 kV	0.95 to 1.05pu	0.95 to 1.05pu
Below 115 kV	0.95 to 1.05pu	0.95 to 1.05pu

Steady-state Thermal Limits

Table 4-11 contains the thermal loading performance criteria applied to transmission lines and transformers in this Study.

Table 4-11: Steady-state thermal criteria

SYSTEM CONDITION	TIME INTERVAL	MAXIMUM ALLOWABLE FACILITY LOADING
PRE-CONTINGENCY (ALL LINES IN)	Continuous	Normal Rating*
POST-CONTINGENCY	Less than 15 minutes after contingency occurs	Short Term Emergency (STE) Rating**
	More than 15 minutes after contingency occurs	Long Term Emergency (LTE) Rating***

*Normal Rating – Maximum loading permitted without incurring equipment loss of life above design criteria.

**Short Term Emergency Rating – Maximum 15 minute loading before thermal damage is experienced.

***Long Term Emergency Rating – Maximum loading allowed for a period of 12 hours (Summer) or 4 hours (Winter)

4.2.2 Steady-state Analysis Results

Table 4-12 summarizes the relative impact of adding 30 MW of wind generation to the substations sites identified in this report. The table offers a cursory assessment by comparing the interconnection conditions before (Base Case) and after the addition of a 30 MW Project. The per unit values (pu) indicate the relative voltage or thermal performance at the interconnection site under likely contingency outage conditions.

The general conclusion reached from the cursory assessment is that the interconnection of up to 30 MW at any of the sites identified above is not expected to have an adverse impact on thermal or voltage related issues on the CMP medium or high voltage transmission system.

Table 4-13 summarizes the relative impact of adding up to a 15 MW of wind generation to the supplemental substations sites identified in this report. See Table 4-9 for the additional sites capable of accommodating an interconnection of up to 15 MW of generation. The table offers a cursory assessment by comparing the interconnection conditions before (Base Case) and after the addition of a 15 MW Project. The per unit values (pu) indicate the relative voltage or thermal performance at the interconnection site under likely contingency outage conditions.

Table 4-12: Summary results of the steady-state analysis on the injection of 30 MW wind-generated energy at various interconnection points

LOCATION	VIOLATION		CONTINGENCY	PRE-PROJECT (per unit)	POST 30 MW PROJECT (per unit)	REMARKS
CMP-Cumberland-1	Voltage	No Violations				No impact
	Thermal	No Violations				
CMP-Cumberland-5	Voltage	34.5 kV Bus	Base Case	1.065	1.065	No impact
		34.5 kV Bus	Base Case	1.078	1.078	
		34.5 kV Bus	Contingency 1	0.929	0.931	
	Thermal	Power Transformer	Base Case	1.006	1.006	
		34.5 kV Section	Contingency 1	1.049	1.047	
CMP-Cumberland-8	Voltage	No Violations				No impact
	Thermal	No Violations				
CMP-Cumberland-10	Voltage	No Violations				No impact
	Thermal	34.5 kV Section	Contingency 1	0.997	1.004	
CMP-Cumberland-11	Voltage	No Violations				No impact
	Thermal	No Violations				
CMP-Cumberland-15	Voltage	No Violations				No impact
	Thermal	No Violations				
Private-Knox-1	Voltage	34.5 kV Bus	Contingency 1	0.837	0.843	Marginal improvement in voltage for loss of transmission Section
		34.5 kV Bus	Contingency 2	0.903	0.909	
		34.5 kV Bus	Contingency 3	0.921	0.927	
		34.5 kV Bus	Contingency 4	0.948	0.954	
		34.5 kV Bus	Contingency 5	0.948	0.954	
		34.5 kV Bus	Contingency 6	0.930	0.937	
		34.5 kV Bus	Contingency 7	0.940	0.943	
	Thermal					

Table 4-12 continued

LOCATION	VIOLATION		CONTINGENCY	PRE-PROJECT (per unit)	POST 30 MW PROJECT (per unit)	REMARKS
CMP-Knox-4	Voltage	34.5 kV Bus	Contingency 1	0.945	0.975	No impact
	Thermal	Power Transformer	Base Case	1.075	1.077	
		Power Transformer	Base Case	1.080	1.081	
CMP-Lincoln-3	Voltage	No Violations				No impact
	Thermal	Power Transformer	Base Case	1.079	1.079	
		Power Transformer	Base Case	1.120	1.120	
CMP-Lincoln-4	Voltage	34.5 kV Bus	Contingency 1	0.938	0.934	No impact
		34.5 kV Bus	Contingency 2	0.951	0.945	
		34.5 kV Bus	Contingency 3	0.949	0.956	
	Thermal	No Violations				
CMP-Lincoln-7	Voltage	34.5 kV Bus	Contingency 1	0.928	0.954	Generation improves CMP-Lincoln-1 voltage during contingencies
		34.5 kV Bus	Contingency 2	0.920	0.942	
	Thermal	No Violations				
CMP-Sagadahoc-2	Voltage	No Violations				No impact
	Thermal	Power Transformer	Base Case	1.120	1.119	
		Power Transformer	Base Case	1.483	1.050	

Table 4-12 continued

LOCATION	VIOLATION		CONTINGENCY	PRE-PROJECT (per unit)	POST 30 MW PROJECT (per unit)	REMARKS
CMP-York-1	Voltage	34.5 kV Bus	Contingency 1	0.910	0.976	Generation improves voltage for loss of transmission Section
		34.5 kV Bus	Contingency 2	0.922	0.973	
		34.5 kV Bus	Contingency 3	0.915	0.966	
	Thermal	Power Transformer	Base Case	1.022	1.022	
		34.5 kV Section	Base Case	1.011	1.011	
		Power Transformer	Base Case	2.132	2.206	
CMP-York-2	Voltage	34.5 kV Bus	Base Case	1.081	1.078	No impact
		34.5 kV Bus	Base Case	0.945	0.946	
		34.5 kV Bus	Contingency A	1.051	1.036	
	Thermal	34.5 kV Section	Base Case	1.029	1.032	
		Power Transformer	Base Case	1.150	1.150	

Table 4-12 continued

LOCATION	VIOLATION		CONTINGENCY	PRE-PROJECT (per unit)	POST 30 MW PROJECT (per unit)	REMARKS
CMP-York-7	Voltage	34.5 kV Bus	Contingency 1	0.843	0.985	Generation improves voltage and thermal performance following Loss of Transmission Section
		34.5 kV Bus	Contingency 2	0.886	0.977	
		34.5 kV Bus	Contingency 3	0.884	0.971	
		34.5 kV Bus	Contingency 4	0.935	0.993	
		34.5 kV Bus	Contingency 5	0.890	0.978	
		12.47 kV Bus	Contingency 6	0.901	1.037	
		12.47 kV Bus	Contingency 7	0.905	1.035	
		12.47 kV Bus	Contingency 8	0.926	0.926	
		34.5 kV Bus	Contingency 9	0.912	0.912	
	Thermal	34.5 kV Section	Base Case	1.020	1.017	
		Power Transformer	Base Case	1.861	1.843	
		Power Transformer	Base Case	1.150	1.149	
		34.5 kV Section	Contingency 1	1.023	1.021	
		34.5 kV Section	Contingency 2	1.134	0.131	
		34.5 kV Section	Contingency 3	1.479	0.598	
		34.5 kV Section	Contingency 4	1.215	0.347	
		34.5 kV Section	Contingency 5	1.343	0.240	
		Power Transformer	Contingency 6	1.066	0.628	
		Power Transformer	Contingency 7	0.324	1.277	
CMP-York-8	Voltage	34.5 kV Section	Contingency 1	0.943	0.993	Improves performance following loss of transmission Section
	Thermal	34.5 kV Section	Base Case	1.268	0.965	
		Power Transformer	Base Case	1.086	1.084	
		34.5 kV Section	Contingency 1	1.016	0.537	
		34.5 kV Section	Contingency 2	1.870	1.163	

Table 4-13: Summary results of the steady-state analysis on the injection of 15 MW wind-generated energy at various interconnection points

LOCATION	VIOLATION		CONTINGENCY	PRE-PROJECT (per unit)	POST 15 MW PROJECT (per unit)	REMARKS
CMP-Cumberland-2	Voltage	No Violations				No Impact
	Thermal	No Violations				
CMP-Lincoln-1	Voltage	Lincoln-1 34.5 bus	Base Case	0.941	0.994	Generation improves voltage
	Thermal	No Violations				
CMP-York-4	Voltage	No Violations				Generation improves thermal performance
	Thermal	34.5 kV Line Tap	Base Case	1.021	0.541	
CMP-York-6	Voltage	No Violations				No Impact
	Thermal	No Violations				
CMP-York-9	Voltage	York 1 34.5 kV	Contingency 1	0.910	0.971	Generation improves voltage and thermal performance
		York 9 34.5 kV	Contingency 2	0.922	0.983	
		York 10 34.5 kV	Contingency 3	0.915	0.975	
	Thermal	34.5 kV Section 1	Base Case	1.011	1.006	
		34.5 kV Section 2	Contingency A	1.146	0.991	
		34.5 kV Section 2	Contingency B	1.250	0.987	

Table 4-13 continued

LOCATION	VIOLATION		CONTINGENCY	PRE-PROJECT (per unit)	POST 15 MW PROJECT (per unit)	REMARKS
CMP-York-10	Voltage	York 7 34.5 kV	Contingency 1	0.843	0.926	Generation improves voltage and thermal performance
		York 1 34.5 kV	Contingency 2	0.908	0.967	
		York 9 34.5 kV	Contingency 2	0.920	0.978	
		York 10 34.5 kV	Contingency 2	0.913	0.984	
	Thermal	34.5 kV Section 1	Base Case	1.013	1.008	
		34.5 kV Section 2	Contingency A	1.131	1.028	
		34.5 kV Section 3	Contingency B	1.143	0.991	
CMP-York-16	Voltage	York 15 34.5 kV	Contingency 1	0.928	0.976	Generation improves voltage and thermal performance
		York 8 34.5 kV	Contingency 2	0.932	0.953	
		34.5 kV Bus	Contingency 3	0.928	0.976	
	Thermal	34.5 kV Section 1	Base Case	1.268	0.963	
		34.5 kV Section 2	Contingency A	1.400	0.984	
		34.5 kV Section 3	Contingency B	1.161	0.752	

4.3 GRID IMPROVEMENTS AND INTERCONNECTION COSTS

4.3.1 Grid Improvements

Based upon the assessment above, no significant grid or transmission improvements to the CMP transmission system are likely to be required for a 15 to 30 MW wind turbine addition. However, there may be a need to improve protection systems, add transformation, or expand a substation to accommodate the physical interconnection. These improvements will need to be assessed on a case-by-case basis.

4.3.2 Interconnection Costs

Interconnection costs will vary with each interconnection site and depend upon a number factors such as (1) distance of site from the coast line, (2) acceptable line route between the on shore cable landing and the interconnection site, (3) available unused circuit positions, (4) site expandability, (5) site compatibility and (6) interconnection constructability. At a minimum, most interconnections of this size will utilize a 34,500-volt power system, which will require an interconnection to an existing facility via a 34.5 kV line terminal equipped with a properly sized circuit breaker, disconnect switches, metering equipment, auxiliary alternating current and direct current (AC & DC) power systems, and protection & control systems. Typical interconnection costs (± 25%) associated with interconnecting a 30 MW generator to an existing 34.5 kV facility would likely consist of the following elements identified in Table 4-14.

Table 4-14: Interconnection costs for a 30 MW wind energy project

INTERCONNECTION ASSOCIATED ACTIVITIES	ESTIMATED ACTIVITY COST (USD)
Real Estate	$50,000
Site Preparation	$35,000
Expansion of Ground Grid	$30,000
34.5 kV Bus Expansion	$25,000
34.5 kV Line Terminal Addition (including Circuit Breaker)	$250,000
Metering System	$60,000
SCADA Systems	$25,000
Protection and Control Systems	$80,000
Protection and Control Shelter	$30,000
Auxiliary AC and DC Power Systems	$50,000
Communication Systems	$45,000
Engineering	$50,000
Commissioning	$60,000
SUBTOTAL	**$790,000**

Additional cost for the generator leader between the submarine cable landing and the substation is estimated to be $ 65.00 per foot to $ 75.00 per foot for aerial line and $300 per foot to $400 per foot for underground lines.

Sites offering a higher voltage than 34.5 kV will additionally require the installation of a power transformer (20/37 MVA) and associated protective equipment to provide a suitable 34.5 kV interconnection. The additional cost of interconnecting to the 115 kV system would require more yard expansion, a high voltage breaker terminal with associated protective relays, and a power transformer. The incremental cost, in addition to those identified above, to create an interconnection to the 115 kV system is projected to be $ 1.2 million.

4.4 SUBSEA CABLE FEASIBILITY (35KM, 45 KM AND 60KM AC CABLE)

An assessment of available submarine cable systems was conducted and it was determined that a 34.5 kV submarine cable, 60 km in length, capable of transmitting up to 30 MW of electricity is possible, but not without performance issues. Due the cable's significant length, voltage drop and cable losses are a concern, with maximum estimated voltage drop and cable energy losses in the eight percent (8%) to nine percent (9%) range. These values would run even higher if not for the application of compensation reactors at each end of the cable to mitigate some of the loading affects caused by the charging currents in the cable.

Based upon information provided by Nexan Energy, an international submarine cable manufacturer, a three-phase cable with 800 mm^2 copper conductors is recommended for a 30 MW project requiring a 60 km cable length to transmit its output. Nexan also recommended that the cable be installed with compensation reactors at each end of the cable. The size of the compensation reactors vary with cable length. For a 60 km, 34.5 kV, 800 mm^2 cable, a 5.2 Mvar reactor at each end is suggested. For a shorter, 35 km cable the reactors can be reduced to 3.0 Mvar.

4.4.1 Subsea Alternating Current (A/C) Cable Selection

The subsea collector cable system should be kept as short in length as reasonably possible. For a 30 MW project with a 60 km collector cable, the minimum cable conductor size should be 800 mm^2 copper with a design maximum operating temperature of 90°C. A cable of this size will provide sufficient capability to transmit the full output of the facility but will only provide marginal voltage regulation on the line along with significant line loss. To improve the voltage regulation of the cable to a more acceptable level, a maximum cable length of 45 km would be more suitable for a 34.5 kV cable system with this level of loading.

4.4.2 Voltage Drop and Power Loss Calculations

800 mm² Submarine Cable Characteristics
Based upon information provided by Nexan Energy, a cable of this type would consist of the following suggested construction:

- 35.0 mm, round, stranded, compressed, copper conductor of 61 strands filled with a semiconducting compound.
- Conductor screen comprised of a semiconducting cross-linked compound.
- 8.0 mm thick cross-linked polyethylene (XLPE) insulation.
- Insulation screen comprised of an extruded layer of semiconducting cross-linked compound.
- Metallic screen comprised of 0.1 mm layer of copper tape.
- Polypropylene yarn fillers and fiber optic cable located in the interstices between the cable cores.
- Inner sheath of 2.2 mm extruded semiconducting polyethylene.
- Armor comprised of 51 to 54 7.5 x 2.5 mm, galvanized steel, flat, armor wires layered in 2 layers applied in opposite directions.
- Outer serving comprised of two layers of polypropylene yarn and bitumen.
- Cable diameter – 149 mm
- Cable weight (in air) – 48 kg/m
- Minimum bending radius – 2.7 meter
- Maximum pulling tension 290 kN

Based upon cable characteristic data provided by Nexan Energy, Figure 4-5 and Figure 4-6 were developed to identify the respective per unit voltage drop and the kW loss over the 34.5 kV 800 mm² cable at different operating conditions (0%, 50%, 80% and 100%) and cable lengths (35 km, 45 km and 60 km).

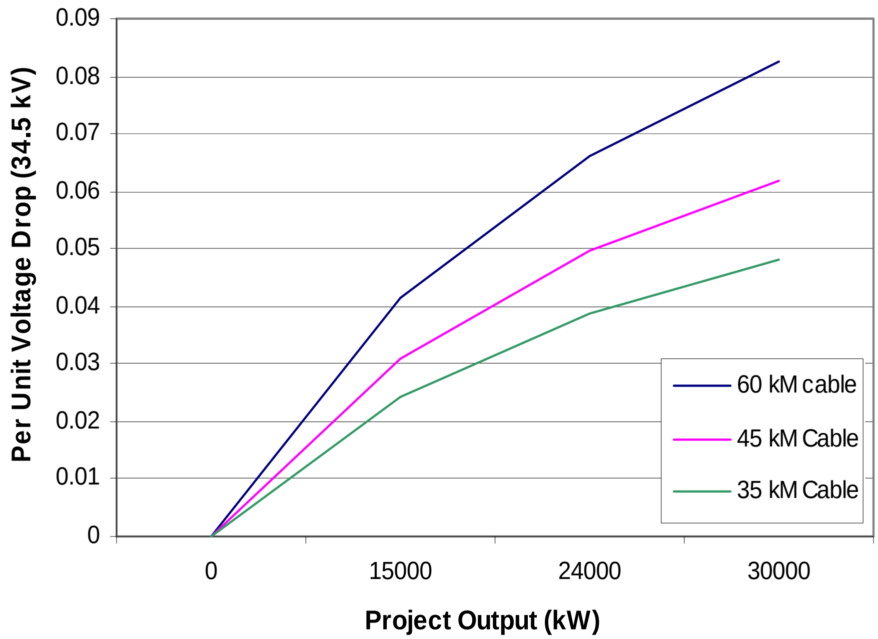

Figure 4-5: Voltage drop characteristics for a 800 mm^2 cable

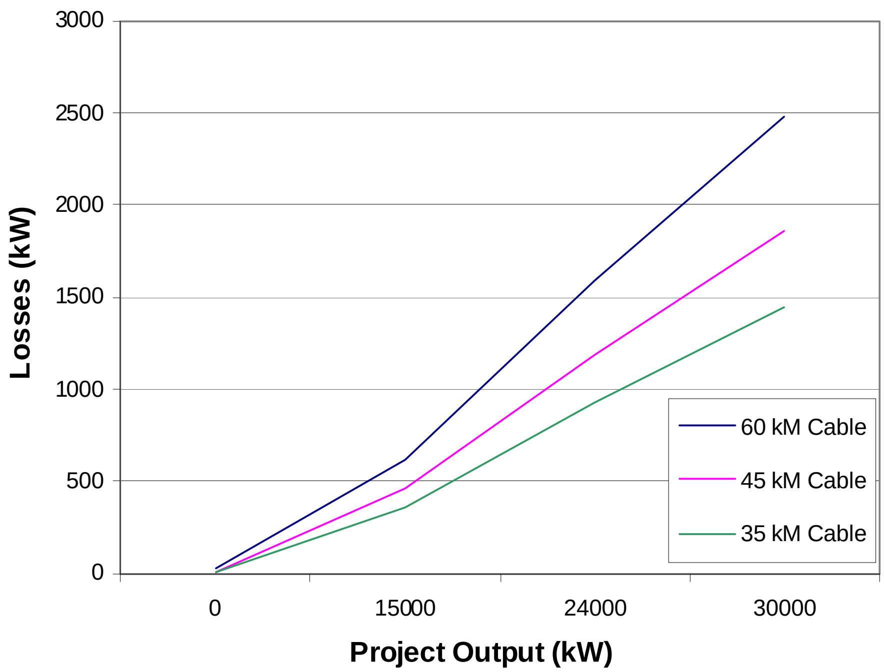

Figure 4-6: Kilowatt (kW) loss characteristics for a 800 mm^2 cable

240 mm² Submarine Cable Characteristics

In addition to the 800 mm² cable specifications, Nexan Energy also provided specifications for a smaller 240 mm² cable which would facilitate the interconnection of a downsized (15 MW) project.

Based upon information provided by Nexan Energy, a cable of this type would consist of the following suggested construction:

- 18.4 mm, round, stranded, compressed, copper conductor of 37 strands filled with a semiconducting compound.
- Conductor screen comprised of a semiconducting cross-linked compound.
- 8.0 mm thick cross-linked polyethylene (XLPE) insulation.
- Insulation screen comprised of an extruded layer of semiconducting cross-linked compound.
- Metallic screen comprised of 0.1 mm layer of copper tape.
- Polypropylene yarn fillers and fiber optic cable located in the interstices between the cable cores.
- Inner sheath of 2.0 mm extruded semiconducting polyethylene.
- Armor comprised of 35 to 37 7.5 x 2.5 mm, galvanized steel, flat, armor wires layered in two (2) layers applied in opposite directions.
- Outer serving comprised of two layers of polypropylene yarn and bitumen.
- Cable diameter – 108 mm
- Cable weight (in air) – 23 kg/m
- Minimum bending radius – 1.9 meter
- Maximum pulling tension 150 kN

Similar to Figure 4-5 and Figure 4-6, Figure 4-7 and Figure 4-8 were developed to identify the respective per unit voltage drop and the kW loss over the 34.5 kV 240 mm² cable at different operating conditions (0%, 50%, 80% and 100%) and cable lengths (35 km, 45 km and 60 km).

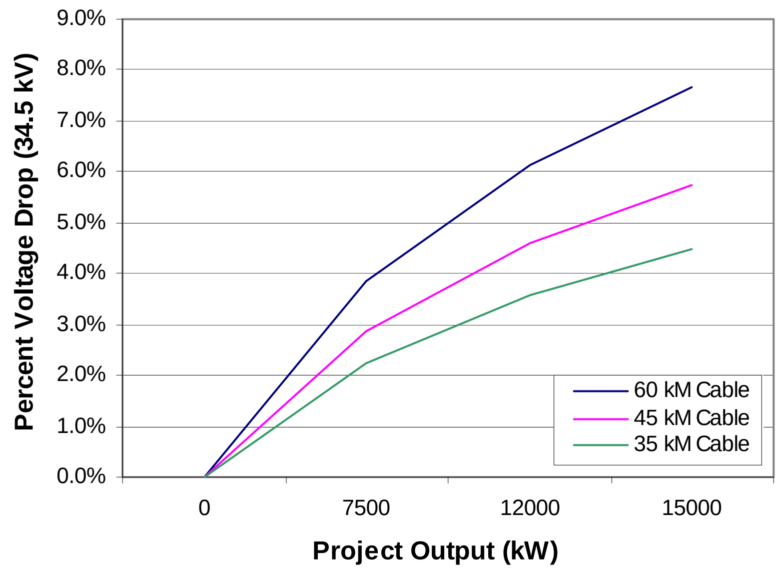

Figure 4-7: Voltage drop characteristics for a 240 mm^2 cable

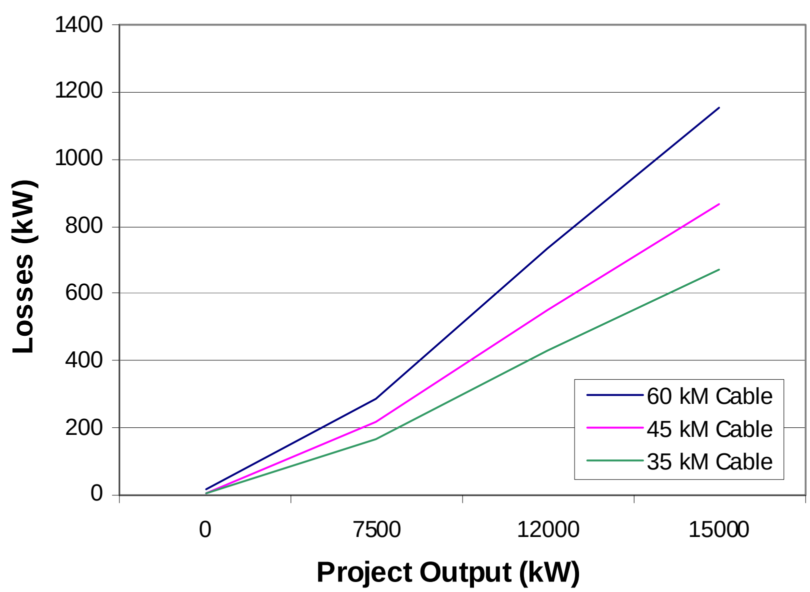

Figure 4-8: Kilowatt (kW) loss characteristics for a 240 mm^2 cable

4.5 LARGE OFFSHORE WIND INTERCONNECTIONS

The preceding interconnection assessments have been focused on the interconnection of small (30 MW or less) offshore projects. Most of the coastal Maine electrical transmission infrastructure has limitations to the amount of generation that can be added to those facilities without significant upgrades. A fair number of sites can readily accommodate the smaller, 15 to 30 MW, projects without major adjustments to the system infrastructure.

Larger projects in the 200 MW to 300 MW range present a broader range of issues and concerns that are beyond the scope of this assessment. Projects of this size are better suited to interconnection to the 345 kV transmission system or significant 115 kV multi-line facilities due to the greater level of capability. The most immediate sites for an off shore interconnection of this size are located in Lincoln County.

4.6 OFFSHORE CABLING ASSESSMENT

This section has been prepared to provide a summary of the coastal-engineering, environmental and permitting issues associated with transmission cable laying/trenching and operations for a proposed demonstration project of a floating offshore wind turbine in the GoM. The intent of this assessment is not to plan a cable route, but rather to provide a summary of considerations for the selection of an appropriate cable route.

An introduction to the key coastal physical forces is presented, along with anthropogenic concerns associated with marine space-use conflicts. The commonly used approaches to installing submarine cables at offshore wind farms are described, along with the interaction and importance of physical forces during the installation process. In addition, guidance suggestions for the preliminary planning of cable routes are provided.

Furthermore, environmental concerns are identified, along with a summary of endangered species and endangered habitats that may be encountered in the area to be considered. The permitting process required for the installation of a subsea transmission line is also discussed, along with identification of the appropriate jurisdictions and regulatory agencies to be involved.

4.6.1 Key Coastal Forces

The primary marine physical processes associated with infrastructure placed in the offshore environment are waves, water levels (tides and surges), currents, and ice. A secondary response to the marine physical forces is the movement of sediments and supporting soils. While this is not intended to be a met-ocean study, some insight into each process is relevant to later discussions, so each will be described briefly. Detailed data on met-ocean conditions in the GoM is provided in Section 3.0.

Waves

In the GoM there are two types of waves: wind waves and swell waves. Wind waves are generated locally within the Gulf itself due to the wind stress over the water. These waves tend to have a relatively short wave period, and are subject to fluctuations associated with the passage of individual weather systems. Swell waves are longer period waves that may be generated hundreds or thousands of kilometers away and have typically travelled great distances before reaching the point of interest.

With regard to extreme wave events, the GoM is subject to hurricanes and extra-tropical storms, as well as North Atlantic storms commonly referred to as Nor'easters. These extreme wave events are likely to be the wave conditions governing design. It is therefore necessary to consider these extreme events when determining extreme loads due to waves.

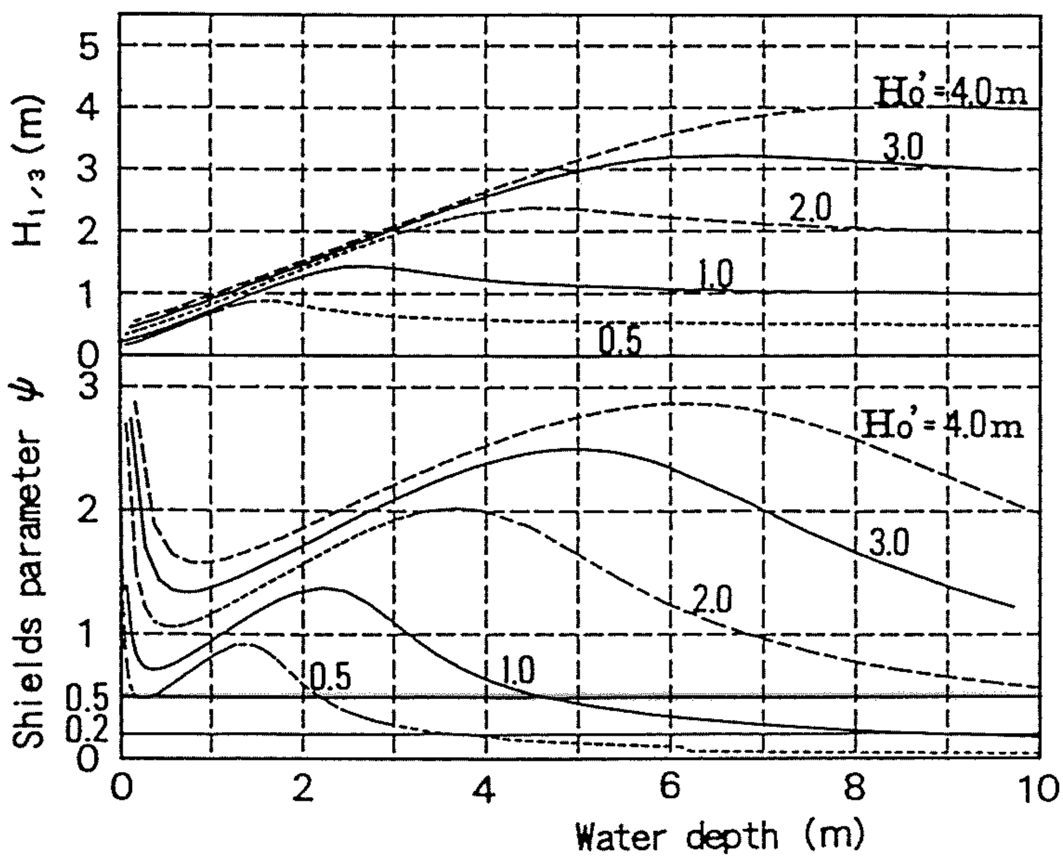

Figure 4-9: Cross-shore distribution of Shields Parameter (ψ) under different wave conditions (Watanabe et al., 1991)

With regard to submarine cabling interests, there are two primary concerns. One is the presence of waves during construction/installation, and the other is the velocities at the bed associated with wave-induced currents that act throughout a cable's operational period of service. Figure 4-9 illustrates that in most wave conditions, nearshore bed material exceeds a Shields parameter of 0.5. This indicates that the material is close to entering the sheet flow regime[3]. Cable in this area would experience scour (described later in this section).

Water levels

Water levels in the GoM are dominated by the motion of the tides. Table 4-15 provides tidal statistics for Portland and Bar Harbor. Information on tidal benchmarks, datums, harmonic constituents, and sea level trends is available at the NOAA National Ocean Service (NOS) website http://tidesandcurrents.noaa.gov . Information is available for the current tidal epoch (1983 – 2001) and the previous (superseded) tidal epoch. Benchmark elevation information relative to North American Vertical Datum of 1988 (NAVD 88) and National Geodetic Vertical Datum of 1929 (NGVD 29) is available via web links to the NOAA National Geodetic Survey (NGS).

Tidal fluctuations are predictable and it is possible to predict future tidal variation with relative ease. Over the short term, water levels also vary in response to climatic conditions (referred to as storm surge). A local rise in the sea surface due to a low pressure system is possible, although relative to the tides on the GoM, the amplitude of water level fluctuations from barometric change are relatively insignificant; on a macro-scale, however, the fluctuations caused by barometric change can drive synoptic-scale currents that impact sediment transport. In nearshore areas, the effects of storm surge can be amplified by wind and wave setup. Over the long term, the changes are related to global sea level rise and local tectonic change.

Long term sea level rise is an ongoing process throughout the world. Historic rates are generally estimated to be on the range of 3.2 mm/year (or 0.16 m over 50 years). The rate of sea level rise is increasing however, and while climate change scenarios are not precise, they range from approximately 0.16m to 0.5 m over the next 50 years (IPCC, 2007 and Rahmstorf, 2007). While there is great uncertainty in climate change estimates, prudence suggests some consideration should be given to it.

[3] Sheet flow describes a condition where when the sediment is mobilized across the seabed. The sheet flow condition is identified as the most important sediment transport mode due to the large sediment transport rate. (Hsu, 2003)

Water levels are of importance to the cabling on potential projects in several ways: first, the tidal change and barometric pressure associated with Nor'easters generates significant currents (discussed in the next subsection), as well as issues associated with installation tension/equipment limitations, and operational slack from the floating unit.

Water levels can be affected by winds, the inverse barometer effect driven by large atmospheric weather patterns (1 mb atmospheric pressure ~ 1 cm change in water level), differential heating and cooling, and ocean currents.

Table 4-15: Tidal Statistics for Portland and Bar Harbor, Maine (based on NOAA National Ocean Service benchmark tables)

TIDAL STATISTICS	Portland (8418150)		Bar Harbor (8413320)	
	(m)	(ft)	(m)	(ft)
Highest Observed Water Level	4.305	14.12	4.941	16.21
Mean Higher High Water (MHHW)	3.019	9.90	3.466	11.37
Mean High Water (MHW)	2.886	9.47	3.336	10.94
North American Vertical Datum 1988 (NAVD88)	1.601	5.25	1.821	5.97
Mean Sea Level (MSL)	1.505	4.94	1.728	5.67
Mean Tide Level (MTL)	1.495	4.90	1.726	5.66
Mean Low Water (MLW)	0.105	0.34	0.116	0.38
Mean Lower Low Water (MLLW)	0	0	0	0
Lowest Observed Water Level	-1.053	-3.45	-0.775	-2.54

Water levels are higher in the GoM – Bay of Fundy system than other areas of the East Coast due to constructive wave-wave interaction as a result of a near match in the natural resonance period of the basin (~13 hours) and the M_2 (12.42 hours) and the N_2 (12.66 hours) tidal constituent periods.

Currents

There are several primary sources of currents throughout the nearshore areas in the GoM. These include wave-induced currents, tidal currents, density-driven currents, and large scale synoptic currents associated with Nor'easters and other surge events. Near the surface, wind-induced currents can also play an important role. In deeper waters offshore, there are additional ocean currents associated with oceanic and regional scale currents however these are of less significance to cabling installation and operation. The importance of currents is significant as it is often not possible to use divers or some types of submarine equipment such as remotely operated vehicles (ROVs) when the currents are too strong, and currents act as driving forces for sediment transport.

Tidal currents are more predictable than wave-induced currents, but the magnitude of the currents can still be a significant limitation for commercial diving operations in support of nearshore cabling and/or ROV work. In addition, the presence of cables or other infrastructure on the sea bed may result in scour, or vibrations induced by vortex shedding that could damage the infrastructure.

Finally, several studies have identified the presence of synoptic currents due to the large-scale Nor'easter events that drive overall currents near the shore to the south along the Atlantic coast of Canada and the United States. These large-scale currents carry material suspended by waves and drive migration of major sand and gravel shoals present in water depths of up to 40 m (about 130 ft).

Ice

Ice is not a significant concern to submarine cables in the GoM and as such will not be discussed.

Sediment Transport

Sediment transport is the process of sediment moving along the sea bed in response to an external force (usually a current). Sediment transport rates in the GoM are generally greatest in nearshore areas with breaking waves and near the mouth of rivers. Sediment transport is the primary driver of dynamic bed change relevant to cabling processes. From the perspective of cabling, there are two major concerns during the operational phase: Scour and the overall movement (or migration) of large seabed features. During installation, the mobility of the sediment is also a critical element that may govern the installation approach.

Scour is the erosion of sediments caused by the presence of a hardened feature on or near the bed. The modified hydrodynamics as the water flows around the structure causes the scour pattern to develop. The concern is that quite often the material that is scouring is supporting soil, which could lead to the failure of the infrastructure. The time-scale of scour can be on the order of minutes and hours in sand, gravel and loosely consolidated fines, however it is slower in clay, generally on the order of weeks, months, and years. Scour is also possible in bedrock, although the process is slower still (measured over years or decades) and is usually dependent upon the presence of an abrading agent such as thin veneers of sand or gravel (Sumer and Fredsøe, 2002). In areas with variable bed conditions, some areas may scour more readily, creating free-spanning sections of cable that could experience fatigue from vortex-induced vibrations as well as additional tensile load.

The longer term morphology of seabed features, particularly sand and gravel deposits is also of concern. There is documented evidence of sand and gravel features on the outer and inner continental shelves migrating at 2 – 12 m (6.5 – 40 ft) per year due to large scale synoptic currents driven by Nor'easters (Swift and Field 1981, and USACE 2008). These features are not as prominent in the rocky areas of Maine's inner continental shelf, however there is some evidence that they exist.

Fine silts and cohesive materials with significant amounts of clay particles on the bed is also a distinct issue with regards to sediment transport – the material that is mobilized enters suspension very easily and is often too fine to settle quickly in the local area of disturbance, instead it is dispersed and settles elsewhere, often very far from the area of disturbance. In general, when conducting underwater construction, silts or clays disturbed may be considered dispersed and not available for backfilling of trenches or other submarine excavations. They are also the material most likely to cause clouding of the water and the negative environmental and construction conditions associated with the reduced visibility. The muddy seabed regions of Maine's inner continental shelf may exhibit these characteristics.

Rare Underwater Events
Submarine cables may be subject to submarine landslides or fault dislocation (earthquakes). These events are considered rare, special cases. During the detailed design and geophysical investigation phases, however, designers should look for fault lines and unstable soil masses.

4.6.2 Marine-based Anthropogenic Concerns

The primary marine-based anthropogenic concerns to offshore power cables are associated with damage to the cables from fishing equipment (in particular, trawlers) and dragged anchors. This condition has long been an issue in the communication and power transmission cable industries. Restrictions on fishing and anchoring activities are often posted on hydrographic charts, and these pose the greatest space-use conflicts for submarine portions of transmission cables. Where existing shipping lanes or fishing grounds are established, alternate cable routes may be the only alternative acceptable to regulatory agencies and insurance companies alike. Where cables must cross these areas, significant mitigation measures should be planned, and shipping/fishing schedules worked around during construction. A separate anthropogenic issue is related to archaeological targets, such as shipwrecks and UXO (unexploded ordnance). In general the cable route must go around these items; surveys done prior to the final cable route planning should detect them.

4.6.3 Mitigation of Primary Hazards and Concerns – Trenching and Armoring

Proactive mitigation against coastal forces and anthropogenic concerns typically involves trenching the cable below the bed surface and re-instatement of the bed above the cable. This provides some degree of protection for the cable and separates the cable from the benthic habitat to reduce the introduction of anthropogenic material in the benthic region. In some cases, trenches are backfilled with material that is more stable than the original material, such as coarse stone and gravel. This is more common in locations where the native material has some stability issues or is too fine to settle back into the trench on its own (Michel et al., 2007). In extreme cases, rock protection or articulating concrete block mattresses may be laid over cables. There is the further opportunity to install cables with additional internal-armor steel cabling. This armoring will not typically protect the cable from all anthropogenic damages (i.e. fishing and anchor drag).

Trenching of submarine transmission cables for offshore wind farms has become standard practice, however in some cases the smaller cables that run between individual units has not been trenched, opting instead for laying an armored cable directly on the bed (Wright et al., 2002). Depth of trenching is usually in the range of one to three m (about three to ten feet), however the cost increases for increasing depth, particularly in firm soils. The following sections will describe the cable-laying process, including the various approaches for trenching. In water depths greater than approximately 1000 m, the ICPC suggests disturbances from anthropogenic sources are very rare and therefore burial is not necessary (Carter et al., 2009). These water depths are not expected to be encountered for the proposed project.

4.6.4 Cable-laying Techniques for Offshore Power Transmission

Transmission cables for offshore wind farms are normally placed below the seabed in a trench, particularly for the main transmission lines. Smaller lines that run between individual turbines within a wind farm are often laid directly on the sea bed. This section describes the process of laying the cables and trenching them. The equipment will be briefly presented, and where appropriate, limitations on its use provided.

Cable-laying Vessels

Cable-laying vessels are purpose-built or specially-modified ships with design features specifically for the laying and maintenance of submarine cables. The primary feature of these vessels is the capability to un-coil and lays the cable directly onto the bottom. This is conventionally done off the stern of the ship, however some vessels are equipped with the capability to deploy cable from the bow of the vessel as well. The vessels normally have clean-rooms available for splicing cables. All of the equipment associated with the deployment of the cable (including ROVs and ploughs) is controlled directly from the ship, and is linked to the laying vessel's positional system.

Although depth restrictions are vessel-specific, in general the vessels are ocean-going vessels and they cannot typically operate in shallow nearshore waters, relying on tenders and other shallow-draft barges to assist with the deployment in water depths less than (typically) 8-10 m. The presence of the cable essentially constrains the vessel to a relatively small area and a single course or heading. Since it is very expensive to cut and splice a cable unnecessarily, cable-laying vessels are often considered immovable obstacles to other sea traffic due to this constrained maneuverability. Their reduced mobility and the cost of severing the cable unnecessarily means that it is advantageous to lay cable in continuous stretches, undisturbed by met-ocean conditions and shipping traffic. It is therefore critical that appropriate planning is conducted to achieve the maximum up-time possible during the cable-laying process.

Mechanical Plough

A mechanical plough is a device towed behind the cable-laying vessel that runs along the bottom and simultaneously digs a trench and lays the cable into the trench. The sledges can be adjusted to achieve optimal burial depth. Under ideal conditions, it is possible for a plough sledge to lay a cable up to five m deep (15-16 ft). With most ploughs, the sediments are displaced in such a way that they are likely to settle back into the trench, essentially covering the cables back over. This is not true, however, in very fine silts and clays, where the material is likely to be re-suspended and be transported away from the trench. Mechanical plowing is relatively efficient in sands and cohesive material with moderate levels of compaction. With stiffer soils, alternative measures may be required. Extremely soft soils (loose organic matter, for example) create some challenges for this installation technique as the ploughs sink into the bed rather than skimming across the top on their skids.

Some modern mechanical ploughs are assisted with high-pressure water jet nozzles. The water jets help to fluidize the sediments, reducing the stress on mechanical components of the plough, and increasing the rate at which the trenching operation can occur without measurably increasing the towing load on the vessel. The addition of the jets also helps the trenching process achieve greater depths in stiffer soils. Under good conditions, mechanical ploughs can trench and lay cables at rates in excess of 18 m (60 ft) per minute.

Jet Plough

Jet-plowing is a technique where a high-pressure jet of water is directed at the bed, fluidizing the bed sediments and creating a trench that a (typically) previously-laid cable settles into. The jets may be mounted to a guide-head from a ship-based pumping system, or located on the underside of an ROV. Guide-heads and ROVs are normally designed to use the existing cable as a guide. This technology is also used to re-bury cables if they become exposed, and to assist with the recovery of previously buried cables. Similar to mechanical plowing, jet-plowing usually results in the material settling back into the trench, unless the material is very fine. ROVs that bear on the soils may become bogged-down in extremely soft soils.

The rate of trenching is dependent upon the conditions. During the installation of the Q7 wind farm in Holland, sandy soils were trenched at approximately 3.3 m (10.8 ft) per minute in the shallow nearshore, and 10.2 m (33.5 ft) per minute in the deeper portions using an ROV-based jet plough (Subtrench Pty Ltd., 2010).

ROV Drilling/Chainsawing
When very firm soils or rock is encountered, an ROV equipped with a rock-saw is required. The saw is essentially an underwater chain saw that saws through rock along the cable route. While the progress is slow and expensive (less than two meters per minute (2 m/min)), the tools are capable of trenching into solid rock where necessary. In many cases, the ROVs that are equipped for jet-plowing can be fitted with the rock-cutting tools. Rock-cut trenches are often backfilled with a stable material.

Dredging
Dredging is a conventional technology that is sometimes used in the installation of buried cables and pipelines, particularly when there are contaminated sediments that cannot be allowed to re-settle onto the bottom. Dredged material can be pumped up to a ship and disposed of elsewhere, or cleaned and pumped back down to the trench. Dredged channels are generally wider, take longer to cut, and are more expensive than the previously-mentioned approaches to trenching.

Energetic Zones – Shoreline Approach and Cable Landing
From a coastal perspective, the most energetic and dynamic zone is near the shore, where waves break. This dissipation of wave energy creates a dynamic environment under constant change – sediment features, particularly on sandy shores, migrate in both the long-shore and cross-shore directions. Natural and anthropogenic features that interrupt the movement of sediment can cause significant and relatively rapid changes to the nearshore bed surface. Nearshore areas also tend to be productive ecological areas. For this reason, cable burial is always recommended, and many recent and proposed projects have taken advantage of horizontal directional drilling (HDD) (Worzyk, 2009).

HDD can be conducted from land, creating a conduit that the cable is passed through. Lengths in excess of 1000 m (3280 ft) can be achieved when working from shore. The use of HDD virtually eliminates any interruption to the local habitat in the nearshore regions and allows the cable to be buried much deeper than conventional trenching technologies would allow. HDD can be conducted in most soil conditions, including rock – although it is more expensive and slower than through soil.

If the cable is not buried to sufficient depth, armor above the cable is recommended to protect the cable from coastal forces. In the nearshore, this typically consists of stone or concrete armor units of considerable size.

4.6.5 Recommended Coastal-Related Investigations to Support Cabling Design and Planning

Two primary studies are recommended to support the cable-laying process in conjunction with these projects. This work should include a geophysical investigation and a coastal engineering study. Each will be described in general below.

Geophysical Investigations

Geophysical investigations are required along the entire cable route. The timing of this work may be synchronized with other offshore field work to minimize repeated mobilizations. While this summary is not intended to provide a complete scope of work for a geophysical investigation, the following elements should be considered for a geophysical study:

- **Desktop study**: The desktop study should prepare a synthesis of known anthropogenic and natural features of relevant importance, including (but not limited to) shipwrecks, fault lines, anticipated sediment types, historical feature migration, historical bathymetry, and the geological history of the area.

- **Multi-beam hydrographic survey**: Det Norske Veritas (DNV, 2007) suggests that multiband coverage is recommended along the planned cable route area at a minimum using the following performance specification: IHO S44 "Special Order" (5th Edition, February 2008). This standard is used as the baseline for most of the other standard reference documents used in hydrographic surveying throughout the world. This will allow for the detection of items on the seafloor and will give an accurate depiction of bathymetric changes along the cable route. Single-beam echo sounders typically do not provide the required resolution for accurate planning of a cable route.

- **Sidescan sonar**: Sidescan sonar investigations can detect objects on the seafloor that are difficult or impossible to trench through. Sidescan sonar is specified as a minimum requirement by BSH (BSH, 2003) along planned cable routes.

- **Sub-surface profiling**: The use of sub-bottom profilers (boomers or chirp units) is useful for detecting layers of different materials within the bed, as well as the possibility of detecting erratics or other features that may make cable trenching difficult. BSH (BSH, 2003) recommends a minimum resolution of 0.5 m along planned cable routes.

- **Sediment quality**: Sediment grab samples along the planned cable route should be tested for contaminants and heavy metals that may create environmental challenges.

- **Archaeological searches**: Magnetometers and drop-cameras are recommended to detect any archaeological or cultural artifacts that require protection under local regulations.

- **Later geotechnical sites**: During the geophysical investigations, it is recommended that possible sites for later geotechnical work be identified and additional geophysical data be collected at these sites, including shallow cores. These shallow cores will provide some understanding of the trenchability of the material. In particular, it may be possible that some sites classified historically as muddy are more consolidated than the remote sensing suggests. Local testing is recommended to estimate the strength of the soils for supporting trenching equipment. In addition to conventional soil properties such as grain size, gradations and shear strengths, recommended tests for trenchability are: strain rate effects, permeability (sands/silt), shell content, plasticity, compressibility and relative density (Offshore Soil Investigation Forum, 1999)

Coastal Engineering Study
In the context of cable route planning, a coastal engineering study should encompass met-ocean investigations and shore/bed morphology.

- **Waves**: A full wave climate should be developed. In most cases, getting a long enough record of the wave climate will require undertaking a wave hindcast, or leveraging an existing wave hindcast. Extreme value analysis and risk-based approaches should be employed to select representative events for further analysis and wave transformation. The measurement of waves near proposed project areas is recommended to calibrate the models to the local conditions. It is also recommended that the wave climate near the cable-landing site be determined for use in sediment transport modeling efforts, and to support the design of protection measures over the cable trench, if necessary.

  It is recommended that wave modeling undertaken for the coastal engineering study be synchronized with wave modeling undertaken for other design elements in the study. DNV (DNV 2007) and GL (GL, 2005) both recommend accurate wave hindcasts be developed and calibrated with site-specific measured waves for the design and planning of offshore wind farms.

- **Water levels**: A desktop study of recorded water levels in the vicinity of the planned cable route is recommended. Where water level data are not available, it is recommended to have fixed measured values for at least 30 days to establish local tidal constituents. In the regional analysis, there are existing NOAA water level recording stations at Portland and Bar Harbor. Water level events captured in observational data will help to understand the surge and setup conditions associated with the passage of storm events in the local area.

In the GoM, this is especially relevant with the passage of Nor'easters. The understanding of the water level and its variability can be used in the calibration of hydrodynamic models.

- **Currents**: Tidal currents, wave-induced currents, and synoptic currents are important in the GoM. It is recommended that existing hydrodynamic models for the GoM be leveraged and the resolution improved in the vicinity of the proposed project area, or new models be developed to gain a full understanding of the currents throughout the study area. Current measurements for calibration of the model(s) are highly recommended. A resolution sufficient to identify areas of strong or focused currents along the cable route should be employed.

  Strong currents can dictate change to bed conditions and provide conditions during construction where the use of divers and remotely operated vehicles is limited. There may be geographic areas where specific tidal windows are required to allow for safe installation of submarine cables, and the hydrodynamic model can identify these for the planning of the installation process.

- **Sediment transport**: A study of the baseline sediment transport conditions across the entire planned cable route is recommended. This includes identifications of dynamic features (ridges and shoals), as well as an assessment of longshore sediment transport and shoreline change in the vicinity of the cable landing area. Any areas that are particularly susceptible to scour can also be identified and appropriate measures recommended.

4.6.6 Summary of Guidance and Constraints

The following represents key guidance issues and coastal engineering considerations to take into account when planning a cable route:

- **Bed material – type**: In general, there are two types of soil conditions to be avoided if possible: bedrock and thick layers of very soft sediments like silts and soft organics. The areas of exposed bedrock may require drilling/sawing to trench the cables, and in the very soft areas, trenching equipment may not be able to be supported by the bed. Mud is the second most common seafloor type on the Maine Inner Continental Shelf, comprising 39% of the seafloor substrate (Department of Conservation, 1996). It may be necessary to work with specialized light equipment to trench through muddy areas if trenching is desired in these areas. It may also be possible that current data (based upon remote sensing techniques) does not provide a good representation of the bed material strength in these areas. Material strength testing is recommended during a geophysical study.

The most preferred material is sand and gravel of medium to medium-low compaction. Unfortunately, these are not common features on the seafloor of Maine's Inner Continental Shelf. Heavily compacted sand and cohesive material is difficult to trench through and is therefore less desirable in areas where trenching will be used. Unfortunately, close to 41% of the geology on Maine's Inner Continental Shelf is comprised of exposed rock (Department of Conservation, 1996). Therefore sites with access to sandy cable routing corridors should be preferred from a cabling perspective.

- **Bed material – quality**: In areas where the sediment contains contaminants or other minerals that should not be re-suspended into the water column, more costly installation measures may be required. If possible, areas with known contaminants should be avoided or minimized. Areas where contaminants are frequently found offshore include offshore disposal sites of dredgeate, the vicinity of current or historical port operations, the mouth of rivers, nearby historical waste outfalls, and offshore mineral extraction sites.
- **Bed conditions – items to be avoided**: Any identified anthropogenic items like shipwrecks and unexploded ordnances should be avoided at all costs, usually by routing the cable around these features. Additional features or areas that should be avoided include areas with a high number of erratic boulders from glaciations and other pipelines/cables. While it is sometimes done, crossing other pipelines and cables is generally expensive and carries with it a greater risk of damage to existing infrastructure; the ICPC dictates the individual or organization laying the second cable is liable for any damages to the first one – repair of damaged cables and pipelines can be extremely expensive.
- **Bathymetry and bed features**: Large sand and gravel ridges and shoals on the inner continental shelf are dynamic and subject to migration and change in form. Most of the offshore ridges and shoals that exhibit migratory behavior in the GoM can be identified by their Southwest – Northeast elongated shape. They may be quite large and in some cases could be unavoidable, but generally placing cables a reasonable distance from these is less risky than placing cable across them. An appropriate distance is the migration rate times the number of years in the planning horizon for the project site (e.g., A cable intended to be in service for 25 years should be a minimum of 12 m/year x 25 years x 2 (factor of safety), or 600 m total from a feature that has historically migrated at 12 m per year). In some cases underwater canyons and rapid changes in bathymetry will necessitate longer lengths of cable than following the level contours.
- **Local complex met-ocean conditions**: The identification of bathymetric features likely to cause localized extreme currents or bed change should be identified, and if possible, these areas avoided or as a minimum trenched through. In locations where wave breaking conditions exist, particularly in the

nearshore, it is highly recommended that trenching or directional drilling be considered. If there are sheltered locations available with minimal or no exposure to breaking waves available for the cable landing, these areas should be considered as they may provide for lower cable trenching costs.

- **Navigation concerns**: Close to one quarter of all damages to submarine cables in the Mediterranean Sea between 1993 and 2007 were caused by anchors (France Telecom Marine). For this reason alone, it is prudent to avoid primary navigation corridors. Additionally, the installation vessel is generally not maneuverable outside of its planned heading during cable installation and is therefore a hazard to navigation. The ICPC recommends that hydrographic charts get updated with cable locations and areas restricting anchoring be identified (Carter et al., 2009). If navigation channels must be crossed, they should be crossed in the most direct way possible, and additional protective measures should be planned.
- **Fishery concerns**: Close to half of all damages to submarine cables in the Mediterranean Sea between 1993 and 2007 were caused by fishing activity and hardware (France Telecom Marine). Similar to navigation concerns, fishing grounds should generally be avoided if possible. The ICPC recommends that hydrographic charts get updated with cable locations and areas restricting fishing be identified (Carter et al., 2009). If fishing grounds must be entered by cable routes, it is recommended that the cables be trenched and appropriate substrate suitable for fish habitat be placed on top of the trench.
- **Undertake recommended studies**: Once sites are selected, it is highly recommended that the geophysical and coastal engineering studies be undertaken to minimize risks and reduce uncertainty related to the laying and/or trenching of cables. It is likely that the investigations will also identify areas of concern that can be avoided to reduce the cost of the cable installation process.

4.6.7 Environmental Concerns and Impacts

Given that the best and most flexible grid interconnection points are within the Bath, Wiscasset, Boothbay and Rockland areas, it is likely the subsea transmission line may run along or under the seabed from a project site onto shore in the area of Linekin Bay and part of the tidal Damariscotta River and Johns Bay to connect with the electrical grid. There are 2,485 known species of plants and animals in the GoM including phytoplankton (310), macrophytes (271), invertebrates (1,414), chordates (37), fishes (252), birds (177), and mammals (24). The GoM supports mainly boreal, cold temperate, and non-migratory species.

The Linekin Bay, Johns Bay and tidal Damariscotta River forms a complex of bays, inlets, bights and estuaries that provide habitat that supports extensive fisheries for benthic fauna, including crustaceans (lobster, rock crab and shrimp), and mollusks (scallop, oyster, and blue mussel aquaculture, and soft shell clam harvest). Lobster and crab have affinity to bottom cover such as rock outcrops and kelp beds and are thus trapped, whereas shrimp are somewhat more pelagic and harvested in trawls. Scallop are harvested with bottom trawls, whereas oyster and blue mussel are raised in floating pen structures near shore in protected coves; clams are harvested manually from intertidal mud flats. The upper Damariscotta estuary represents the northernmost point of distribution of native populations of the Virginia oyster (*Crassostrea virginica*). The upper extremity of the estuary is one of a few remnant Virginian refugia ecosystems remaining in the GoM (P. Larsen, Bigelow Laboratory, Boothbay Harbor, personal communication).

Several migratory fish species may transiently occupy the area considered for the subsea cable. The estuary directly or indirectly supports a significant anadromous alewife run that migrates up the tidal river to spawn in Damariscotta Lake in Newcastle during May and June. Juvenile alewife exits the estuary during September and October. Atlantic salmon inhabit the adjoining Sheepscot River watershed, and some component of this population may pass through the Linekin Bay/Damariscotta River area during the marine migration. In the spring (late April through June) pre-spawning adults would enter the freshwater river and juvenile smolts would exit to begin the marine phase of their maturation. Some post-spawned adults may leave the river and potentially pass through a project area in the fall (late October through November). Most of the tidal and estuarine area in the Midcoast area between the Kennebec and Damariscotta rivers (including a potential project vicinity) is known to be inhabited by shortnose and Atlantic sturgeon.

The Endangered Species Act (ESA) prohibits any action that results in the take of a federally listed species. A Biological Assessment is required to determine if the installation of the cable would result in a take of a federally listed species (see Section 5.1.2) and if this is determined to be the case, an incidental take permit will be needed. To obtain an incidental take permit, a habitat conservation plan needs to be developed with input from the National Marine Fisheries Service (NMFS). The Marine Mammal Protection Act (MMPA) prohibits the take of marine mammals. Similar to the ESA, the MMPA contains an incidental take provision. Some marine mammals (i.e., Northern right whale and marine turtles) are also on the ESA list.

Federally listed species in this area that will need to be assessed include five endangered whales: northern right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), finback whale (*Balaenoptera physalus*), sperm whale (*Physeter catodon*), and sei whale (*Balaenoptera borealis*), two endangered turtles: leatherback turtle (*Dermochelys coriacea*), Atlantic ridley turtle, also known as Kemp's ridley (*Lepidochelys kempii*), and one state and federally listed threatened turtle: loggerhead turtle (*Caretta caretta*). The shortnose sturgeon (*Acipenser brevirostrum*) is a federally listed endangered fish, as is the Atlantic salmon (*Salmo salar*). NMFS recently completed as

ESA status review for Atlantic sturgeon (*Acipenser oxyrinchus*) and determined that listing the species as threatened is warranted for the GoM distinct population segment.

In addition there are 32 species that will need an Essential Fish Habitat (EFH) assessment as required by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSA) (amended in 1976 and 1998). This EFH assessment is based on the regulations implemented in the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) EFH Final Rule, 50 Code of Federal Regulations (CFR) Part 600 (NOAA 2002). The objective of this EFH assessment is to describe how the actions of a proposed project may affect EFH and EFH-managed species within the area influenced by the proposed project. According to NMFS, EFH within the Project area includes those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. Table 4-16 is a list of EFH-managed species and life stages that have been determined to occur within the proposed cable area.

4.6.8 Permitting Considerations for Interconnection Cable

Permitting requirements for the installation of a subsea interconnection cable for projects in State waters are governed by Public Law 2009, Chapter 615. The law gives Maine Department of Environmental Protection (DEP) permitting authority over offshore wind power projects statewide. The Natural Resources Protection Act (NRPA) was amended through the law, creating a new general permit process for offshore wind energy demonstration projects. It also directed the Bureau of Parks and Lands (BPL) to enact a rule by April 9, 2011, that establishes a fee schedule for submerged lands leases for renewable ocean energy projects.

The intent of the new law, consistent with findings of the Governor's Ocean Energy Task Force (OETF) is to streamline the permitting process and limit duplication of reviews and approvals by lead agencies. Essentially this means that the same application "package" can be utilized in applying for the various agency approvals.

Table 4-16: Essential Fish Habitat designated species for Midcoast Maine

SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
American Plaice, *Hippoglossoides platessoides*	X	X	X	X
Atlantic Cod, *Gadus morhua*	X	X	X	X
Atlantic Halibut, *Hippoglossus hippoglossus*			X	X
Atlantic Herring, *Clupea harengus*	X	X	X	X
Goosefish, *Lophius americanus*		X	X	X
Haddock, *Melanogrammus aeglefinus*	X	X	X	X
Ocean Pout, *Macrozoarces americanus*			X	X
Offshore Hake, *Merluccius albidus*		X	X	X
Pollock, *Pollachius virens*	X	X	X	X
Redfish, *Sebastes spp.*		X	X	X
Red Hake, *Urophycis chuss*	X		X	X
Sea Scallop, *Placopecten magellanicus*				X
Silver Hake, *Merluccius bilinearis*	X	X	X	X
White Hake, *Urophycis tenuis*	X	X	X	X
Windowpane, *Scophthalmus aquosus*			X	X
Winter Flounder, *Pseudopleuronectes americanus*			X	X
Witch Flounder, *Glyptocephalus cynoglossus*	X	X	X	X
Yellowtail Flounder, *Limanda ferruginea*	X	X	X	X
Red Deepsea Crab, *Chaceon quinquedens*			X	X
Barndoor Skate, *Dipturus laevis*			X	X
Little Skate, *Leucoraja erinacea*			X	X
Smooth Skate, *Malacoraja senta*			X	X
Thorny Skate, *Amblyraja radiata*			X	X
Winter Skate, *Leucoraja ocellata*			X	X

Leases or easements are required for utility cables and therefore a proposed project connecting to the ISO-NE grid will require a submerged lands lease from BPL. A permit will be required from the United States Army Corps of Engineers (USACE) under Section 10 of the Rivers and Harbors Act and Section 404 for the Clean Water Act. The application must include a written request with the following:

- Application for lease or easement of Submerged Lands;
- Application for a wetlands alteration permit, or equivalent application from the Department of Environmental Protection; an application for a building, development, great ponds, or equivalent application from the Land Use Regulation Commission; and
- Any other permitting materials prepared for other agencies with jurisdiction

Generally, the BPL will issue a Preliminary Finding within 60 days of the application, unless additional information is requested. Issuance of the finding begins a 30-day review of impacts from state and federal agencies including but not limited to the Department of Marine Resources (DMR), the Department of Environmental Protection (DEP), the State Planning Office (SPO), the Department of Transportation (MEDOT), and USACE. Qualifying activities cannot adversely impact access to or movement across the waters of the State; public trust rights – fishing, waterfowl hunting, navigation, and recreation; and/or services and facilities for commercial marine activities.

As noted above, the Maine NRPA was amended by law giving DEP authority over offshore wind demonstration projects. While the application has not been specifically modified, it is anticipated that generally the same information required under the prior NRPA application process will be necessary. This includes the following:

- Pre-application meeting;
- Supply of applicant information;
- Project description, location, size of area impacted and site plans;
- Assessment of the amount of impact on resources; and
- Any proposed mitigation measures

The application must also be provided to the Maine State Historic Preservation Officer (MSHPO). The applicant may also submit the application to the USACE. If it chooses not to, DEP will provide a copy to the USACE and coordinate review. The processing timeline for a NRPA permit can take up to 120 days.

Maine statute stipulates that no agency of the State or any political subdivision of the State can issue a lease or conveyance of public land for the purposes of constructing a transmission line unless a certificate of public convenience and necessity (CPCN) is issued by the Maine Public Utilities Commission (PUC).

A permit will also be required from USACE under Section 10 of the Rivers and Harbors Act and Section 404 for the Clean Water Act, for the portion of the subsea cable route in federal waters (over three nautical miles (3 nmi) from the coastline). Due to their cooperative process, USACE will review the same application filed with DEP and typically strives to issue written authorization (required for their Category 2 activities or individual permits) within the same timeframe as the state review process. Under the USACE General Permit review process (in addition to DEP), approvals may be required from Maine Department of Conservation: Land Use Regulation Commission (LURC), Maine Department of Marine Resources: Aquaculture Leases and Maine Department of Conservation, Bureau of Parks and Lands, Submerged Lands.

Due to the location of the proposed cable relative to fish and marine mammal habitat and migration routes, the NMFS will need to be consulted under Section 7 of the Endangered Species Act. It is anticipated that the agency would determine that a proposed project is not likely to affect adversely affect species known to inhabit or pass through the area.

The 2009 Maine state law specifically prevents a coastal municipality from banning the interconnection siting, but there still may be local zoning and/or permitting requirements to be addressed.

For sections of the cable proposed to be located in federal waters, a Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) lease for the Project area would grant one or more easements to allow for installation of the cable route. The easements would be applied for as part of a Construction and Operation Plan (COP) and would be subject to review under the National Environmental Policy Act (NEPA) as part of the COP and would be subject to Coastal Zone Management Act (CZMA) consistency determinations, ESA reviews and other aspects of BOEMRE permitting as further described under the general lease site permitting section of this report (Section 5.1).

4.6.9 Summary Conclusions of Guidance

Cable Installation Conclusions

The general conclusion surrounding the literature review is that trenching of cables is preferred to minimize the risk of damages, and that the technology to trench through all materials exists. Unfortunately, the dominant conditions present on Maine's Inner Continental Shelf do not appear to support easy or cost-effective trenching. While it may be possible to plan a cable route in trenchable materials using information presently available, given the short time period and demonstration nature of the proposed installation, a thorough quantification of risks associated with not trenching the cables could be considered.

It may also be possible to undertake additional studies on the muddy areas of the ICS to see if indeed these areas could support the trenching of cables. Existing literature suggests that most trenching equipment gets bogged down in very soft material and the cables are very difficult to recover for maintenance. If the mud is more consolidated than the Department of Conservation 1996 report on the seabed composition suggests, the material may indeed support trenching and would be the preferred approach over trenching through the bedrock.

Environmental Impact Conclusions

Potential cable routes may come onto shore in the area of Linekin Bay and part of the tidal Damariscotta River and Johns Bay. This embayment provides habitat that supports extensive fisheries, benthic fauna, lobster, rock crab, shrimp, scallop, oyster, blue mussel aquaculture and soft shell clam harvest. Federally listed species in this area that will need to be assessed include five (5) endangered whales, two (2) endangered turtles and two (2) listed and one proposed for listing fish species. In addition, 32 EFH-managed species will require an assessment. These areas will need to be assessed relative to the final cable routing zone to assess the ultimate effect of the transmission cable.

Permitting and Legislative Conclusions

Several state and federal agency approvals will be required for the construction of a subsea transmission line, primarily through permit application processes. Recently enacted state law, intended to streamline the permitting process, places primary state permitting authority with Maine Department of Environmental Protection (MDEP). However, formal permit approvals from and consultation with other agencies is necessary, as well as a submerged land lease. It is recommended that a meeting with all participating agencies take place before entering the permitting process, to confirm the information necessary and to develop a schedule of filings and reviews with agency staff.

5.0 Impact Assessment

5.1 PERMITTING

The section broadly outlines the major permitting requirements for the design, construction and deployment of a "Stepping Stone" wind farm, an up to 30 MW wind farm located 10 – 50 nmi offshore in federal waters, also referred to as Phase 3 of the University of Maine (UMaine) and *DeepCwind* Consortium's Offshore Wind Energy Project Plan ("Plan"). This Plan is illustrated in Figure 5-1.

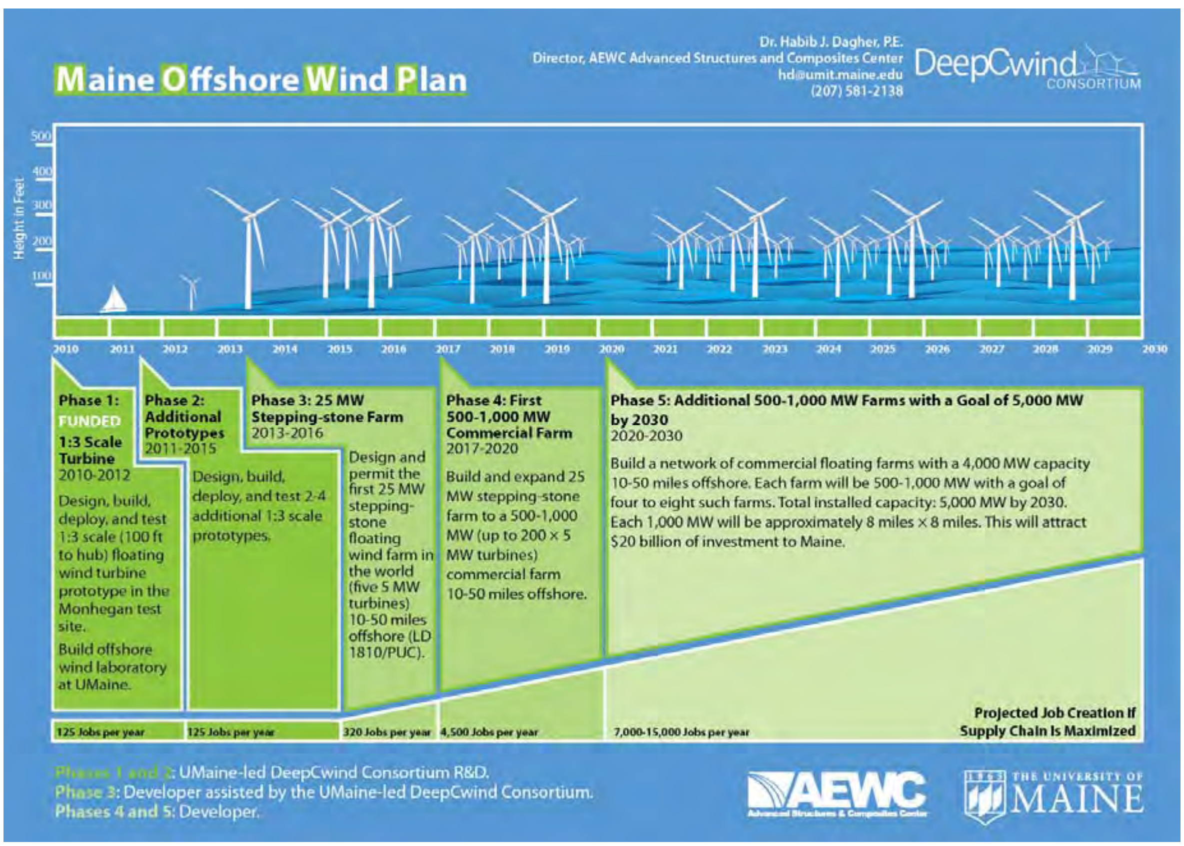

Figure 5-1: DeepCwind Consortium's Offshore Wind Energy Project Plan

Phase 3 will likely involve a transmission line that will run along or under the seabed from a project site onto shore to connect with the electrical grid, and an onshore laydown area where project materials will be stored.

The permitting overview that follows is a preliminary assessment of the permits and other approvals required for the Phase 3 project. Permitting of Phase 3 (up to 30 MW Offshore Wind Energy Project on the Outer Continental Shelf) will include state, federal, and municipal/local permits or authorizations. These are discussed in more detail in Sections 5.1.1 through 5.1.4. Separate discussion of permitting an onshore assembly and staging area may be found in Section 5.1.5.

Because the up to 30 MW Project itself will be located in federal waters, it will not need state or municipal approvals other than Coastal Zone Management Act (CZMA) consistency review (see Section 5.1.2). It is likely, however, that many, if not all, of the state and municipal approvals discussed in Section 5.1.1 will be required for the electric transmission line that will run through state waters and onto the shore, as well as any assembly or deepwater area located in state waters.

5.1.1 State Permits and Approvals

1. Maine DEP Site Location of Development Permit for Offshore Wind Power Project That Impacts State Waters or Lands

The Site Location of Development Act ("Site Law")[4] regulates any "development of state or regional significance that may substantially affect the environment" (Development). An Offshore Wind Power Project[5] with an aggregate generating capacity of three (3) MW or more is a Development that requires Site Law approval.[6] However, an Offshore Wind Power Project (Project) would not fall within the expedited permitting area and therefore must go through the traditional and more rigorous Site Law approval process rather than the expedited process, which has relaxed standards.[7]

[4] 38 M.R.S. § 481 *et seq*.

[5] "Offshore wind power project" means a project that uses a windmill or wind turbine to convert wind energy to electrical energy and is located in whole or in part within coastal wetlands as defined in 38 M.R.S. § 480-B(2). "Offshore wind power project" includes both generating facilities as defined by Title 35-A, Section 3451, Subsection 5 and associated facilities as defined by Title 35-A, section 3451, Subsection 1, without regard to whether the electrical energy is for sale or use by a person other than the generator. 38 M.R.S. § 482(8).

[6] 38 M.R.S. §§ 482(2)(J), 484.

[7] The expedited permitting area includes coastal islands or "all islands in waters subject to tidal influence in the unorganized and deorganized areas" of Maine, but does not include the water itself. 35-A M.R.S. § 3451(3); P.L. 2008, Ch. 661, Sec. C-6.

a. Application Requirements and Review Period

The Site Law approval standards include provisions addressing technical and financial capacity, "no adverse impact on the natural environment," soil types, storm water management and erosion control, groundwater, infrastructure, flooding and blasting.[8] A developer must also demonstrate sufficient right, title and interest to the development area,[9] which may be established through the submerged land lease process discussed below. The "no adverse effect on the natural environment standard" requires a developer to make "adequate provision for fitting the Development harmoniously into the existing natural environment"[10] and to show that the Development will not adversely affect scenic character, air and water quality, or other natural resources in the area.[11] Furthermore, Projects of at least three (3) MW must be designed and sited to avoid unreasonable adverse shadow flicker effects, constructed with adequate setbacks to protect public safety.[12]

Although the Site Law application is filed with the DEP, since the location for the 3-5 MW offshore wind turbine does not fall within the expedited area set forth in statute, the Bureau of Environmental Protection (BEP) may assume jurisdiction over the Project permit application as long as it satisfies one of several criteria, including, but not limited to, (1) involving a policy, rule or law that the Board has not previously interpreted or (2) generating substantial public interest.[13] An application for Site Law approval of a Project would likely satisfy both of these criteria, so the BEP would likely assume jurisdiction.

[8] 38 M.R.S. § 484.

[9] 06-096 Maine Department of Environmental Protection (DEP) Ch. 372(9).

[10] Wind Energy Developments that are in the expedited permitting area are not required to meet the standard that the Development "fits harmoniously into the existing natural environment in terms of scenic character and existing uses related to scenic character." 35-A M.R.S. § 3452. However, since an Offshore Wind Power Project is not in the expedited permitting area, that standard would be required for Site Law approval.

[11] DEP regulations further address the "no adverse environmental effect" standard of the Site Law in Chapter 375. Chapter 375 requires, among other things, the preservation of historic sites, noise control, no unreasonable effect on scenic character, and the protection of wildlife and fisheries, including no adverse effect on wildlife and fisheries lifecycles and no unreasonable disturbance to the habitat of threatened or endangered species, seabird nesting islands, or shorebird nesting, feeding and staging areas. 06-096 Me. Dept. of Env. Prot. Ch. 375. Offshore Wind Projects of at least three (3) MW are exempt from the Site Law requirement to the extent that DEP determines the Bureau of Parks and Lands (BPL) is considering pertinent existing use issues in its review of the Development area. 38 M.R.S. § 488(25).

[12] 38 M.R.S. § 484(10). The Site Law statute also provides that expedited wind energy developments must provide significant tangible benefits as defined in 35-A M.R.S. § 3451(10) and 3454, but this requirement would not apply to an Offshore Wind Power Project because it does not fall within the expedited area.

[13] 38 M.R.S. § 341-D(2).

b. Permit Details

The Site Law approval is valid on an ongoing basis but the approval is void if construction of the Project does not begin within two years from the date of the Site Law approval. If the approved development is not completed within five years from the date that the approval is granted, the BEP may reexamine the development approval and impose additional terms or conditions to respond to significant changes in circumstances that may have occurred during the five-year period.[14]

The BEP may approve a Development in phases, but the application for approval must include plans for all phases of the development to be undertaken. Even if the BEP approves one of several phases of the development based on the available evidence for those phases, the entire proposed development must comply with the Site Law standards in order for each phase to be approved.[15]

c. Applicability of Other Laws and Approvals

Although most Developments located entirely within LURC jurisdiction are exempt from Site Law approval, Projects of at least three (3) MW located within LURC jurisdiction are expressly subject to the Site Law requirements.[16] The DEP may review and approve the entire Project under the Site Law process, if there is a portion of the project area that is located in DEP jurisdiction (e.g., the transmission line that comes ashore), and that portion of the project area constitutes a "Development."[17] Although it is not expressly stated in the Site Law statutes, it appears from the LURC statutes that LURC will retain jurisdiction of a Project only if (1) it is located within one nautical mile (1 nmi) of an island within the unorganized and deorganized areas and (2) if a project qualifies as a community-based offshore wind energy project.[18] Therefore, it is likely that even though the wind turbine will be within LURC jurisdiction, DEP will assume Site Law review of the entire Project. This reflects the general intention from the Governor's Ocean Energy Task Force to have the DEP review commercial Offshore Wind Power Projects.

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[14] 06-096 Maine Department of Environmental Protection Ch. 372(12).

[15] 06-096 Maine Department of Environmental Protection Ch. 372(10).

[16] 38 M.R.S. § 488(9).

[17] 38 M.R.S. § 488(9).

[18] 12 M.R.S. § 685-B(2-C). A "Community-based offshore wind energy project" means a wind energy development with an aggregate generating capacity of less than three (3) MW that meets the following criteria: the generating facilities are wholly or partially located on or above the coastal submerged lands of the State; the generating facilities are located within one nautical mile of one or more islands that are within the unorganized and deorganized areas of the State and the project will offset part or all of the electricity requirements of those island communities; and the development meets the definition of "community-based renewable energy project" as defined by Title 35-A, section 3602, subsection 1. 12 M.R.S. § 682.

If DEP does review and approve the Project, no permit is required from LURC for any aspects of the Project that are covered by the DEP approval.[19] In the unlikely event that LURC retains jurisdiction over the Project, it would be reviewed under LURC's development review and approval statute.[20]

An applicant may appeal a decision of the DEP to the BEP or to the Superior Court. A decision by the BEP may be reconsidered by the BEP or appealed directly to the Superior Court. Any decision of the Superior Court may be further reviewed by the Maine Supreme Judicial Court sitting as the Law Court.[21]

2. Natural Resource Protection Act Approval (NRPA)

The Natural Resources Protection Act (NRPA), 38 M.R.S. § 480-A, *et seq.*, regulates certain activities in, on or over any protected natural resource or adjacent to certain protected natural resources. The developer would need to obtain a NRPA permit for such activities as dredging, bulldozing, removing or displacing soil, sand, vegetation or other materials, filling, or any construction of any permanent structure.[22] Protected natural resources likely to be impacted by an Offshore Wind Power Project (including the turbines, the transmission line, the assembly area or the onshore laydown area and substation) include coastal wetlands and areas of significant wildlife habitat.[23] Coastal wetlands are defined in pertinent part as tidal and subtidal lands and all areas with vegetation present that is tolerant of salt water and occurs primarily in a salt water or estuarine habitat.[24] "Significant wildlife habitat" means, among other things, wildlife areas as mapped by the Department of Inland Fisheries and Wildlife (DIFW) or within any other protected natural resource, habitat for threatened and endangered species, critical spawning areas for Atlantic Salmon, shorebird nesting, feeding and staging areas and seabird nesting islands.[25]

[19] 38 M.R.S. § 488(9); 12 M.R.S. § 685-B(1-A)(B).

[20] 12 M.R.S. § 685-B.

[21] 38 M.R.S. §§ 341-D(4), 346.

[22] 38 M.R.S. § 480-C(2).

[23] 38 M.R.S. § 480-B(8). Keep in mind that with respect to onshore activities, there are other protected natural resources that may also qualify for protection under NRPA, such as freshwater wetlands.

[24] 38 M.R.S. §§ 480-B(2), (8). Under NRPA, an Offshore Wind Power Project is defined as a project, including generating and associated facilities, that uses a windmill or wind turbine to convert wind energy to electrical energy and is located in whole or in part within coastal wetlands. 38 M.R.S. § 480-B(6-A).

[25] 38 M.R.S. § 480-B(10).

a. Application Requirements and Standards

Although NRPA includes a permit by rule process for certain limited activities,[26] it is more likely that the developer of a Project will need to file an individual application for a NRPA permit. All NRPA permit applications for Projects must be filed with the DEP (rather than LURC), unless the Project is a Community-Based Offshore Wind Energy Project.[27] To obtain an individual permit, the applicant must demonstrate that the proposed activities will not unreasonably interfere with existing scenic, aesthetic, recreational or navigational uses; will not unreasonably harm any significant wildlife habitat, threatened or endangered plant habitat, aquatic or adjacent upland habitat, travel corridor, freshwater, estuarine, or marine fisheries or other aquatic life; and that the proposed activities meet standards relating to soil erosion, natural water flow, water quality, flooding, sand supply, outstanding river segments, and dredging.[28]

Applicable rules set forth by the DEP describe more specific standards for activities affecting wetlands and water bodies (Chapter 310) and significant wildlife habitat (Chapter 335), as well as processes for evaluating impacts to scenic and aesthetic uses resulting from activities in, on, over or adjacent to protected natural resources (Chapter 315).

b. Review Period

There is no statutory deadline for the DEP Commissioner to make a decision on the NRPA application, but he must render the decision as expeditiously as possible after acceptance of the permit application.[29]

As with the Site Law Permit, decisions by the DEP may be appealed to the BEP or to the Superior Court; a decision by the BEP may be reconsidered by the BEP or appealed directly to the Superior Court; and any decision of the Superior Court may be further reviewed by the Maine Supreme Judicial Court sitting as the Law Court.[30]

3. Erosion and Sedimentation Control Law

Maine's Erosion and Sedimentation Control Law, 48 M.R.S. § 420-C, does not require a permit but requires erosion control measures be put in place prior to commencing any activity that involves filling, displacing or exposing soil or other earthen materials

[26] 06-96 Maine Department of Environmental Protection Ch. 305.

[27] 38 M.R.S. § 480-E-1(3).

[28] 38 M.R.S. § 480-D. NRPA contains additional requirements for Offshore Wind Power Projects that do not require a Site Law permit (e.g., less than three (3) MW), but that is not applicable to this case which will require either the Demonstration Permit (which dispenses with a NRPA permit requirement) or a Site Law permit. 38 M.R.S. § 480-D(11).

[29] 38 M.R.S. § 344.

[30] 38 M.R.S. §§ 341-D(4), 346.

in a project or portion of a project located in the organized area of the State.[31] The goal of this Law is to prevent unreasonable erosion of soil or sediment beyond the project site or into a protected natural resource. Since the requirements only apply to organized areas, the erosion control standards may not apply to the offshore wind turbines themselves, but would likely apply to a transmission line as it comes onshore, or to an onshore substation or laydown area.

4. Stormwater Program

Maine's Stormwater Program is made up of the Stormwater Management Law set forth in 38 M.R.S. § 420-D, and Waste Discharge License Law set forth in 38 M.R.S. § 413.

a. Stormwater Management Permit

Maine's Stormwater Management Law, 38 M.R.S. § 420-D, and the implementing regulation, Chapter 500 (stormwater management), provide stormwater standards for projects located in organized areas that include one or more acre of disturbed area. Since an Offshore Wind Power Project would be located primarily in the unorganized areas of the State, the DEP is evaluating the applicability of this law to these projects, but if the transmission line disturbs more than an acre as it comes onshore, this law will likely be triggered.

b. Waste Discharge Permit (Maine Construction General Permit)

Maine's waste discharge law, 38 M.R.S. § 413, *et seq.*, provides that "no person may directly or indirectly discharge or cause to be discharged any pollutant without first obtaining a license therefore from the [DEP]." The DEP will only issue a permit if it finds that the discharge by itself, or in combination with other discharges, will not lower the quality of the receiving waters below the existing or anticipated quality-based water classification, or, if it does, that there will be an important economic or social benefit to the State.[32] It is not clear whether this law would apply to an Offshore Wind Power Project, but further consultation with the DEP is needed before ruling it out.

c. Relationship of Stormwater Approvals with Other Laws

The DEP has consolidated the application process for the Stormwater Management Permit, the Waste Discharge Permit (Maine Construction General Permit) and the Site Law Permit. If a developer applies for a Site Law Permit, then they are not required to apply separately for a Stormwater Management Permit, but the Project may be required to meet standards set forth in the Stormwater Management Law.[33] If a

[31] 38 M.R.S. § 420-C.

[32] 38 M.R.S. § 414-A(1).

[33] 38 M.R.S § 420-D(5).

developer pursues a Demonstration Permit in collaboration with UMaine for the Offshore Wind Energy Research Center site near Monhegan Island, however, it will not be required to obtain Site Law approval and in that instance, it is possible that the University would have to get separate a Stormwater Management and/or Maine Construction General Permit.

5. Maine Endangered Species Act
Under the Maine Endangered Species Act (MESA) as amended, a state agency or municipal government may not permit, license, fund or carry out projects that will significantly alter the essential habitat or violate protection guidelines for an endangered or threatened species listed under MESA, unless a variance is granted.[34] This restriction only applies to species that are listed as endangered or threatened pursuant to 12 M.R.S. § 12803. A variance from this restriction can only be granted if the DIFW Commissioner certifies that the proposed action would not pose a significant risk to any population of endangered or threatened species in the State and a public hearing is held on the proposed action.[35] Additionally, MESA prohibits the "taking" of any endangered or threatened species as a result of an activity, even if the activity is otherwise permitted, unless the activity falls within an exception prescribed by DIFW or an incidental take permit is obtained for that activity.[36]

The Department of Marine Resources (DMR) also maintains a list of state endangered and threatened marine species, but that list only includes federally listed endangered and threatened species under the federal Endangered Species Act (ESA).[37] A "take" of a state listed marine species is governed by the federal ESA and MESA's "take" provisions described above do not apply.

DEP considers DIFW and DMR's comments and recommendations regarding a project's impact on listed species as part of its review of a development project for a Site Law or NRPA Permit.

6. Maine Historic Preservation Commission
The Maine State Historic Preservation Officer (SHPO), who is under the umbrella of the Maine Historic Preservation Commission (MHPC),[38] advises state agencies responsible for permitting projects that may impact historic or cultural resources, including potential archeological resources that are beneath coastal waters. Additionally, the SHPO reviews impacts of federal projects on resources listed or

[34] 12 M.R.S. § 12806(1).

[35] 12 M.R.S. § 12806(2).

[36] 12 M.R.S. §§ 12808(2), (3).

[37] 12 M.R.S. §§ 6973, 6975.

[38] 27 M.R.S. § 501 *et seq*.

eligible for listing in the National Register of Historic Places. If the MHPC and/or the SHPO determine that a project will result in an adverse effect to a cultural or historic resource, they will consult with the project proponent to find ways to avoid, minimize or mitigate such effects.

7. Submerged Lands Lease
Developers of ocean energy projects will need to obtain a state submerged lands lease or easement from the Maine Bureau of Parks and Lands (BPL) pursuant to 12 M.R.S. § 1862(13). A lease or easement applicant must engage in a joint interagency pre-application meeting with BPL, DMR, and DEP/LURC, and the process must take into account comments from the Marine Resources Advisory Counsel and relevant lobster management policy counsels. Full-term leases last 30 years. However, under the renewable ocean energy submerged lands lease program, prior to issuance of a 30-year lease, if requested by the applicant, BPL may issue a 30-year lease and a 2-year lease option, or 3-year or 5-year leases for specific project start up activities as set forth in 12 M.R.S. § 1862(13)(B)(5). Annual rent for leases will be established through BPL rulemaking, but a Demonstration Project in the UMaine Test Site is exempt from payment of annual rent for a submerged land lease.[39]

8. Public Utilities Commission Approval
Maine Public Utilities Commission (PUC) approval is not required for generator leads.[40] However, if a public utility such as Central Maine Power, Bangor Hydro Electric Company or even a merchant transmission company were to own and construct the transmission line running from the Project to the grid, the PUC will need to issue a Certificate of Public Convenience and Necessity, which would involve a separate proceeding at the PUC and a determination of public need for the line.[41]

5.1.2 Federal Permits, Leases and Approvals

1. Bureau of Ocean Energy Management, Regulation and Enforcement (formerly Minerals Management Service) – OCS Lands Lease
The Bureau of Ocean Energy Management, Regulation and Enforcement (Bureau of Ocean Energy or BOEMRE), is the agency that was, until very recently, the Minerals Management Service (MMS). The Energy Policy Act of 2005 (EPAct 2005) designates BOEMRE as the lead federal agency for Projects in federal waters (a development located in, on, or over federally owned Outer Continental Shelf (OCS) lands from the

[39] Although the Submerged Land Lease statute exempts a University Demonstration Project from annual rent for a lease, it does not expressly exempt it from the requirement of applying for a lease in the first place. Since the Demonstration Project technically falls within the definition of a Renewable Ocean Energy Project subject to the lease requirement, further investigation is needed to clarify whether a University Demonstration Project is exempt from the lease requirement itself in addition to the lease payment.

[40] 35-A M.R.S. § 3132(1)(B).

[41] 35-A M.R.S. § 3132(2).

three (3) nmi limit of state jurisdiction to the outer limits of the United States Exclusive Economic Zone (EEZ) at 200 nmi.

BOEMRE has an Alternative Energy Program that includes regulations to govern the leasing of OCS areas for wind power and other forms of renewable energy development on the OCS. The regulations covering renewable energy leases are codified in 30 C.F.R. Part 285. The renewable energy lease regulations set forth a two-tiered system of leases: (1) a limited lease that lasts only five (5) years and limits the amount of electricity that can be sold on the grid, and (2) a commercial lease that lasts for approximately 30 years (with possible renewals) that does not limit the amount of electricity sold. While a commercial lease will convey preferential rights to project easements on the OCS for the purpose of installing transmission and distribution systems, a limited lease will not convey any preferential rights to obtain a commercial lease in the leased area (although the regulations recognize that the limited lessee will be recognized in the process). The BOEMRE process for issuing a lease includes both a competitive and a non-competitive track. Both tracks include National Environmental Policy Act (NEPA) review and a Coastal Zone Management Act (CZMA) consistency determination.

Under the regulations, the applicant for a renewable energy lease on the OCS must submit specific plans at the requisite times. Applicants for a limited lease must submit a General Activities Plan (GAP) that describes the site assessment and/or development activities. Applicants for a commercial lease must submit a Site Assessment Plan (SAP) which covers resources and other data gathering activities and the testing of technology devices that would be conducted to gather information to develop the project, and a Construction Operation Plan (COP) that describes the construction and operations for the project itself, covering all activities for the project and all planned facilities, including onshore and support facilities, and all anticipated project easements.

At the present time, the State of Maine is in consultation with BOEMRE to develop the Maine Deepwater Wind Energy Pilot Project that creates and implements a streamlined, three-year process for the environmental review and siting of an advanced, deepwater wind energy project, including lease issuance and approval of a project-specific assessment plan. Note that the three-year process does not include the two-years of prior environmental studies or surveys necessary for filing. Additionally, the goal would be to have all other applicable state and federal environmental reviews and approvals made and completed within three years from when BOEMRE either (a) determines no competitive interest in an RFI or if competitive interest is identified, then (b) selects a potential lessee through its competitive process.

2. Clean Water Act/Rivers and Harbors Act Approvals (USACE)
The installation of wind turbine generators and an electric service platform (if applicable), the installation of submarine cable systems and the cable landfall transition

structures (if applicable) would be subject to regulatory permitting review and approvals under Section 404 of the Clean Water Act (CWA) and Section 10 of the Rivers and Harbors Act (RHA). The Army Corps of Engineers (USACE) is the agency primarily responsible for permitting under both of these sections. Additionally, the RHA permit requirement, or any other federal permit requirement, may trigger Section 401 of the CWA, which would in turn require the DEP to issue a water quality certification.

Section 404 of the CWA requires a permit for the discharge of dredged or fill material into the navigable waters of the United States.[42] In order to obtain a Section 404 permit, an applicant must demonstrate that the proposed discharge would not significantly degrade waters of the United States, that there is no less damaging practical alternative to the proposed discharge, and that steps have been taken to avoid, minimize and in some cases mitigate for unavoidable adverse effects, and the project is not contrary to the public interest.

Section 10 of the RHA requires authorization to build any structure in any water of the United States and to excavate or fill, or in any manner alter or modify the course, location, condition or capacity of any port, harbor, or the channel of any navigable water of the United States.[43] To obtain Section 10 approval, the applicant must show that the proposed activity will not significantly obstruct or alter navigable waters and the project is not contrary to the public interest. The USACE has very detailed application forms and requirements that spell out what an applicant must submit for review.

Under Section 401 of the CWA, any applicant for a federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which may result in any discharge into the navigable waters, shall (1) provide the licensing or permitting agency a certification from the state in which the discharge originates or will originate, or, if appropriate, from the interstate water pollution control agency having jurisdiction over the navigable waters at the point where the discharge originates or will originate; and (2) demonstrate that such discharge will comply with the applicable provisions of the water quality standards and effluent standards and limitations set forth in the CWA.[44] Thus, if the Offshore Wind Energy Project requires an USACE Permit pursuant to Section 404 of the CWA or Section 10 of the RHA, it is likely that the developer would need to get a water quality certificate from the Maine DEP.

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[42] 33 U.S.C. § 1344.

[43] 33 U.S.C. § 403.

[44] 33 U.S.C. § 1341.

Finally, the CWA also prohibits discharge of pollutants into waters of the United States unless a National Pollutant Discharge Elimination System (NPDES) permit has been issued.[45] However, the power to issue this permit has been delegated to the Maine DEP and it is incorporated into Maine's waste discharge permit process discussed above.

3. Department of Energy/Federal Energy Regulatory Commission
At this preliminary stage, it appears that United States Department of Energy (DOE) or Federal Energy Regulatory Commission (FERC) approval is not required for an Offshore Wind Energy Project located in state or federal waters. This should be confirmed as the project advances. FERC does make sure that the interconnection does not compromise reliability standards and, depending on the terms of the interconnection agreement between the developer and the public utility into whose system the generator lead line will connect (likely Central Maine Power), FERC approval may be required.[46] It should also be noted that the electric reliability coordinator for the New England region, ISO-NE, will also need to approve the interconnection agreement.

4. Federal Aviation Administration
Federal Aviation Administration (FAA) notification is required for any structure that rises more than 200 ft above the ground or is located within a certain distance from an airport or heliport.[47] Since the wind turbine generator will likely exceed the 200 foot threshold, it will require permitting with FAA and FAA-approved lighting and marking.[48]

5. United States Coast Guard
The United States Coast Guard (USCG) has safety and regulatory jurisdiction over projects located in the navigable waters of the United States. A permit for private aid to navigation on fixed structures in waters of the United States may be required to allow placement of wind turbines and related structures in marine waters.[49] The wind turbine generators and substation platform(s) (if applicable) are subject to USCG review for authorization to mark and light them. A navigational risk assessment prepared by the USCG may be required.

[45] 33 U.S.C. § 1342.

[46] FERC approval may also be required if the transmission line is owned by a public utility or a merchant transmission line company (not the generator) and the line travels through Federal waters. However, additional research will be needed to confirm.

[47] 49 U.S.C. § 44718(a); 14 C.F.R. § 77.13(a).

[48] FAA Advisory Circular 70/7460-1k.

[49] 14 U.S.C. § 85; 33 C.F.R. Parts 62-67.

6. Other Federal Review of the Project

a. National Environmental Policy Act

Under the National Environmental Policy Act (NEPA), before the federal government issues a permit for a proposed activity, it must evaluate the environmental impacts of its proposed action.[50] As part of the review process, the lead federal agency, in this case BOEMRE, must prepare environmental review documents (either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) depending on the expected level of environmental impact) and obtain state and federal agency review and comment on the proposed project. Thus, federal agencies such as the United States Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS) and the Environmental Protection Agency (EPA), among other agencies, will have an opportunity to coordinate environmental review of a proposed Project, even those portions located in state waters.

b. Endangered Species Act

The Endangered Species Act (ESA) prohibits any action that results in the "take" of any member of a species federally listed as threatened or endangered.[51] To "take" a member of a listed species means to harass,[52] harm,[53] pursue, hunt, shoot, wound, kill, trap, capture or collect the endangered species, or to attempt to engage in any such conduct.[54] If the construction or operation of a Project may result in a take of federally listed species, an incidental take permit should be obtained for such activities. In order to obtain an incidental take permit, the applicant must develop a habitat conservation plan in concert with the relevant federal environmental agencies.[55] The ESA is jointly administered by the USFWS and NMFS. Listed fish species in the GoM include Atlantic Salmon and Atlantic Sturgeon.

The Bald and Golden Eagle Protection Act also prohibits the taking of bald and golden eagles.[56]

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[50] 42 U.S.C. § 4321, *et seq*.; many Federal agencies also have NEPA regulations or guidance.

[51] 16 U.S.C. §§ 1538(a)(1)(B), (C) (ESA section 9).

[52] "Harass" is an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. 50 C.F.R. § 17.3.

[53] "Harm" is an act which actually kills or injuries wildlife. Such acts may include significant habitat modification or degradation by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. 50 C.F.R. § 17.3; 50 C.F.R. § 222.103.

[54] "Take" through "harm" can occur by means of habitat modification. HCP Handbook at 3-18; *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*, 515 U.S. 687, 707 (1995).

[55] 16 U.S.C. § 1539(a)(1)(B), (2); FWS/NMFS, Habitat Conservation Planning Handbook.

[56] 16 U.S.C. § 668.

c. Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) prohibits the "taking" of marine mammals (e.g., whales, dolphins), unless there are specific exceptions under the statute. Similar to the ESA, the MMPA contains an incidental take provision and is jointly administered by USFWS and NMFS. Marine mammals such as the Northern right whale and marine turtles are also on the ESA list, and therefore also on the MESA list.

d. Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) prohibits the taking of migratory birds.[57] The Act protects all common songbirds, waterfowl, shorebirds, raptors (eagles and hawks), owls, ravens, crows, native doves and pigeons, swifts, martins, swallows and other migratory bird species.[58] Protection extends to species' feathers, plumes and other body parts, as well as nests and eggs, but a "take" under the MBTA is not applied as broadly as in the ESA and it does not include habitat modification or alteration.[59] Unlike the ESA, there does not appear to be a mechanism under the MBTA to obtain an incidental take permit for activities related to offshore wind power that may result in unintended death or harm to covered species.[60] An unintentional violation of the MBTA can be a misdemeanor and can result in fines of up to $15,000 or up to 6 months of imprisonment, or both.[61] The MBTA is administered and enforced by USFWS.

e. Magnuson-Stevens Fisheries Conservation and Management Act

Under Section 305 of the Magnuson-Stevens Fisheries Conservation and Management Act (MSFCMA), federal licensing and permitting agencies are required to consult with NMFS and consider its recommendations regarding a proposal's potential impact on "essential fish habitat." The New England Fishery Management Council (NEFMC) has taken an active interest in wind power projects proposed for New England's ocean waters and provided comments regarding potential fisheries impacts. The Atlantic States Marine Fisheries Commission (ASMFC) may also participate in environmental reviews.

[57] 16 U.S.C. §§ 703, *et seq*. The definition of take includes "to pursue, hunt, shoot, wound, kill, trap, capture, or collect." 50 C.F.R. § 10.12.

[58] See 50 C.F.R. 10.13 (list of protected species).

[59] 50 C.F.R. § 10.12.

[60] Special purpose permits are available for take of migratory birds, but at first blush, they do not appear to be applicable to activities related to wind power. Further investigation is needed to confirm. 50 C.F.R. §§ 21.11, 21.27.

[61] 16 U.S.C. § 707.

f. National Historic Preservation Act

The National Historic Preservation Act (NHPA) aims to direct federal agencies to act as responsible stewards of the nation's resources when their actions affect historic properties.[62] Section 106 of the NHPA requires federal agencies to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings. Historic properties include, among other things, sites (both prehistoric and historic), buildings, structures, and objects that are included in or eligible for inclusion in the National Register of Historic Places.

Historic preservation consultations may also involve the State Historic Preservation Officer (discussed above), Tribal Historic Preservation Officers of federally recognized tribes, and the National Trust for Historic Preservation (NTHP), local governmental agencies and other interested parties. These entities may consider, among other factors, any visual impacts from the proposed Offshore Wind Energy Project upon a historic property.

g. United States Department of the Navy

The United States Navy has shown interest in being consulted early on in the development review process undertaken by state agencies for Offshore Ocean Energy Projects located in Maine waters. The Navy may also choose to comment through the NEPA or other federal review processes.

h. Coastal Zone Management Act – Federal Consistency Review

Under the federal Coastal Zone Management Act (CZMA), Maine has the authority to review federal actions for consistency with the enforceable policies of its federally approved coastal zone management program.[63] Federal actions potentially subject to CZMA review include federal agency activities, federal license and permit decisions, and federal funding. Under the CZMA, federal agency activities, including leasing decisions, must be "consistent to the maximum extent practicable" with applicable enforceable policies; and a federal agency may not issue a federal license or permit if, in exercising its federal consistency review authority, the state objects that its issuance is inconsistent with one or more specified enforceable policies.

The Maine State Planning Office (SPO) is the point of contact and coordinator for this federal consistency review process. State land use and environmental laws, primarily those administered by DEP and LURC, provide Maine's enforceable policies for CZMA purposes and to the extent practicable the State implements its

[62] 16 U.S.C. § 470

[63] 16 U.S.C. § 1451, *et seq.*

federal consistency review authority through review and issuance of pertinent licenses and permits under these core laws. Following the state review process and in accordance with DEP and LURC decisions, as applicable, SPO provides the State's consistency concurrence with or objection to the federal agency's or federal applicant's consistency determination or certification, as applicable. The Secretary of Commerce has jurisdiction to hear an appeal of an objection to an applicant's consistency certification *de novo* under national interest criteria. The State's decision regarding a federal agency's consistency determination may also be appealed. Additional, detailed information regarding Maine's CZMA review process may be reviewed on-line at the following website: http://www.maine.gov/spo/coastal/permitting.htm.

i. Oil Pollution Act

The Oil Pollution Act of 1990 (OPA) amended the CWA and addressed the wide range of problems associated with preventing, responding to, and paying for oil pollution incidents in navigable waters of the United States.[64] The OPA created a comprehensive prevention, response, liability and compensation regime to deal with vessel- and facility-caused pollution to United States navigable waters. The OPA requires vessels to submit to the authorizing federal agency plans detailing how they will deal with a worst-case discharge and contingency plans to prepare and plan for oil spill response regionally. The OPA may or may not be applicable to an up to 30 MW wind farm depending on the role of installation and construction vessels in the project.

j. Clean Air Act

The Clean Air Act (CAA) contains provisions relating to air emissions from certain OCS activities in order to control air emissions from sources on the OCS.[65] An OCS "source" includes any equipment, activity or facility that, among other things, is regulated under the Outer Continental Shelf Lands Act (this may be triggered by the OCS land lease), or is located on the OCS or in or on waters above the OCS. While vessels are not an OCS source, they are considered a "source" when they are physically attached to an OCS facility, and when within 25 miles from the source when en route to or from the source. At that time, emissions from vessels associated with the "source" will be considered direct emissions from the "source." Therefore, activities of vessels on the OCS during the construction phase may trigger a requirement for a CAA permit. The EPA is the administrative agency for the CAA.

[64] 33 U.S.C. §§ 2701-2761.

[65] 42 U.S.C. 7627.

5.1.3 Municipal and Local Approvals

1. Shoreland Zoning

The Mandatory Shoreland Zoning Act requires municipalities in Maine to protect shoreland areas through adopting shoreland zoning maps and ordinances that provide for allowable activities in certain areas. The shoreland areas covered by the law include areas within 250 ft of the normal high-water line of any great pond, river or saltwater body, areas within 250 ft of the upland edge of a coastal wetland, areas within 250 ft of the upland edge of non-forested freshwater wetlands ten or more acres in size, and areas within 75 ft of the high water line of a stream. The Act also gives a municipality the authority to regulate land-based structures that extend over and onto state-owned submerged lands. Municipalities are primarily responsible for administering the shoreland zoning law, but the municipalities' shoreland ordinances must be at least as stringent as and may be more protective than DEP's model ordinance guidelines (DEP Rules Ch. 1000).

2. Local Approvals

Local land use approval will be determined by the ordinances in the affected towns. For example, local land use approval may be required for the transmission line as it comes ashore, the substation (if a new one is constructed or existing one is expanded), and any newly constructed onshore laydown area. Obtaining local land use approval may require a zoning change, variance or other project-specific approval. However, a municipality is prohibited from enacting or enforcing a land use ordinance that prohibits the siting of ocean energy projects, including but not limited to, their associated facilities, within the municipality.[66] A local building permit could also be required, and further investigation will be needed to determine if any loading and unloading activities during construction will require municipal, harbor master or shellfish commission review and/or approval.

A permit for the transmission facilities to travel in the public way may also be required, depending on the configuration of the project. If the transmission facilities or the transmission line, once it comes ashore, need to be constructed and/or maintained along a road, street or other public way, the developer will need to obtain a license from the applicable licensing authority in charge of that road (either the municipality or Maine Department of Transportation (ME-DOT)).[67]

[66] 30-A M.R.S. § 4361.

[67] 35-A M.R.S. §§ 2305-B, 2501, 2503.

5.1.4 State and Municipal Approvals

Although the up to 30 MW pilot project itself would not need state or municipal approvals (other than the CZMA consistency review discussed above) because it will be located in federal waters, it is likely, however, that many, if not all, of the state and municipal approvals discussed above will still be required for the electric transmission line that will run through state waters and onto the shore, as well as any assembly or deepwater area located in state waters. Further examination will need to be conducted to determine whether the state permitting for the transmission line will fall within the jurisdiction of the DEP or LURC, as it will likely travel through both jurisdictions.

Additional municipal approvals may be required for an assembly site located in municipal waters such as, for example, Rockland, if the site falls within Rockland's municipal jurisdiction (though likely this will also be state jurisdiction).

5.1.5 Permitting of Onshore Assembly and Staging Area

1. Natural Resources Protection Act

The land-based assembly and staging area required for the proposed offshore wind development project may trigger the NRPA, as described above in Section 5.1.1(2), if the project will be located in, on, or near a protected natural resource as defined by the Act.[68] Given the expected need for the land-based support area to be located near the coast to facilitate transport of the completed towers, it is possible that the project will be located on or near a coastal wetland. In addition, construction of support areas may include certain activities that require a permit under NRPA, including dredging, bulldozing, removing or displacing soil, sand, vegetation or other materials, as well as the construction of a permanent structure.[69] Therefore, to meet the permit requirement, the project will have to conform to the standards required by NRPA.[70]

2. Site Location Development Act

The land-based construction project will also likely trigger the Site Law requirements as described above in Section 5.1.1(1). Site Law requires construction of "any development of state or regional significance that may substantially affect the environment" to meet the required standards for development before approval of the project.[71] Construction of the support area may trigger the permit requirement because any new buildings, parking lots, roads and paved areas for the project will likely cover an excess of three (3) acres – meeting the definition of a "structure" under

[68] 38 M.R.S. § 480-C; 38 M.R.S. § 480-B(8).

[69] 38 M.R.S. § 480-C (2).

[70] 38 M.R.S. § 480-D

[71] 38 M.R.S. § 483-A.

Site Law and therefore qualifying as a development of significance.[72] In addition, it is possible that power transmission requirements for the area may trigger additional permitting requirements under Site Law.[73]

3. Erosion and Sedimentation Control Law

Construction of the land-based support area will likely require filling, displacing or exposing soil and will therefore trigger the erosion and sedimentation control requirements under Maine law, as described above in Section 5.1.1(3). Though the law does not require permit approval, the law does require construction projects to have erosion control measures in place before beginning activities that may result in soil erosion.[74] This may require additional measures to be taken to prevent erosion during the construction of the assembly and staging area or the roads leading into such an area (if applicable).

4. Storm Water Program

a. Storm Water Management Permit

Construction of the staging area will require approval of the project's storm water management system by the Maine DEP, as noted above in Section 5.1.1, because the project will likely include one acre or more of disturbed area. To receive approval, storm water management must meet standards adopted by the DEP, and may have to conform to particular rules if the project is located near a watershed of a body of water most at risk for development.[75]

b. Waste Discharge Permit

The land-based construction and staging area will require a waste discharge license, as described in Section 5.1.1(4)(b) because it is likely that construction of the wind turbines and tower will result in some waste which may qualify as a pollutant under the statute. The DEP will issue a license if it finds that the project conforms to the requirements identified by statute.[76]

5. Maine Endangered Species Act

If any of the activities related to the construction and/or operation of the land-based construction and staging area result in the taking of any endangered or threatened species, or adverse impact to their designated habitat, those activities would likely be prohibited by the Maine Endangered Species Act, as described in Section 5.1.1(5).

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[72] 38 M.R.S. § 482 (6).

[73] 38 M.R.S. § 487-A.

[74] 38 M.R.S. § 420-C.

[75] 38 M.R.S. § 420-D.

[76] 38 M.R.S. § 414-A.

6. Maine Historic Preservation Commission

As described in Section 5.1.1(6), the Maine Historic Preservation Commission may be involved in permitting a project that has potential impacts on historic or cultural resources, including archaeological resources. Therefore, it may be necessary to consult with the Commission to determine whether this project will have such an impact and what will be required to meet the Commission's approval and perhaps mitigate the effects of the project.

7. Mandatory Shoreland Zoning Act

If the land-based construction and staging area is located near a shoreland area as defined by the Mandatory Shoreland Zoning Act, described in Section 5.1.3(1), the project may trigger a municipal ordinance regulating construction and activity near the shore. Once a site is chosen, research should be done to determine the exact requirements of the local municipalities' applicable ordinance. This ordinance may, or may not, be part of a larger municipal zoning scheme, as municipalities may treat shoreland areas differently.[77]

8. Local Zoning Ordinances

Municipalities within Maine may have their own municipal zoning requirements, which may dictate the potential locations for the land-based construction and staging area within the municipality, in conformation with the municipality's comprehensive plan.[78] Once a site (or potential sites) has been chosen, research will be required to determine the exact requirements of a particular municipality. In addition, municipalities may assert that water-based activities within the three (3) nmi limit are within their boundaries and thus subject to local regulation.

9. Waste Management

As both the construction and operation of the land-based construction and staging area will likely result in waste, management and disposal of such waste will have to comply with the requirements of Maine's waste management laws.[79] Municipalities may provide waste disposal services for industry, but regardless, waste disposal efforts will likely have to conform to the requirements of the municipality in which the site is located.[80] Certain activities are prohibited, such as discharge of hazardous waste, and other activities are highly regulated, such as fluids from motor vehicles and construction and demolition debris.[81]

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[77] 38 M.R.S. § 435.

[78] 30-A M.R.S. § 4352.

[79] 38 M.R.S. § 1302

[80] 38 M.R.S. § 1305

[81] 38 M.R.S. § 1306

10. Minimum Lot Size

Maine's Minimum Lot Size statute may dictate requirements for disposal of waste.[82] The support area would likely be defined as "other land use activity" which would require an actual measurement or computation of waste generated or likely to be generated to determine requirements for disposal of waste by means of subsurface waste disposal.[83] This may or may not apply to the site because it would depend on the methods used for waste disposal.

11. United States Army Corps of Engineers Wetlands Permit

Depending on the location of and the sizes of the onshore assembly and staging area, an USACE wetlands permit under CWA Section 404 may also be required. Note that DEP, LURC, USACE and other federal agencies work cooperatively on wetlands permitting under the terms of the Maine Programmatic General Permit.

12. Federal Aviation Administration Requirements

The Federal Aviation Administration (FAA) has specific requirements for construction of tall structures that may apply to the construction and staging area.[84] In particular, any construction of more than 200 ft in height above the ground requires notification to the FAA Administrator.[85] If the wind turbine towers will be raised while at the staging area, this may require notification to the FAA and the installation of aircraft warning lights.[86] Even if the project does not require raising the towers at the staging area, there are additional FAA notice requirements that may be site-specific as they relate to "any construction or alteration of greater height than an imaginary surface extending outward and upward" based on the slope of the landscape and proximity to airport runways.[87]

5.1.6 Key Statutory Definitions Related to Offshore Wind Energy

1. Wind energy development

"Wind energy development" means a development that uses a windmill or wind turbine to convert wind energy to electrical energy for sale or use by a person other than the generator. A wind energy development includes generating facilities and associated facilities. [35-A M.R.S. § 3451(11) (definition of wind energy expedited permitting act)]

[82] 12 M.R.S. § 4807-A

[83] Id.

[84] 14 C.F.R. § 77.5

[85] 14 C.F.R. § 77.13

[86] Id.; 14 C.F.R. § 77

[87] 14 C.F.R. § 77.13

2. Associated facilities
"Associated facilities" means elements of a wind energy development other than its generating facilities that are necessary to the proper operation and maintenance of the wind energy development, including but not limited to buildings, access roads, generator lead lines and substations. [35-A M.R.S. § 3451(1) (definition of wind energy expedited permitting act)].

3. Generating facilities
"Generating facilities" means wind turbines and towers and transmission lines, but not including generator lead lines, that are immediately associated with the wind turbines. [35-A M.R.S. § 3451(5) (definition of wind energy expedited permitting act)]

4. Development of state or regional significance that may substantially affect the environment
"Development of state or regional significance that may substantially affect the environment," in this article also called "development," means any federal, state, municipal, quasi-municipal, educational, charitable, residential, commercial or industrial development that . . . is an offshore wind power project with an aggregate generating capacity of three (3) MW or more. [38 M.R.S. § 482(2)(J) (SLODA Defs.); *see also* PL 615, Sec. E-15]

5. Offshore wind power project
"Offshore wind power project" means a project that uses a windmill or wind turbine to convert wind energy to electrical energy and is located in whole or in part within coastal wetlands as defined in 38 M.R.S. § 480-B(2). "Offshore wind power project" includes both generating facilities as defined by Title 35-A, Section 3451, Subsection 5, and associated facilities as defined by Title 35-A, Section 3451, Subsection 1, without regard to whether the electrical energy is for sale or use by a person other than the generator. [38 M.R.S. § 482(8)]

6. Offshore wind energy demonstration project
"Offshore wind energy demonstration project" or "project" means a wind energy development in one of three designated areas in state waters that uses a wind turbine to convert wind energy to electrical energy and that employs no more than two (2) wind energy turbines, each of which may use different technology, for the primary purpose of testing and validating a turbine blade design, floating platform or other support structure, mooring or anchoring system or other offshore wind energy technology that the applicant certifies is designed for use in ocean waters and is not in use elsewhere in the GoM for commercial production of electricity and that may also include:

i. Up to three (3) meteorological towers per wind energy turbine proposed;

ii. One submerged utility line that is sized to transmit:

1. An amount of electricity less than or equal to that produced by the offshore wind energy demonstration project; or
2. Up to 25 megawatts of electricity if the line is intended to serve multiple offshore wind energy demonstration projects located within the Maine Offshore Wind Energy Research Center and the department has not previously granted approval for such a submerged utility line pursuant to this section; and

iii. A wave energy test project. [38 M.R.S. § 480-HH(1)(H); see also P.L. 270 (LD 1465)]

5.1.7 Application Schedule

The critical path for state and federal permitting of up to a 30 MW Project in federal waters is anticipated to be the Outer Continental Shelf (OCS) leasing and permitting process through BOEMRE. As noted previously, the State of Maine is in consultation with BOEMRE to develop the Maine Deepwater Wind Energy Pilot Project, which would develop and implement a streamlined, three-year process for environmental review and siting of an advanced, deepwater wind energy project, including lease issuance and approval of a project-specific assessment plan. The other major state (e.g., Site Law) and federal (e.g., CWA Section 404/Section 10) permits are anticipated to require six (6) to 18 months for permit review and approval. All of these timelines are predicated on the development of "complete" permit applications that sufficiently address the permitting requirements. As part of the development of all of these permit applications, a minimum of two (2) seasons (spring and fall), and likely four (4) seasons, of bird and bat monitoring will be required. Conservatively, the time required to perform these studies, as well as additional required surveys, and prepare the permit applications is estimated to be at least two (2) years. Therefore, at a minimum, developers should expect a five-year permitting process from the start of necessary environmental studies and surveys (two (2) years) to permit issuance (an additional three (3) years beyond studies and surveys under streamlined permitting). An example timeline for BOEMRE and other state and federal approvals is included in Section 8.0. If the Maine Deepwater Wind Energy Pilot Project proposed to BOEMRE is not finalized, and current BOEMRE OCS leasing procedures are followed, then this permitting period could increase upwards to nine (9) or ten years.

5.2 PHYSICAL ENVIRONMENT AND INFRASTRUCTURE CHARACTERIZATION

Developing sufficient information regarding key characteristics of the physical environment surrounding potential test park sites, assembly areas, grid interconnection points, and associated subsea cable and tow routes is essential to determining the feasibility of an offshore wind project. This section provides a summary of a desktop-level survey of available data describing the physical environment and existing infrastructure within the GoM. Potential impacts to the physical environment and infrastructure from offshore wind development are described in the following subsections. Data described was generally obtained as digital geospatial files for use and analysis in GIS software, unless specified otherwise.

5.2.1 Jurisdictional Boundaries

State and federal regulatory boundary information was obtained from a review of legislation and relevant agency sources. These boundaries are critical to determining regulatory and permitting jurisdictions. A visual depiction of pertinent coastal boundaries may be seen in Figure 5-2. Jurisdictional boundaries were obtained from the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) (formerly the Minerals Management Service (MMS)) for use in this feasibility study.

Different jurisdictional zones represent different permitting and regulatory requirements. Per Maine law LD 1810, offshore wind energy projects must be situated a minimum of ten (10) nmi from state lands, measured from Mean Lower Low Water (MLLW), not including uninhabited islands or coastal wetlands. Sites greater than three (3) nmi from MLLW are subject to federal permitting and regulation. Subsea cables and other permanent offshore structures that cross into state waters will be subject to state and federal permitting and regulations.

A schedule of permitting requirements has been prepared for the proposed site and described in Section 5.1.7. Early and regular communication with state and federal agencies will be crucial to the smooth development of an offshore wind facility.

5.2.2 Wind Resource

Offshore wind turbines should be situated in an area that has mean annual wind speeds of 8 m/s or greater to maximize commercial viability. Sources of wind data for this study include the Gulf of Maine Ocean Observing System (GoMOOS) and National Data Buoy Center (NDBC) buoy systems, providing data at the ocean surface (discussed further in Section 5.2.3 – Met-ocean Data), and the National Renewable Energy Laboratory (NREL), a division of the Department of Energy (DOE). NREL data provides information regarding wind speeds and trends in upper levels of the atmosphere. Figure 5-3 shows mean annual wind speeds at 50 m for the GoM based on wind speed data provided by NREL.

Areas with mean annual wind speeds of less than 8 m/s are not likely to support a commercially viable offshore wind farm and should not be considered. With that said, almost all areas located ten (10) nmi from the coastline exhibit Class 6 or better (i.e., $\geq$ 8 m/s) wind speeds on annual average. As specific areas of interest are selected for development, further investigation of wind speeds should be considered if an area of interest does not appear to have enough data to support this criterion. This may include deployment of additional buoy instrumentation consisting of traditional anemometers and/or LiDAR or SODAR-based wind measurement devices to develop wind speed profiles with height at the specific location of interest.

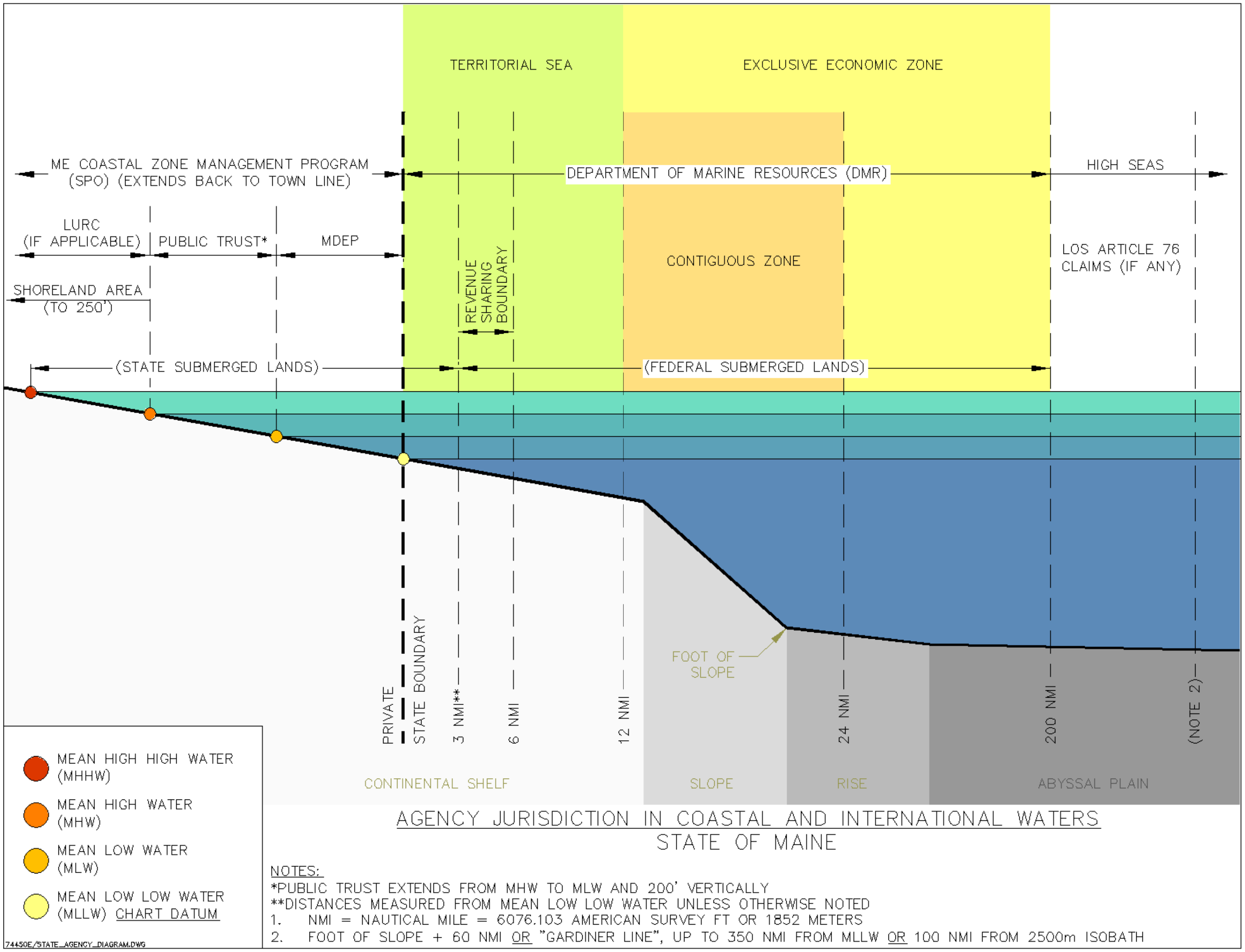

Figure 5-2: Jurisdictional boundaries for coastal and international waters

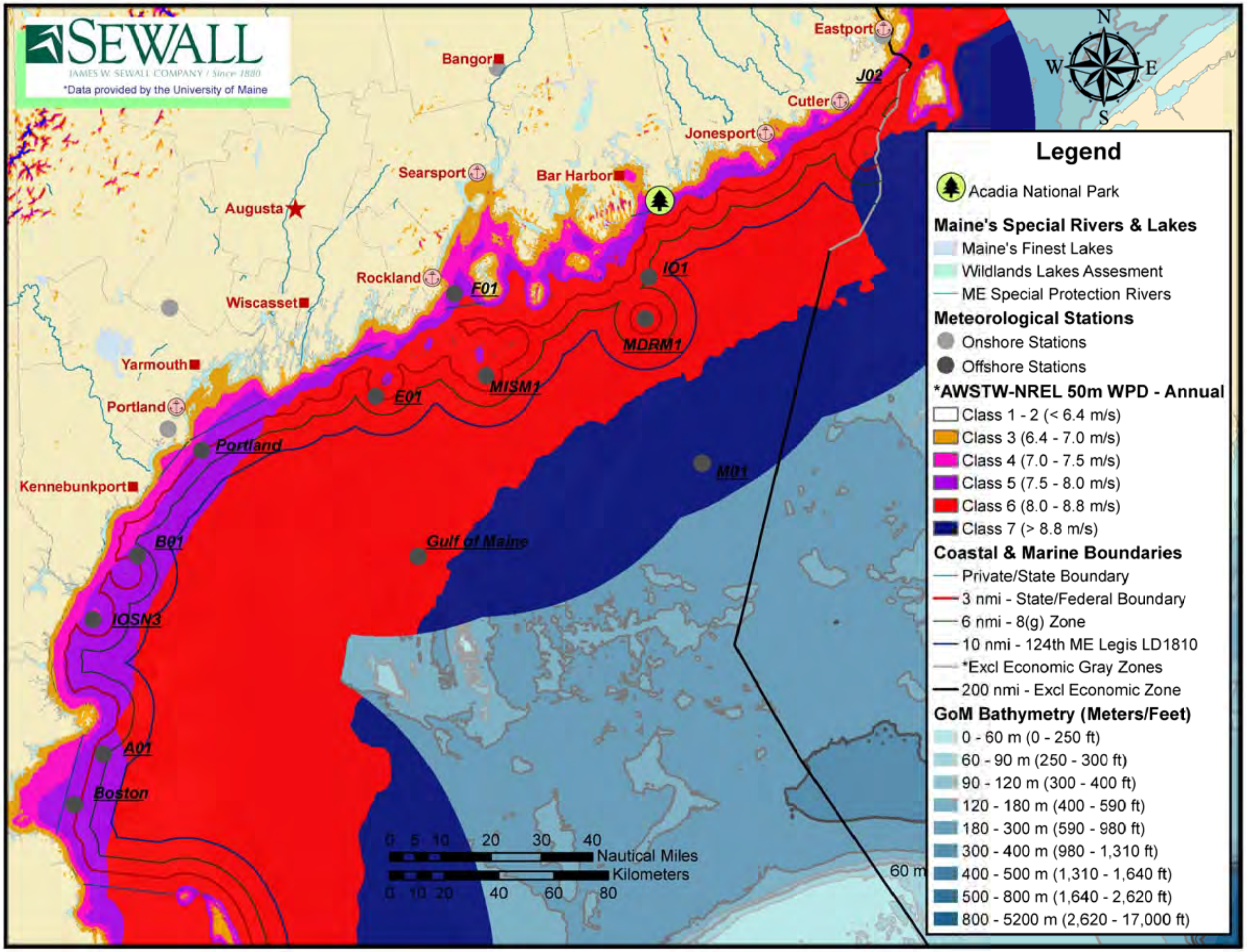

Figure 5-3: Mean Annual Wind Speed (m/s) at 50 meter height above mean sea level

5.2.3 Met-ocean Data

Met-ocean data includes meteorological and oceanographic information important for project siting and design, including currents, significant wave height, temperature and salinity. The primary source of met-ocean data for this study is from five buoys in the GoM operated by UMaine/GoMOOS and the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center. These five buoys are part of the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS) and labeled E01, F01, NOAA Buoy 44005, NOAA Buoy 44007 and NOAA Station MISM1 – Matinicus Rock, Maine.

The availability of wind, current, wave, salinity and temperature data from these buoys is summarized in Table 5-1. For more information regarding met-ocean data and data sources, see Sections 3.1, 3.2, and 3.3. Additionally, refer to Figure 3-1 for a map of the buoy and NOAA weather station locations and Appendix B.1 for a summary of wind speed and significant wave height for selected buoy locations in the GoM.

Table 5-1: Gulf of Maine (GoM) buoy data availability

DATA DESCRIPTION	E01	F01	NOAA 44005	NOAA 44007	Station MISM1 – Matinicus Rock, ME
Wave Time History	Y	Y	Y	Y	
Wave Height	Y	Y	Y	Y	
Current at 2 meters (m)	Y	Y			
Current at all depths	Y				
Average Wind Speed	Y	Y	Y	Y	Y
Salinity at 1 m	Y	Y			
Salinity at 20 m and 50 m		Y			
Water Temperature at 1 m	Y	Y	Y	Y	
Water Temperature at 2 m	Y	Y			
Water Temperature at 20 m and 50 m		Y			

Extreme wave data is essential for the design of the turbines in order to assess potential impact forces on the turbine structures. The turbine structures must be designed to withstand the toppling effects of extreme wave conditions. Another design issue is the destabilization of the turbine and floating platform due to wave and wind conditions, including failure of the anchoring and mooring system.

Gathering sufficient data to assess adequately the forces of wind and waves on the turbine structures is essential to the design process of a successful offshore wind farm project. Turbines and anchoring systems should be designed for worst-case situations. The most efficient method for gathering more site-specific data for an area of interest would involve relocating one of the currently inactive NERACOOS buoys and repurposing the buoy. A similar process was recently followed in June of 2010 by UMaine to deploy the E02 buoy in the DeepCwind project area south of Monhegan Island.

5.2.4 Bathymetry

Bathymetry consists of seafloor topographic data for use in determining water depths. PUC RFP requirements dictate that offshore project locations must have a minimum water depth of 300 ft (91 m). Currently, the primary sources of data for desktop-level analyses include digital bathymetric contours of the GoM from the USGS and NOAA electronic navigational charts.

For this study, existing bathymetric contour data was supplemented with a field hydrographic survey by Sewall of a discrete portion of an approximately 1.75 miles by 1.75 miles area of the Penobscot Bay, located at an area of particular concern within the Bay that is known Junkin's ledge. For a complete description of this data, and USGS bathymetric data, see Section 3.7.

Sites that largely do not meet these bathymetric criteria will not be feasible. Changes to the ocean floor to deepen towing routes or wind farm locations would be prohibitively expensive and would require significant additional permitting and environmental monitoring. Further hydrographic survey of discrete areas along potential towing routes within wind farm sites may be warranted if the overall area of interest meets water depth criteria. A comprehensive hydrographic survey of any proposed tow out route is recommended after the project progresses to the design and permitting phase.

5.2.5 Topography

Topographic data represents the elevations of land areas of the state that are above mean sea level. Primary sources of topographic data for desktop analyses include contour files and digital elevation models based on USGS topographic quadrangle maps. The maps generally represent 10-ft to 20-ft contour intervals. The low-resolution USGS topographic data can be easily supplemented with site-specific topographic surveys, including use of traditional land surveying techniques as well as aerial photography and photogrammetric mapping.

For general project planning and scoping, USGS digital elevation data is sufficient to support project decision-making. However, once the project progresses to the design and permitting phase, additional site-specific topographic surveys will be necessary, particularly for the transmission line route and electric substation interconnection. Typically, for land-based wind projects, the transmission line topographic data is generated using aerial photography and photogrammetric mapping techniques. The use of aerial mapping is much more efficient and cost-effective than traditional land surveying. The accuracy of aerial mapping is severely affected by leaf cover and other obstructions that prevent a good view of the ground surface. As a result, the planning of aerial surveys is very important to make sure that the surveys are conducted during the spring and fall "leaf-off" time periods to maximize the potential accuracy of the survey. The aerial mapping may also be supplemented by traditional land surveys of the substation site and potential sites for an operations and maintenance facility.

5.2.6 Geophysical Survey Data and Surficial Bottom Sediments

The geophysical composition of the surficial soils along the ocean floor is needed for the design of any structures that may rest on or be embedded in the seabed, including anchoring systems. Primary existing data sources for surficial sediments include USGS East Coast Sediment Texture Database, USGS Continental Margin Mapping, USGS BARNHARDT: Maine Inner Continental Shelf Sediment Data, and MGS Surficial Geology of the Maine Inner Continental Shelf map series. These datasets provide information about general trends in the geology of surficial sediments. For a complete description of these data and their accuracy, see Section 3.10. Figure 5-4 shows the surficial sediment distribution for the GoM based on USGS Continental Margin Mapping work of Poppe et al (2005).

Surficial sediment conditions in the GoM include mud, sand, gravel and rock. Anchoring or foundation systems will need to be designed according to the seafloor geology in the areas ultimately selected for project development. As anchor and foundation design is contingent upon surficial sediment conditions, it will be necessary to perform geophysical and geotechnical engineering investigations at project-specific locations for any proposed offshore wind turbines. These investigations would include, but would not be limited to, in-situ testing, surficial sediment sampling, core sampling of deeper sediments (not reflected in the surficial data presently available), and subsequent classification and analysis of engineering parameters of sample sediment/rock.

Comparatively small areas of the sea floor will be impacted by the presence of the anchors for each turbine, but by their nature, proposed anchoring system will likely become permanent fixtures on the ocean floor. As a result, the type of anchor/foundation will need to be fully described in project permitting documents (e.g., descriptions of dimensions, material, estimated lifetime, etc.) for review and approval by federal regulatory authorities and commenting agencies.

5.2.7 Wetlands and Coastal Marshland

Wetlands and coastal marshland information is needed to assess landside and nearshore impacts for grid interconnection and service facilities. General wetlands geographic information was obtained from the National Wetlands Inventory (NWI), supported by the United States Fish and Wildlife Service (USFWS). The NWI data consists of broad-scale wetland delineation from aerial imagery and topographic mapping that is suitable for desktop-level screening, research and planning activities, but is of insufficient detail for project design and permitting. The location of the grid interconnection point may require the crossing and/or trenching of coastal marshland or wetlands along the transition from subsea cable to overhead power main. Permanent impacts may include, at a minimum, trenching and filling of an underground electric cable run, the installation of utility poles for overhead lines, along with clearing a landside utility corridor to the interconnection point for maintenance and construction. There may also be wetland and coastal marshland impacts related to the landside storage and marine assembly areas that will be required for the construction of the proposed offshore wind farm. These impacts may range from temporary disturbance of staging areas, along the coast or inland, to semi-permanent or permanent structures or lay down areas constructed for storage of turbine components and associated materials. Wetland disturbance from these construction activities must be included in the total disturbance calculations.

The USACE should be notified regarding any wetland disturbance along the coastline. If wetland disturbance exceeds 4,300 square ft, a permit from USACE will be required. Maine Department of Environmental Protection also regulates inland wetlands and permitting will be required if disturbance exceeds one acre. Effort should be made to minimize wetland impact as much as possible to limit the amount of environmental disturbance and related permitting needed to construct the grid interconnection. For a detailed description of permitting requirements, see Section 5.1.

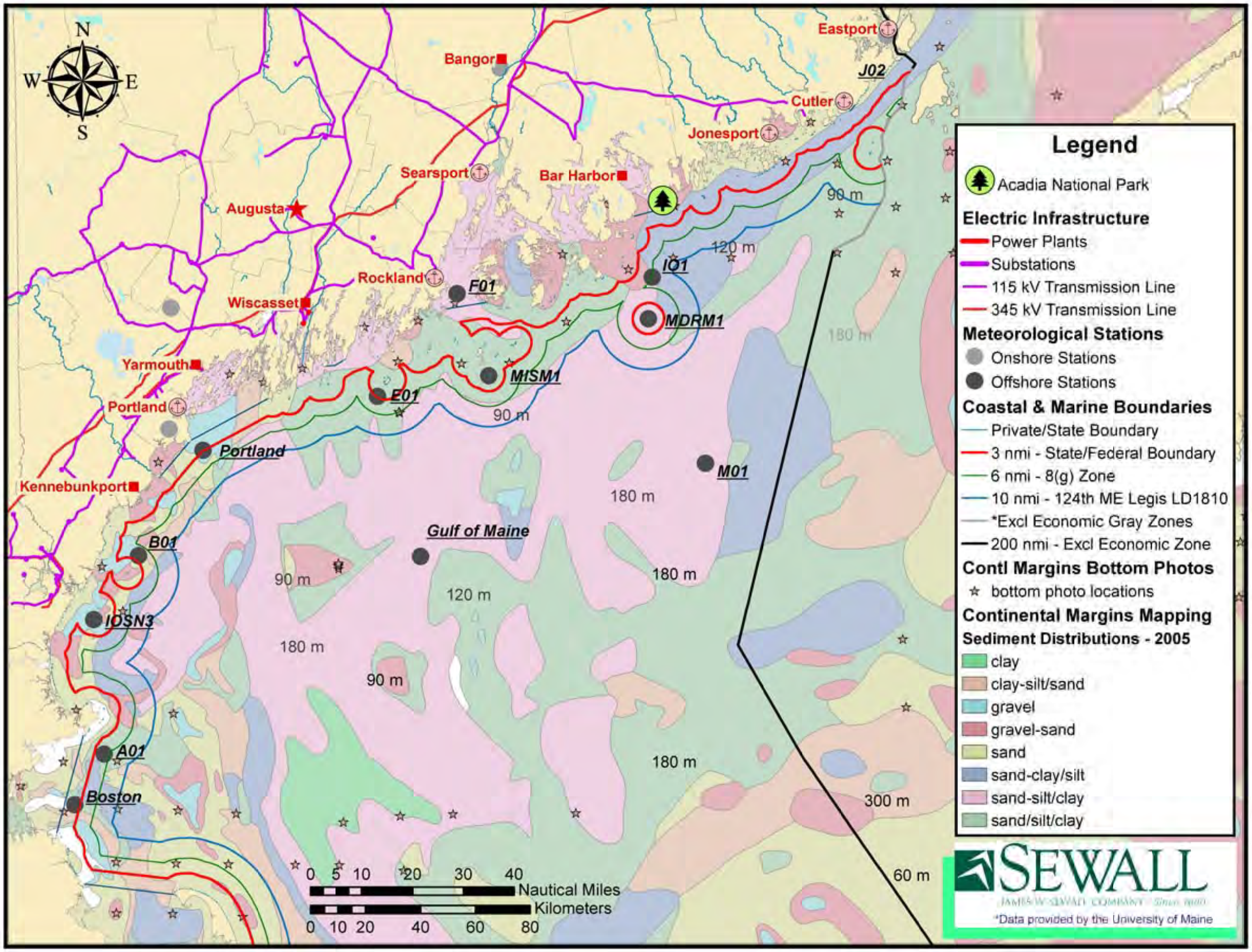

Figure 5-4: Gulf of Maine surficial bottom sediment distribution (after Poppe et al., 2005)

5.2.8 Grid Interconnection Points

The permanent landside portion of any proposed offshore wind project will include the transition from subsea cable to overhead power line and construction of a transmission line to the grid interconnection point. As summarized in Section 4.0 of this report, there are 79 substations that could serve as potential interconnection points within ten (10) miles of the coast. These locations were converted from a series of latitude and longitude points into a GIS shapefile by Sewall. List of potential interconnection sites was reduced from 79 to 21, and then down to a final 15 (see Table 4-8 in Section 4.2). The final location of the grid interconnection will play a major role in determining the subsea cable route and necessary transmission line construction.

Construction of the grid interconnection may encounter various obstacles. As discussed in Section 5.2.7, the presence of wetlands on or around the potential interconnection location may result in environmental impacts and additional permitting. See Section 5.1 for a detailed discussion on site permitting requirements.

Other items to note include the physical accessibility of the site, as well as the proposed corridor from the subsea cable route. The transition from subsea to overhead utility lines will require utility pole design and installation; potential coastal trenching for subsea cable; as well as the clearing of a corridor from the shore to the grid interconnection location. At the actual substation, grading and other aspects site development, such as vehicle accessibility and other utilities, will be site-specific. The degree of permitting and site design will depend on the final selection of grid interconnection point and the distance from the end of the subsea cable route to the interconnection substation.

5.2.9 Subsea Cable Routes

Existing subsea cables and permitted cable corridors need to be identified to evaluate areas of interest for potential conflicts with existing cables, as well as investigate the potential to reactivate unused cable routes. Additionally, areas on navigational charts where dragging is prohibited often represent cable routes and should be reviewed. The location of existing cable lines and no-dragging corridors was obtained from the NOAA Office of Coast Survey (NOAA-OCS). Figure 5-5 shows the cable routes identified within the GoM. Towing routes and potential project areas should be evaluated where they intersect cable areas and no-dragging corridors to verify that there will be no conflict. It may be beneficial, however, for the location of the proposed subsea cable from the wind farm to coincide with existing no-drag corridors, where possible. Anchoring locations for the turbines should be examined to remove any conflict with existing subsea utilities.

5.2.10 Military Activity/Restricted Zones

Certain areas along the coastline are designated for military activity and zones of restricted access. Geospatial information for these areas was obtained from electronic navigation charts (ENCs) from NOAA-OCS. The information obtained shows coastal restricted areas, military zones, unexploded ordnance areas, and other explosives dumping grounds information. Figure 5-5 shows the location of military and other restricted areas within the GoM.

It is essential to know the location of areas of military activity and restricted zones and identify areas of concern where towing routes, offshore wind farm location, subsea cable, or other construction activity may intersect or abut said areas. Unexploded ordnance and other explosives dumping grounds must be avoided in all aspects of the project. Activity within coastal restricted areas will be dependent on the types of restrictions imposed by the military branch, and will require explicit permission from the military branch. It is advisable to avoid conflicting with these restricted areas. Requirements for permission to conduct construction activities in other military zones will vary depending on the type of zone. A review of areas of concern, along with early communication with the jurisdictional military branch, is essential to ensure the smooth progression of the project.

5.2.11 Shipping Lanes and Ferry Routes

Shipping lanes need to be identified in order to evaluate any potential impact on transportation in state or federal waters. The location of established shipping lanes was obtained from NOAA-OCS. As part of the navigable waters of the United States, shipping lanes are under the jurisdiction of the United States Coast Guard (USCG). Available data on shipping lanes includes harbor approach areas, traffic separation zones, and recommended vessel routes. Figure 5-6 shows the location of shipping lanes within the GoM.

The offshore wind farm project location should not interfere with established shipping lanes. Transportation of materials to marine assembly and storage areas and towing of turbine components to the offshore site will create additional marine traffic. Shipping and towing schedules and routes must be coordinated with the USCG to prevent conflicts or unnecessary delays on commercial waters. In addition, the turbine structures themselves are subject to USCG review, regarding navigational risks and marking and lighting. See Section 5.1 for additional permitting and review information.

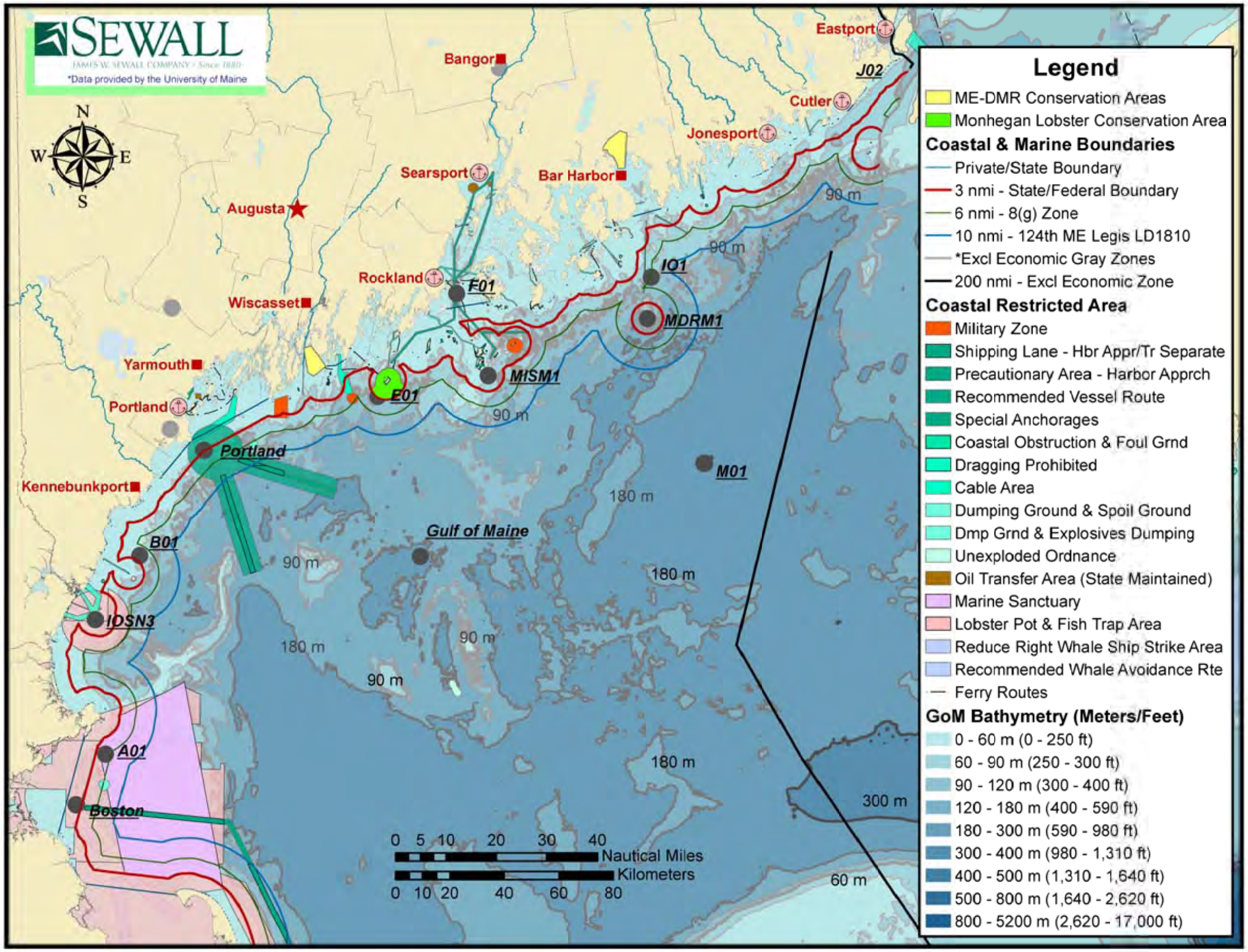

Figure 5-5: Restricted Areas and Coastal Hazards in the Gulf of Maine

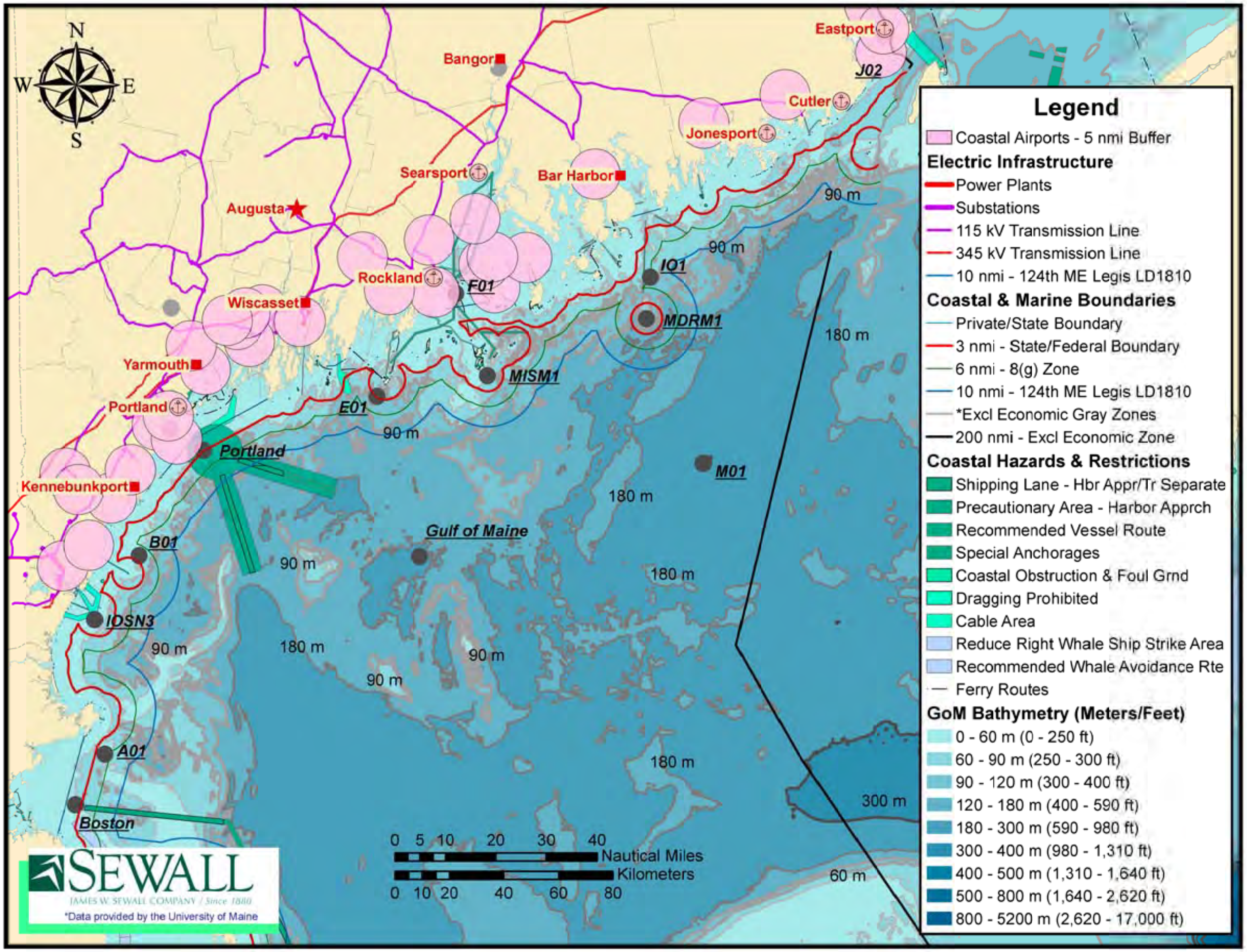

Figure 5-6: Infrastructure and Transportation Features in the Gulf of Maine

Ferry routes can also affect the selection of potential project areas and tow routes. Within the Penobscot Bay, there are three active ferry routes that cross the bay between Rockland harbor and Matinicus Island, North Haven and Vinalhaven. These ferry routes represent potential conflicts. There are also three ferry routes between Monhegan Island and the mainland, which could represent potential, although minor, conflicts with potential subsea cable routes. Figure 5-6 shows the location of ferry routes within the GoM.

5.2.12 Coastal Wildlife and Migratory Marine Species

The GoM contains numerous migratory marine species including, but not limited to, many species of fish, marine mammals, and some sea turtles. Some of these species have been listed as threatened or endangered and are protected under the Endangered Species Act. Reflective of the need to preserve critical habitat for these and other marine species, marine sanctuaries and other marine protected areas have been designated throughout the GoM. Other areas of critical habitat for coastal wildlife have also been identified by DMR, DIFW and NMFS, including inland waterfowl and wading bird habitat, coastal seabird nesting areas, and eelgrass beds. Geospatial information showing areas of concentration for highly migratory species, marine sanctuaries, marine protected areas, critical habitat and breeding grounds was obtained from NMFS and the Maine Office of GIS (MEGIS). Figure 5-7 shows the coastal wildlife and habitats, while Figure 5-8 shows marine migratory species of concern. Current information on marine protected areas can be obtained from the National Marine Protected Areas (MPA) website: http://www.mpa.gov.

It is important to look at the cumulative properties of the offshore wind farm site, including the subsea cable route, towing routes, marine assembly and storage areas to identify impacts, if any, on designated critical habitat or marine protected areas. It is possible that if towing routes cross a protected area, towing components may be restricted to certain times of the year to prevent disruption of migratory routes or other marine life activity. Some protected areas may restrict development or moorings, which would directly affect offshore wind farm construction. If the offshore wind farm location itself overlaps a marine protected area, in-depth environmental monitoring and assessment may be required to determine the extent of impact on the protected species. For this reason, and to minimize impact on the environment, it is advisable to avoid encroaching on these areas with permanent offshore structures. For a detailed discussion of environmental impacts, see Section 5.3.

5.2.13 Economic and Extractive Resources

Commercial fishing is a very important industry to the State of Maine and an important part of the local economy in the coastal and island communities where many fishermen live and work. Areas of restricted fishing are therefore important not only from an environmental conservation standpoint, but also from an economic perspective. There are a number of areas of restricted fishing activity in the GoM, ranging from year-round closures to seasonal closures to one or two-week closures for certain protected species. Figure 5-9 shows many of the areas that restrict commercial fishing activities. Geospatial information for these areas was obtained from NMFS and MEGIS.

There are also dynamic and seasonal management areas that restrict the speeds of certain sized vessels (greater than or equal to 65 ft) to reduce the likelihood of collisions with endangered North Atlantic right whales. Dynamic Area Management (DAM) and Seasonal Area Management (SAM) zones reflect areas of historic right whale and other marine mammal activity that have restricted fishing and the use of floating rope in previous years. Figure 5-9 shows the DAM zones in the GoM for the past two years. As of April 2009, commercial fishermen have been required to use sinking rope, and the DAM/SAM zones have been renamed as Dynamic Management Areas (DMAs) and Seasonal Management Areas (SMAs). The DMAs and SMAs still represent areas of restricted commercial fishing and boating activity. In SMAs, all vessels 65 ft or longer must travel ten (10) knots or less. For DMAs, mariners are requested, but not required, to avoid either the DMA or travel through them at ten (10) knots or less. Updated information on current DMAs and SMAs can be obtained from the NOAA Fisheries Office of Protected Resources (http://www.nmfs.noaa.gov/pr/shipstrike/).

5.2.14 Cultural and Archaeological Resources

Maine's nearshore coastal zone has the potential to host a variety of cultural resources. A long history of fishing and marine commerce produced many shipwreck sites along the Maine coast. Maine's complex sea level history resulted in subaerial exposure of regions between the modern day coast and depths of 60 m between 13,000 and 5,000 years ago. Human occupation of these areas is established by the recovery of artifacts from Maine's nearshore region. Cultural and archaeological resources in the GoM include, but are not limited to, shipwrecks, lighthouses, significant viewsheds and recreational areas. The primary source of data for coastal shipwrecks is from the NOAA Automated Wreck and Obstruction Information System (AWOIS). Lighthouse data was compiled from information from the National Park Service (NPA), Maritime Heritage Program (MHP), Lighthouse Heritage, National Historic Lighthouse Preservation Act (NHLPA) of 2000, Great American Lighthouse Resource (GALR), and other local sources. Figure 5-10 shows the location of lighthouses and shipwrecks in the GoM.

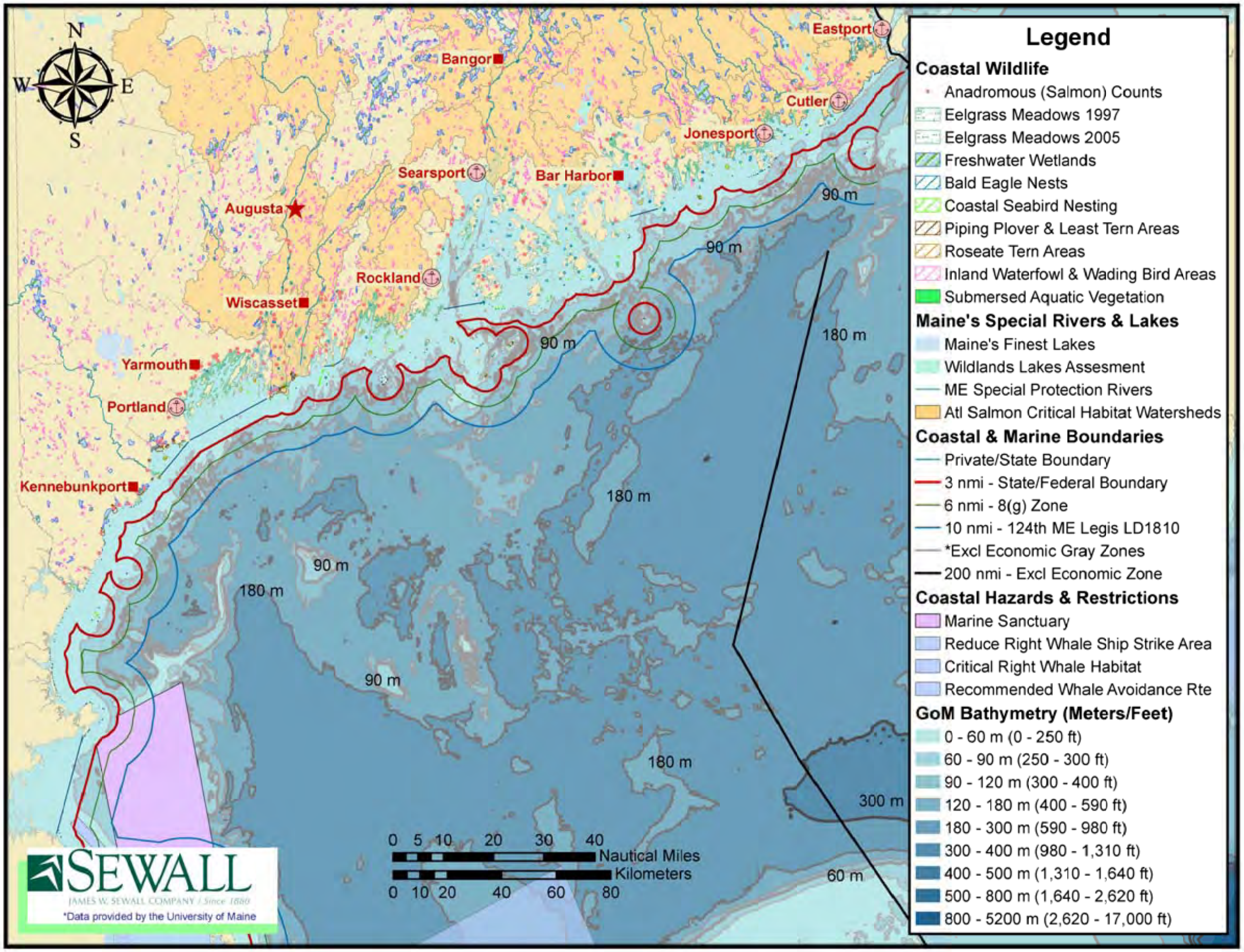

Figure 5-7: Coastal Wildlife in the Gulf of Maine

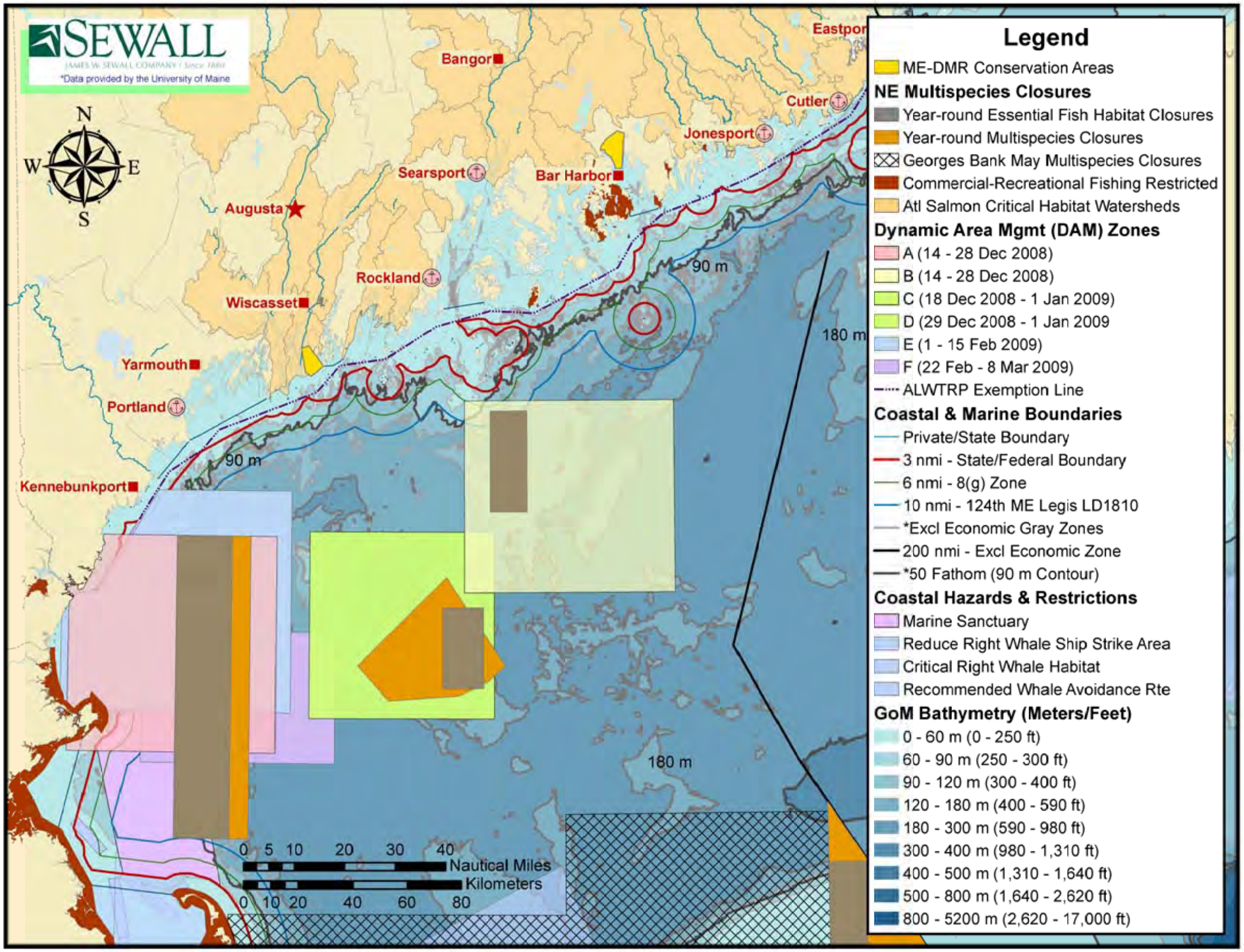

Figure 5-8: Marine Migratory Animals of Concern in the Gulf of Maine

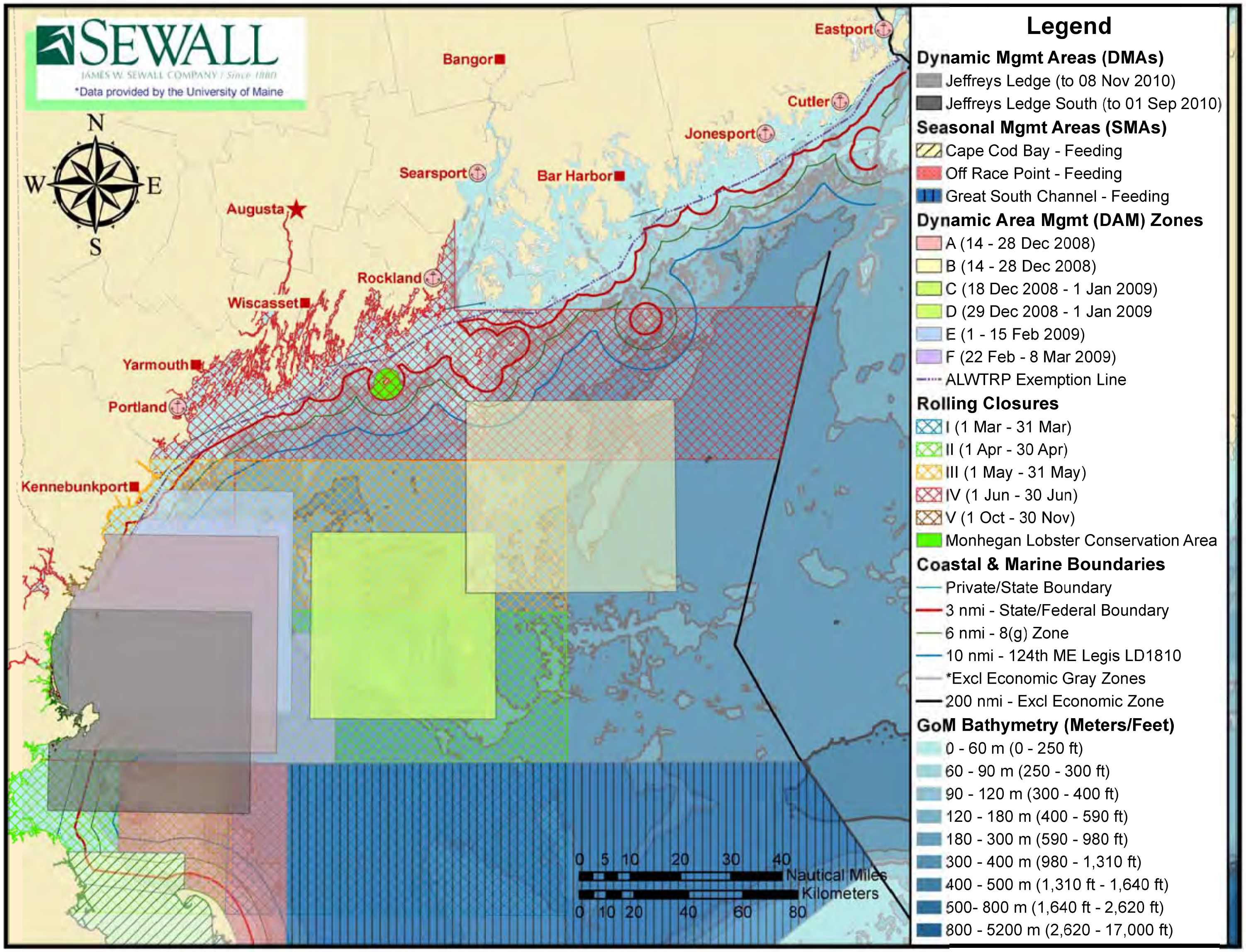

Figure 5-9: Coastal Economic and Extractive Resource Areas of Use in the Gulf of Maine

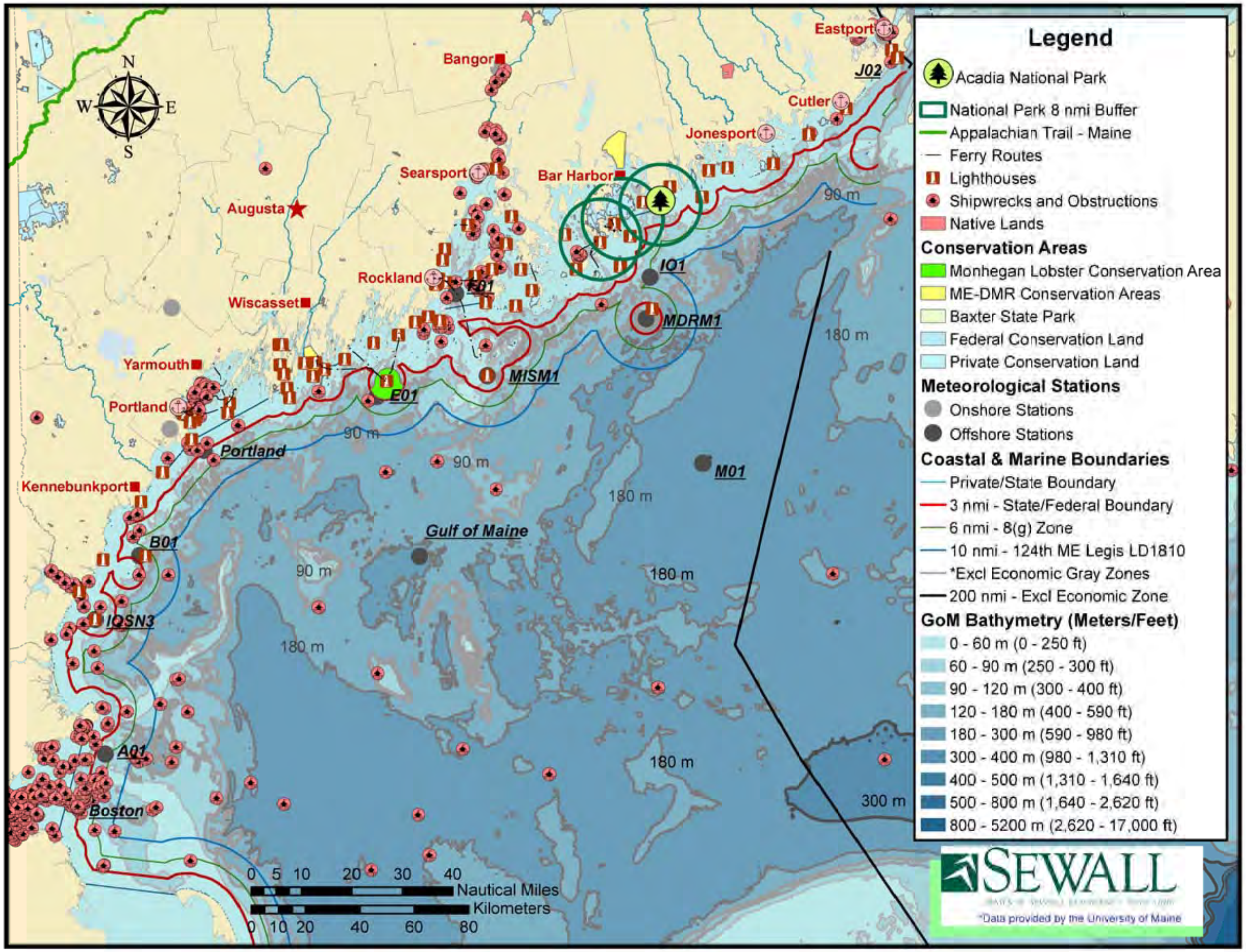

Figure 5-10: Cultural and Aesthetic Features in the Gulf of Maine

It is important to note that many lighthouses, all along the Atlantic coast, are being sold to private owners. As these lighthouses are sold and transition from active to private status, they are designated by the National Park Service (NPS) as cultural features and then regulated under the National Historic Preservation Act (NHPA). The regulated viewshed for these cultural resources is eight (8) miles, while the regulated viewshed for active lighthouses is typically only miles (5) miles. Accordingly, viewshed analyses need to be conducted for any private lighthouses within eight (8) miles of any of the components of a proposed offshore wind project, including the subsea cable route, tow out route and marine assembly area. The eight (8) mile viewshed would also apply to Acadia National Park.

Cultural and archaeological resources are unique and often historically significant. Therefore, it is important that any offshore wind development avoid detrimental impacts on these features. Considerations should include views of the turbines interfering with vistas from shore, behind lighthouses, or other areas where their presence may create aesthetic issues for observers. Legislative limits placed on developing closer than ten (10) nmi from land should obviate most of these concerns (see Section 5.2.1 and discussion of LD 1810). Depending on the location of landside marine assembly and storage areas, similar concerns with views or accessibility to cultural resources may need to be addressed on a case-by-case basis; however, these would generally be considered to be temporary impacts. Other concerns may include navigating around cultural or archeological resources during construction. Towing routes should avoid subsea features such as shipwrecks. In the event that towing routes lie above recorded shipwrecks or other underwater feature, an evaluation will need to be performed to ensure that the towed turbine component will not collide with the structure. Turbines should not be located over shipwrecks or other underwater features as anchoring systems may damage the resource and the stability of the anchoring system may be compromised. Viewsheds and recreational areas are somewhat subjective and should be evaluated on a local level once the proposed wind farm site and towing routes have been established. Public meetings may be warranted in areas of high tourism to hear community concerns and allay fears that turbines might spoil the ocean coastline and its viewshed.

Section 106 of the National Historic Preservation Act requires that impact of projects on cultural resources must be assessed and plans to avoid, minimize or mitigate any adverse affects be implemented. This includes not only identification of submerged geoarcheological evidence of historical human occupation, but shipwrecks and other artifacts that may provide evidence of historic human life and culture. Identification of submerged cultural and historical resources of significance that may be affected by marine development should be evaluated using a successful Maine SHPO-approved strategy. This strategy relies on a trained geoarcheologist to analyze trusted data and images from (a) side scan sonar geophysical surveys, used to identify the presence of historic shipwrecks; and (b) detailed multi-beam bathymetric surveys and seismic reflection profiles, used to identify the presence of landforms and geomorphic settings that have a high potential to be submerged prehistoric cultural resources.

5.2.15 Recreational Uses

Recreational uses of the coastal zone include recreational boating, sailing, and tourism activities, including whale-watching tours and tours of historic lighthouses. Figure 5-11 shows the location of national parks, lighthouses and windjammer sailing cruises in the GoM. Recreational uses are not anticipated to impact significantly the siting of offshore wind turbines, the subsea cable route or the marine assembly area; however the USCG will require the project to have a navigation safety plan that establishes exclusion zones around the offshore structures (i.e., wind turbines, substation platforms).

5.2.16 Necessary Additional Surveys

In the previous Sections 5.2.1 through 5.2.15, potential actions or surveys that may be required for final development of an offshore wind farm in the GoM have been described. In summary, the following additional surveys will likely be necessary to support design and permitting of up to a 30 MW offshore wind pilot project:

- Site-specific wind measurements (e.g., anemometer supplemented with LiDAR or SODAR)
- Site-specific met-ocean measurements (e.g., repurposing of inactive GoMOOS/NERACOOS buoys)
- Bathymetric surveys of the project area, tow out route and subsea cable route
- Topographic surveys of the transmission line route
- Geophysical and geotechnical engineering studies of the offshore project area and subsea cable route to characterize the bottom substrate and the type and depth of surficial sediments
- Delineation of freshwater wetlands, vernal pools, coastal wetlands, coastal marshland and essential fish habitat areas in the vicinity of the construction/assembly area and along the subsea cable and transmission line route

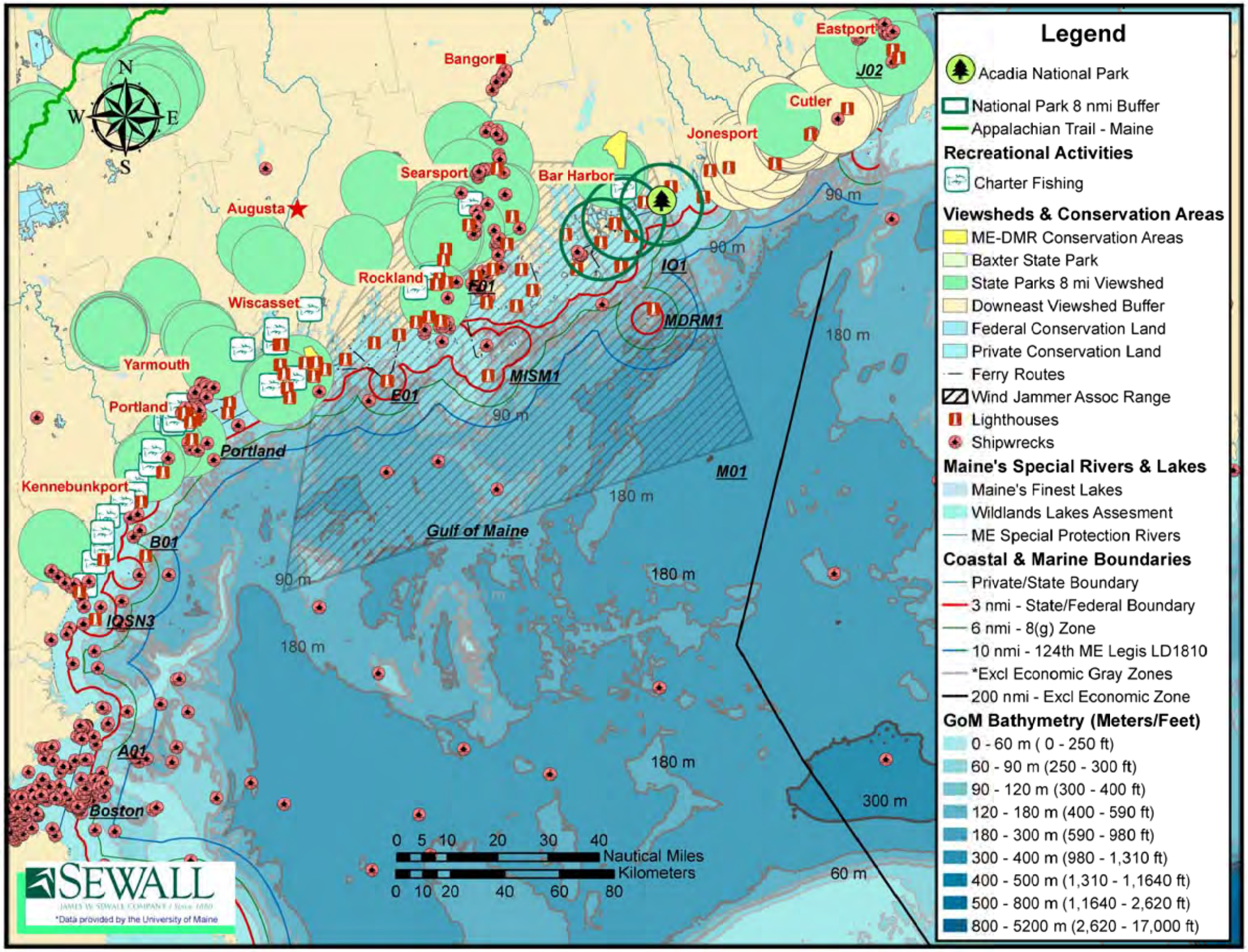

Figure 5-11: Recreational Uses of the Coastal Zone in the Gulf of Maine

5.3 ENVIRONMENTAL CONSIDERATIONS

5.3.1 Introduction of Environmental Considerations

The majority of studies to date of environmental impacts of wind turbines are based largely on the European experience. As of February 2011, no wind turbines have been installed in marine waters off the continental United States as compared with over 700 in marine waters off of the European coast. Most of the European installed turbines are on monopole platforms or use gravity-based structures or jackets; are all connected rigidly to the seafloor, and in waters depths of less than 45 m (and mostly less than 20 m).

Gill (2005) notes that offshore renewable energy development results in various interactions with the local environment and its biota. Potential modes of interaction are collision and avoidance; noise and vibration; electromagnetic fields (EMF); and changes in habitat heterogeneity, sediment transport and water movement. He further notes that such developments could: (1) affect sound and EMF-sensitive species at the individual or population level; (2) lead to changes in migratory patterns, fatalities and injuries to animals; (3) alter nutrient regimes, species diversity and abundance, production and biomass, community composition and size structure; and (4) have other indirect effects. This assessment is only partially transferable to floating, deepwater wind installations because the structures, the disturbances caused during installation, the initial and modified habitats, and the species in deep water are substantially different from those near shore. Consequently, the extent to which the European experience generalizes to deepwater wind development off the Maine coast is limited, leaving substantial information gaps. Nonetheless, with these important caveats, environmental impacts studies associated with European offshore wind installations will be valuable for assessing potential impacts in the GoM.

In an effort to consider and address potential concerns relating to the development of offshore wind in Maine coastal waters, Governor Baldacci of Maine established the Maine Ocean Energy Task Force (OETF) in November 2008. The primary objective of the OETF was to recommend strategies to meet or exceed the goals established in the Maine Wind Energy Act (i.e., 2,000 MW wind capacity by 2015; and 3,000 MW by 2020), including identification of potential economic, technical, regulatory and other obstacles to development of grid-scale offshore wind energy facilities off the coast of Maine. The Environmental Impacts Subcommittee Final Report to the Maine Ocean Energy Task Force (OETF) made several recommendations regarding offshore wind development. The report states the following:

> *There is a great deal of information concerning the habitat, species and existing uses in the Gulf of Maine. There is an even greater amount of information necessary to fill gaps in this information. Comprehensive data-gathering efforts must continue to add*

to current information about the ecosystem as a whole so public and private decision-making is guided by the best available information. Such information should be publicly available and used to supplement the Coastal Atlas as recommended by Subcommittee 2.

The Subcommittee also noted the following:

The Gulf of Maine is a dynamic ecosystem that has great value environmentally, economically and emotionally. Regulation and management of offshore renewable energy projects must take a precautionary approach and must be able to adapt to the best available data as it becomes available in order to minimize adverse impacts. This will require sustained monitoring of environmental impacts to identify and respond to unanticipated changes in the environment. Regulation must take into account not just the construction and operation of offshore renewable energy projects but also cumulative impacts of such projects.

We review in this section the environmental considerations related to the building, installation and operation of up to a 30 MW deepwater offshore wind project in federal waters, with connectivity to coastal areas of the State of Maine. Our review is organized into seven (7) parts, which are described in the following subsections:

- Section 5.3.2 briefly describes the physical environment and the large-scale biogeography of its communities;
- Section 5.3.3 provides an overview of major species groups found in the areas under consideration, highlighting environmentally sensitive or valuable sites and protected areas;
- Sections 5.3.4 – 5.3.7 discuss potential effects on major species groups in four primary impact categories:
  - physical interaction with turbines
  - alteration of benthic habitats
  - acoustic effects, and
  - electromagnetic field effects
- Section 5.3.8 summarizes the study findings in a risk matrix, articulates a series of priority questions and recommends site-specific and/or technology-specific surveys and studies

The study designs suggested in Section 5.3.8 are appropriate to fill the current knowledge gaps and extend understanding of potential development effects of moored, offshore wind turbines. The studies suggested are designed to be appropriate to the scale of a small wind farm but also helpful in anticipating effects of scaling up to a larger, more commercially viable installation and designing studies to test those predictions at the larger spatial scale and longer time scales.

In developing this assessment, recent studies conducted in association with permitting of the proposed Cape Wind development in Nantucket Sound, as well as initial environmental resource studies in anticipation of offshore wind development in New Jersey and Rhode Island were considered. It is important to note that not all of the information related to the Cape Wind, New Jersey, and Rhode Island projects is transferrable because these installations are currently designed to be fixed rigidly to the seabed and will be deployed in waters shallower than those being considered for offshore wind development in Maine.

5.3.2 Physical Environmental and Large-Scale Biogeography

The geographic area considered in this chapter meets the criteria specified in LD 1810 for a deepwater wind pilot project, specifically sited in waters at least 300 ft deep and at least ten (10) nmi from the Maine coast and from any islands that are inhabited (Figure 5-12).

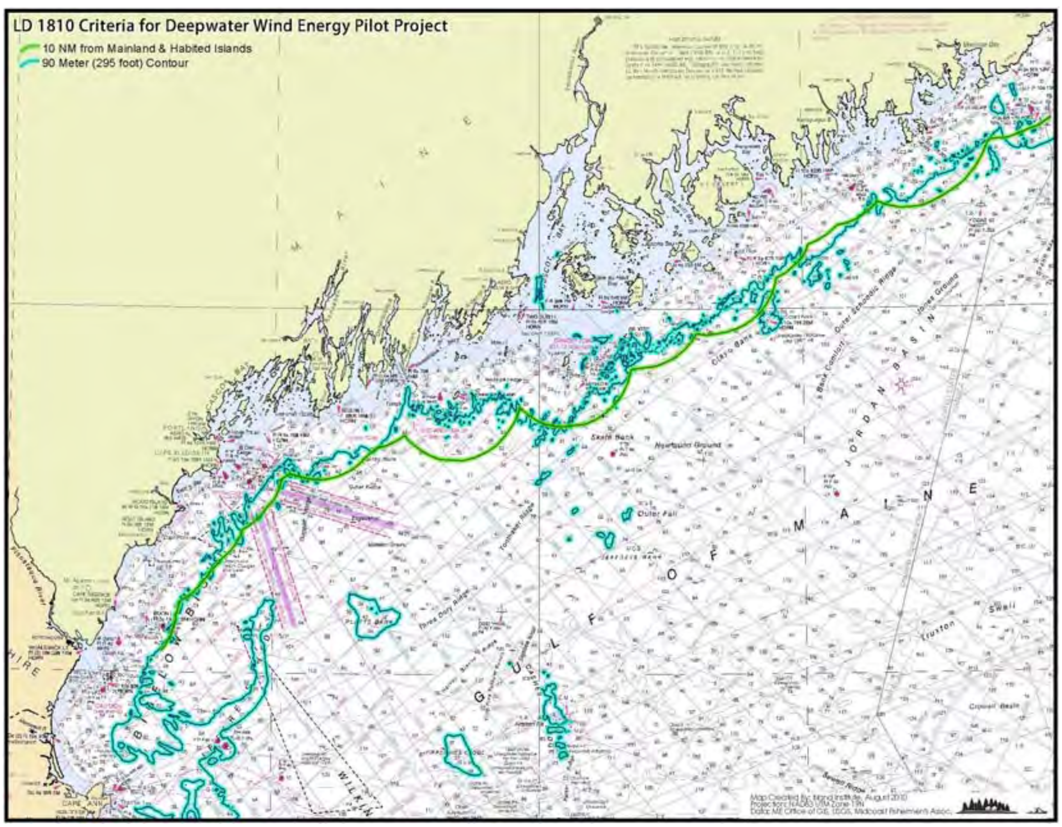

Figure 5-12: LD 1810 Criteria for Deepwater Wind Energy Pilot Project

This restriction places the proposed sites near the edge of the GoM's northern coastal shelf (Figure 5-12). Bottom type at this range of depths in the GoM is more than 70% mud. The midshelf front in the GoM generally follows the 50-m isobath, placing the proposed sites in the southwestward, isobath-following currents known as the Eastern Maine Coastal Current and the Western Maine Coastal Current. At the transition near the mouth of the Penobscot River and Jeffrey's Bank (not to be confused with Jeffrey's Ledge farther southwest), a partial flow separation and recirculation occurs at the division between the eastern gyre that circulates cyclonically around Jordan Basin and the western gyre that circulates cyclonically around Wilkinson Basin. In general, the warmer western gyre stratifies earlier in the year and more stably than the cooler eastern gyre. Mean coastal current velocities are of order 0.1 m/s, with substantially higher tidal velocities in some locations. Except where they are topographically focused, near-bottom currents will be substantially slower, as evidenced by the deposition of mud.

Summer nutrient limitation makes stratified seas sensitive to mixing and upwelling. Thus offshore sites can be more sensitive to mixing effects than are sites inshore where stratification breaks down frequently due to frictional effects at the seabed and injection of momentum at the surface from wind stresses and breaking waves. Islands have long been known to cause stirring; an island in a current is analogous to a stirring rod moving at the same relative speed in terms of its mixing effects, and the mixing can have interacting components due to tides and a steady current (Simpson et al., 1982). Islands also cause persistent structure in the curl and divergence of the wind stress that leads to upwelling (Chelton et al., 2004). Such island effects on phytoplankton abundance have been documented in the region of interest (Townsend et al., 1983). Broström (2008) has predicted, based on models of wind stress, that large, offshore, floating wind farms could produce upwelling velocities of one meter per day (1 m/d), sufficient to cause phytoplankton blooms. Nutrient alterations in this region are of interest because nutrient supplies are known to affect occurrence and persistence of harmful algal blooms. Local mixing is also feasible if the floating support structure for a turbine extends through the thermocline, although again the small horizontal dimension of the platform ("stirring rod") limits these effects.

Benthic megafaunal and macrofaunal densities decrease with water depth. The megafauna is usually defined loosely as those organisms large enough to see in bottom photographs; the term combines ideas of size and lifestyle on the surface of or just above the bottom. The macrofauna is defined more strictly in terms of animals larger than a size cutoff, usually 1.0 mm, 0.5 mm, 0.4 mm, and 0.3 mm, and operationally by retention on a sieve with openings of that mesh size. Macrofauna can be epifaunal (living outside the sediments as does the megafauna) or infaunal (living in the sediments). Sedimentary infauna is sampled by cores, grabs or dredges. Megafaunal species diversity in the target depth range is lower than on the shallow shelf and correlates with diversity in bottom type (rock, gravel, sand and mud). Macrofaunal diversity continues to increase to water depths greater than 1000 m, which are not reached inside the GoM. Ecosystems in the GoM cannot be considered to be in stable or steady "baseline" state. Fishing and climate change have elicited major changes whose future trajectories are poorly constrained by models (National Marine Fisheries Service 2009).

Although they are not in steady state, the GoM contains environments that are particularly sensitive for various oceanographic and biological reasons. Two areas have such broad significance to numerous species groups that they would likely require much more study before permitting would be considered there, and in our estimation results of those studies are likely to indicate prohibitive risk to both endangered species and others. These areas are the region surrounding and including Jeffrey's Ledge in the Western GoM south to Cape Cod and the eastern Maine coastal shelf and Jordan Basin area in the northeastern GoM to the Bay of Fundy.

Jeffrey's Ledge: The earliest seasonal blooms of phytoplankton occur in the shallow western GoM, where numerous species, including cod and northern shrimp, converge to release eggs and larvae into a productive milieu with abundant prey of a wide range of sizes. This early season (January-February) bloom generally occurs in the area from Jeffrey's Ledge to Cape Cod and is noted for its frequency of right whale sightings, especially in the fall when larger biomasses of more mature plankton have accumulated (Weinrich et al., 2000) (See Figure 5-13).

Eastern Maine shelf and Jordan Basin: The northernmost GoM, from about Jonesport northeastward, represents the other pole of right whale activity (Figure 5-13) and experiences the convergence of many migratory species, including endangered Atlantic salmon that move through the area after leaving natal streams. Slowest to bloom is the region in and surrounding the Bay of Fundy because of turbidity from sediments suspended by tidal mixing. The bloom here, however, persists once light levels are sufficient because that same tidal mixing constantly renews supplies of inorganic nutrients, which continue southwestward in the Eastern Maine Coastal Current. It is the site of late-season congregations of many species. North-south flyways intersect between Maine and Nova Scotia, giving this region a high density of bird traffic.

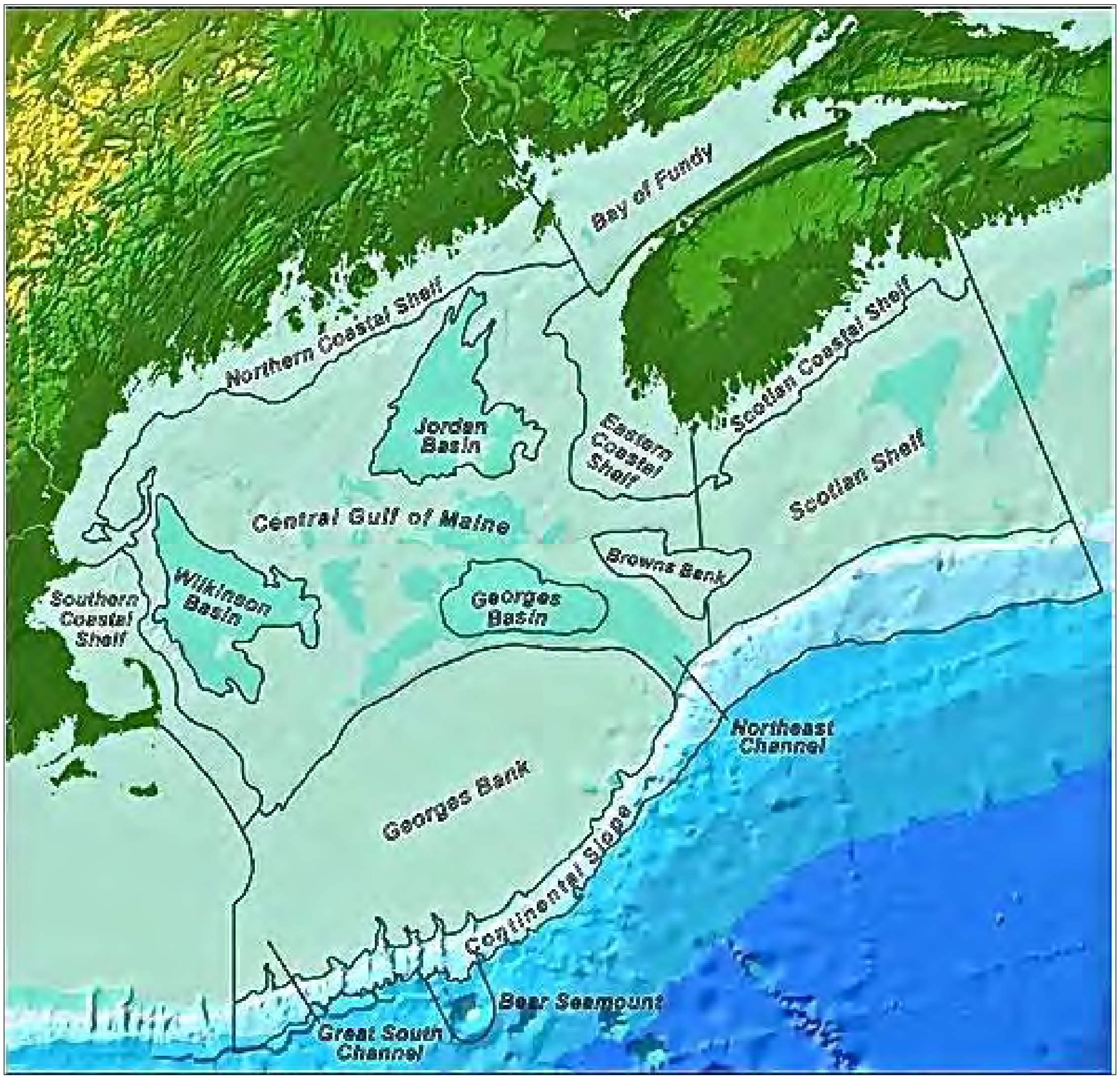

Figure 5-13: Gulf of Maine physioregions (from the Gulf of Maine Census of Marine Life). Note the outer boundary of the Northern Coastal Shelf is defined by the 100 meter (m) depth contour.

5.3.3 Species Groups of Potential Concern in Considered Areas

Of particular relevance to offshore wind discussions are environmental concerns related to species listed as endangered, threatened, or protected that utilize the ocean and coastal region under consideration, particularly whales and seabirds (Source: Managing Maine's Nearshore Coastal Resources: Appendix B.2, p.65). Commercially valuable species are also of particular concern for consideration in terms of both environmental effects and existing uses. Commercially fished species are noted in Section 5.4, and included in the review of species groups, below.

Birds and bats (including threatened or endangered species), R. Holberton

The GoM region provides critical breeding grounds for birds and important migration routes for both birds and bats. Bats play a critical role in terrestrial ecosystems, and many species or populations within species are declining rapidly due to habitat loss and disease. Many populations of migratory birds, including shorebirds, waterfowl, seabirds, and songbirds, have experienced dramatic declines over the past half-century due to loss of wintering and breeding habitats needed during the stationary period of the annual cycle, as well as suitable stopover areas needed to rest and refuel during migration. The Gulf's islands provide essential nesting grounds for many seabirds, some of which are listed by state and/or federal agencies as endangered or of concern. Many landbird migrant populations have been listed by state and/or federal agencies as well.

The birds that inhabit the GoM region during some or all of their life cycles are diverse and comprise many species of freshwater and marine waterfowl, including ducks, geese and associates (approximately 40 spp.). These birds include seabirds such as gulls (28 spp.), gannets (1 sp.), alcids (6 spp.) and pelagic species such as shearwaters and petrels (7 spp.), cormorants (2 spp.), grebes (6 spp.), loons (3 spp.), shorebirds (40 spp.), and wading and marsh birds (17 spp.). They may be found along Maine's coastal and offshore areas, which depend on the time of year. In addition, over 150 landbird species occur in the region and breed and/or migrate along coastal and offshore areas, with many of them making extensive overwater flights on migration between the Canadian Maritimes and southern New England. In addition to their value to biodiversity and ecosystem structure, birds play an important economic role in the region's tourism industry, and a major activity in state and federal non-governmental organizations (NGOs) revolves around organizing birding activities at key breeding and stopover sites in Maine.

See Appendix B.2 (Section 10.2.2) for a list of birds that are documented to breed in the state, migrate regularly through the GoM region, or at some point in their life histories, spend part of their non-breeding period in the GoM region. Terrestrial and freshwater species are included as they can migrate along the coast (within three (3) nmi) and offshore (three (3) to 100 nmi) and have been documented doing so.

Surveillance radar studies 40 years ago in the GoM region (coastline and open ocean) showed that migrating and resident birds of all types can be expected across a wide range of altitudes that include the "rotor-swept zone" of both test and full-scale turbines. Thus, monitoring bird and bat activity related to offshore energy development requires extensive knowledge of movement biology (temporal and spatial movements with regards to foraging areas, breeding and stopover habitat use, flight patterns such as flight altitudes during ongoing, ascending and descending flights, flight direction, response to weather, etc.) of seabirds, shorebirds, waterfowl, landbirds, and bats during the breeding as well as the non-breeding (migration, winter) periods.

The GoM has extensive seabird nesting colonies, managed primarily by state and federal agencies or NGOs as important seabird restoration sites. The nesting season is a critical data period for any site within 30-50 km of any of the major seabird nesting refuge islands that line the entire coastline of the GoM. Much of the Gulf has been designated by Maine Audubon, in conjunction with Maine DIFW and under the guidance of Birdlife International, as “Important Bird Areas” (IBAs). IBAs are regions considered vital to bird populations on a world or regional scale. In Maine, at least 15 bird species are listed as threatened or endangered, and 50 are listed as species of conservation concern (see http://www.maineaudubon.org/conserve/iba/index.shtml) and Appendix B.2 (Section 10.2.2 – IBA site descriptions).

Recent studies by the UMaine Laboratory of Avian Biology (http://sbe.umaine.edu/avian/) and USFWS Maine Coastal Islands National Wildlife Refuge documented a major flyway in the GoM, with over a half-million birds estimated moving over Maine’s Midcoast region as they head south across the Gulf from the Canadian Maritimes during fall migration. Several species of bats also live in and migrate through the GoM region and have been documented moving offshore as well as along the coast. It was shown in 2010 that this flyway is equally active during spring months.

Consideration with respect to birds and bats should include temporal patterns of presence and functional relationships between the proposed activities in a given region and how they may affect: (1) birds’ access to resources for rest, refuge, nesting and ability to obtain food; (2) ability to hear conspecifics, prey, and predators in order to maintain critical social groups, find food, and evade predation; and, (3) ability to maintain energetic condition needed for optimal survival and reproduction, which may be affected by increased avoidance behavior of activities associated with turbine construction, deployment, and operation.

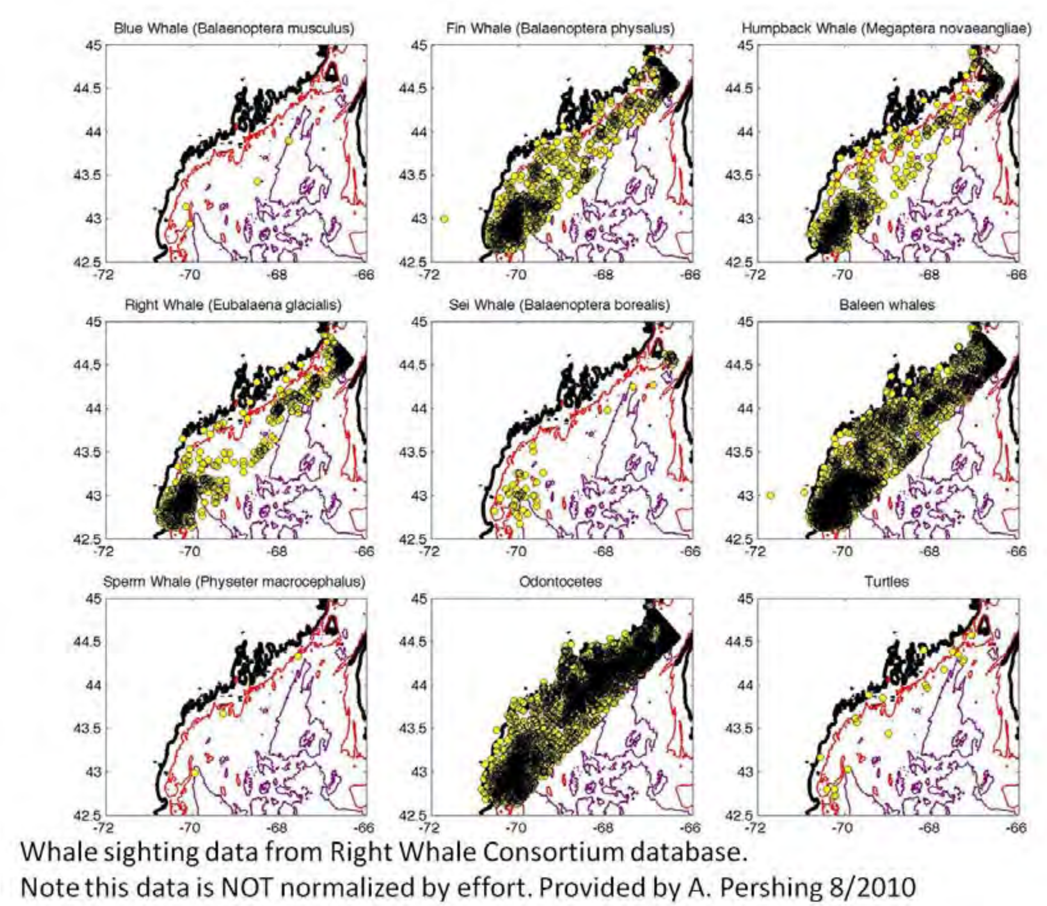

Figure 5-14: Whale Sighting Data (Right Whale Consortium)

Marine mammals (including threatened or endangered species), A. Pershing
The same productivity that sustains the region's fish populations and fisheries also draws a wide variety of temperate and subpolar marine mammals to this region. The Right Whale Consortium Sightings Database has records of six (6) species of baleen whales, 11 species of toothed whales, and two (2) species of seals in waters along the coast of Maine. In addition to the mammals, two (2) species of sea turtles have been reported in the GoM. The majority of these species are most common during spring, summer, and fall, when prey is abundant.

All marine mammals are protected under the MMPA, and many are considered endangered and are listed under the ESA. In particular, all of the baleen whales except minke are endangered. Among all of the species in the database, right whales are of particular concern. The GoM and adjacent Scotian Shelf contain all of the known feeding areas for this critically endangered species, and it is likely that all of the approximately 400 right whales in the North Atlantic visit the Gulf each year.

From the point of view of site selection, it is impossible to declare any region of the GoM to be an area where marine mammals cannot be found. However, certain areas have clear seasonal associations with particular species (Figure 5-14). Within the region considered here, Jeffreys Ledge and the waters off Grand Manaan Island are the most consistent and active whale feeding areas, and all of the baleen whales with the exception of blue whales, can be observed in these areas. Other areas with consistent whale sightings include the waters east of Mt. Desert Rock and south of Boothbay Harbor. It is important to reiterate, however, that both the frequency of boat traffic and local whale abundance factor into the apparent density of whale sightings illustrated. The difficulty of surveying whales during winter means that we know very little about whale distributions during this season. For the last several years, however, there have been consistent sightings of right whales in northern Jordan Basin during early winter. There is growing evidence that this may be the first mating area identified for this population, and thus, should be considered an area of special concern.

Useful information on marine mammals is found in several ongoing databases:

- Right Whale Consortium Database – contains sightings of marine mammals and large fishes. The database is strongly biased towards areas and seasons where both right whales and boaters, including whale-watching vessels, are common; however, it is the most comprehensive database for cetaceans in our region.
- The Maine DMR maintains a database of sightings in Maine state waters and nearby federal waters.
- OBIS-SEAMAP is an online database with worldwide whale sightings. It provides useful information on species ranges.
- The Marine Mammal Stranding Network provides information on marine mammal distributions based on the occurrence of injured or dead animals.

Sea turtles (including threatened or endangered species), R. Steneck
Three (3) turtle species are federally or state listed leatherback, loggerhead, and Atlantic Ridley. All three (3) sea turtles know to inhabit the GoM (Atlantic Ridley, loggerhead and leatherback) are rarely encountered in Maine. The Atlantic Ridley turtle is "very rarely encountered in the Gulf of Maine" (Maine DIFW Wildlife assessment). The two most common sea turtles in the GoM (e.g., loggerhead and leatherback) are primarily tropical in their distribution. Nevertheless, sightings of both species extend up the eastern seaboard (Shoop and Kenney 1992). Loggerheads prefer warmer sea temperatures than leatherback (i.e., sea temperatures warmer than 22.2 °C and 20.4 °C, respectively) and sightings of both species are largely confined to summer (Shoop and Kenney 1992). Both sea turtles are rare in the GoM. Loggerhead turtles are most abundant south of Cape Cod. Leatherbacks are the world's largest sea

turtles, and they have the largest geographic range. Sightings are concentrated south of Long Island, New York, but they have been seen as far north as Nova Scotia.

Benthic macrofauna (infauna and epifauna) in and on soft substrata, P. Jumars
The benthic macrofauna at depths between 100 and 250 m in the GoM is best known through historical surveys conducted by the United States National Marine Fisheries Service (Wigley and Theroux 1981; Theroux and Wigley 1998). Detailed species and abundance information on specific sites is scarce, with the exceptions noted below and a few other studies that included samples in this depth range (e.g.: Maurer and Leathem 1980, 1981).

Benthic megafauna including corals and epifauna — both hard and soft substrata, R. Steneck
Megafaunal dominance (i.e., dominant species or higher taxonomic divisions) changes, and diversity and abundance decline, with distance from shore and water depth. Species also vary with substrate composition.

Away from the coastal shelf (100-m contour) the dominant epibenthic invertebrate megafaunal taxa are (in order of abundance) sedentary brittlestars (*Ophiuroidea*), seastars (*Asteroidea*) and sessile anemones (*Cerianthus, Pennatula, Bolocera*). An additional 13 species constitute only a few percent of the remaining total from a large ROV survey at depths ranging from 144 to 381 m conducted in the Central GoM physioregion (n=27,276 organisms; Langton and Uzmann 1989).

Closer to the shelf edge and in shallower water, large decapods such as crabs (*Cancer borealis*) and the lobster (*Homarus americanus*) become more abundant (Figure 5-15 and Figure 5-16). Maine's inshore trawl survey records lobster densities two orders of magnitude higher than is reported in the NMFS trawl surveys in the Central GoM physioregion. Closer to shore, rock outcrops increase and species diversity and abundance increase with the added habitat heterogeneity.

Substrate characteristics affect species composition and population densities in many communities. Lobsters are shelter-preferring organisms, and they are often at highest population densities in boulder substrata (Steneck and Wilson, 2001). Since the extirpation of most natural predators of lobsters, they now can live in sediment habitats but at lower population densities than in rocky regions where lobster densities are aggregated (Steneck and Wilson, 2001, Butler et al., 2006). Unlike crabs that have a carapace fused to their sternum, lobsters cannot live in soft, flocculent mud that is common in areas that are frequently disturbed by trawling. It is likely that mooring chains anchoring the wind generators will create small areas that will be unattractive to lobsters. If frequent chain sweeps on the bottom do not occur, then the anchors and chains will probably attract lobsters since any hard substrate increases the habitat carrying capacity for this species (Steneck 2006a).

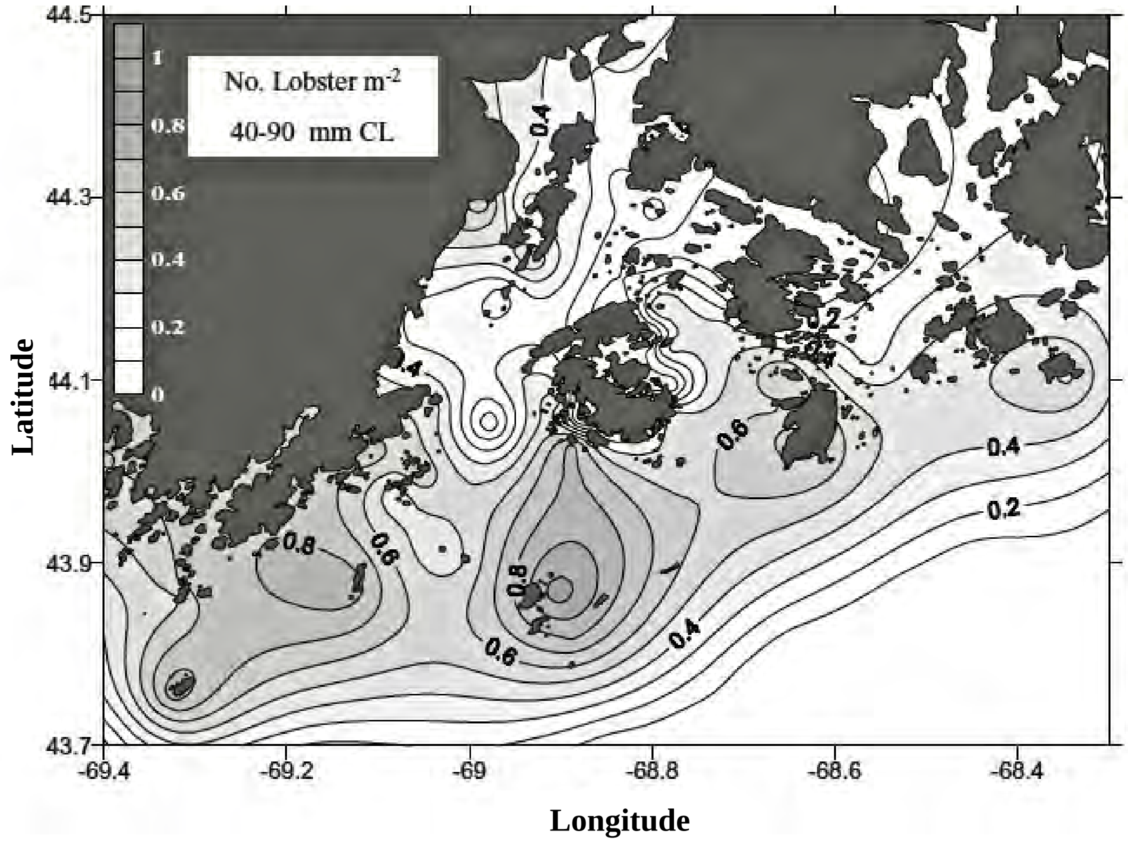

Figure 5-15: Lobster population densities in Midcoast Maine (from Steneck and Wilson, 2001)

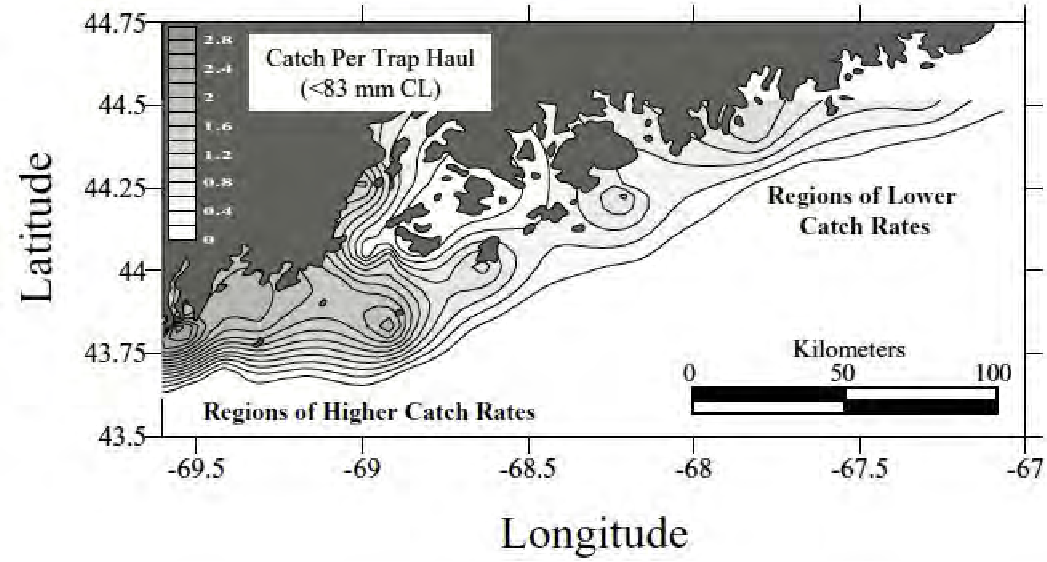

Figure 5-16: Catch per unit effort of pre-recruit lobsters in Midcoast Maine (from Steneck and Wilson, 2001)

In the central GoM physioregion, mud and silt habitats are strongly dominated by *Pennatula* (sea pen gorgonians) and *Ophiuroidea* (brittlestars). At larger sediment grain sizes (including sand and coarse sand), taxa with the highest densities were ophiuroids (brittlestars) and *Cerianthus* (anemones). Among gravel, cobble and boulder habitats, larger *Bolocera sp.* (anemones) and *Asteroidea* (seastars of the genera *Asterias, Hippasteria, Henricia, Crosaster and Solaster*) dominated the benthos (Langton and Uzmann 1989).

Corals occur in two taxonomic groups of Cnidaria; the stony corals (*Scleractinia*) and the soft corals (*Alcyonacea*). Deep- and cold-water corals are relatively rare in the western North Atlantic compared to the eastern North Atlantic (Figure 5-17). In fact, the most recent cold-water coral geographic database show no corals anywhere on the northern coastal shelf or the central GoM physioregions near Midcoast Maine (Scanlon et al., 2010).

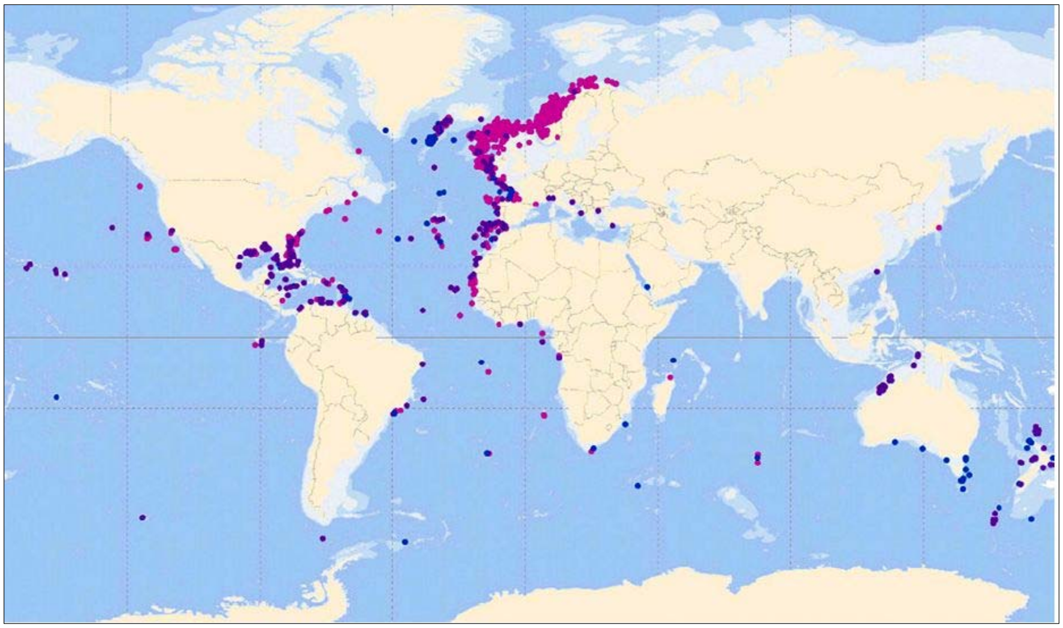

Figure 5-17: Global distribution of cold-water corals (Freiwald et al., 2004)

There are 15 species of scleractinian corals in the western North Atlantic within the continental shelf spanning from Cape Hatteras to the GoM, including Georges Bank (Cairns and Chapman, 2001). Most live on seamounts and the continental shelf (including Georges Bank) but not in water depths found in the central GoM (Cairns 1981). The most notable exception is *Lophelia prolifera* that is common in the western North Atlantic south of Nova Scotia, but still in relatively deep (280 – 2165 m) water. Thus, the relatively shallow GoM is not habitat for stony corals, and none were reported from the region's massive megafaunal survey (Langton and Uzmann 1989).

The gorgonian Alcyonacea soft corals coral are better represented in the GoM but still in low abundance. They have rigid axial skeletons, creating carbonate bioherms that can be habitats for fishes (Auster, 2005). Of the 17 soft coral species reported for the western GoM (Watling and Auster, 2005), three are common (Watling, pers. comm.). All three species live on rock habitats, and they are most abundant on Georges Bank and in the eastern GoM (Figure 5-18). Given this distribution, it is likely they could recruit to anchors and chains used for wind turbine mooring systems.

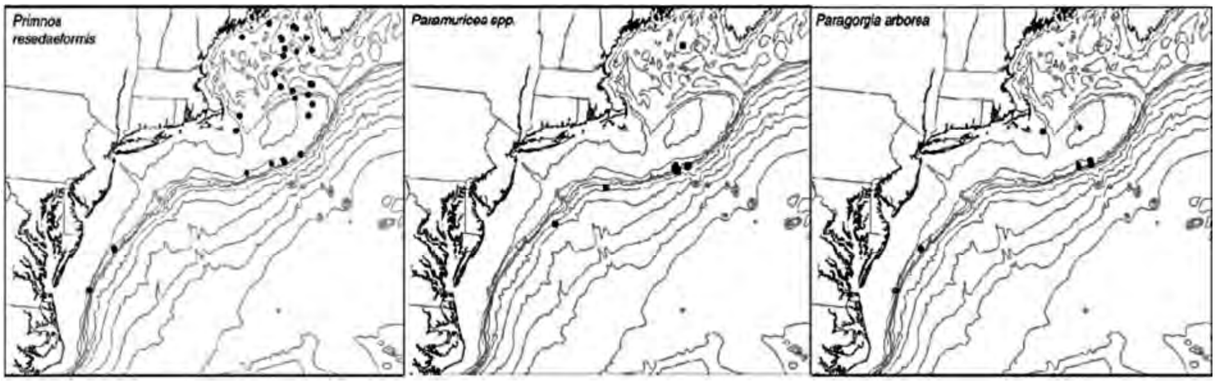

Figure 5-18: The distribution pattern of the three most abundant Alcyonacea species in the Gulf of Maine (after Watling and Auster, 2005)

Fishermen anecdotally report these species being found in the past near coastal Maine. While today, they are found in micro-refugia where fishing trawls cannot harm them, in the past they were believed to be more widespread (Watling, pers. com.). Shrimp trawls that frequent proposed wind energy sites undoubtedly have destroyed most coral colonies in recent decades. It is possible that the trawl-free zone required for the wind-generation area could become a refuge for colonization and development of deep-water corals in the future.

Beyond being regionally rare today, deep-water corals do not thrive in sediment-dominated benthic communities. All corals require hard substrate to settle (Cairns 1981), but the size of the clast can be small. Auster (2005) examined diversity of all deep-water corals in and around the GoM and determined that diversity of corals was greatest in boulder habitats without mud and lowest in boulder habitats with mud (Figure 5-19). Note that the curve with the highest species richness (BG 2) is from boulder substrates without mud whereas the lowest species richness (BG 1) was from the same habitats with mud.

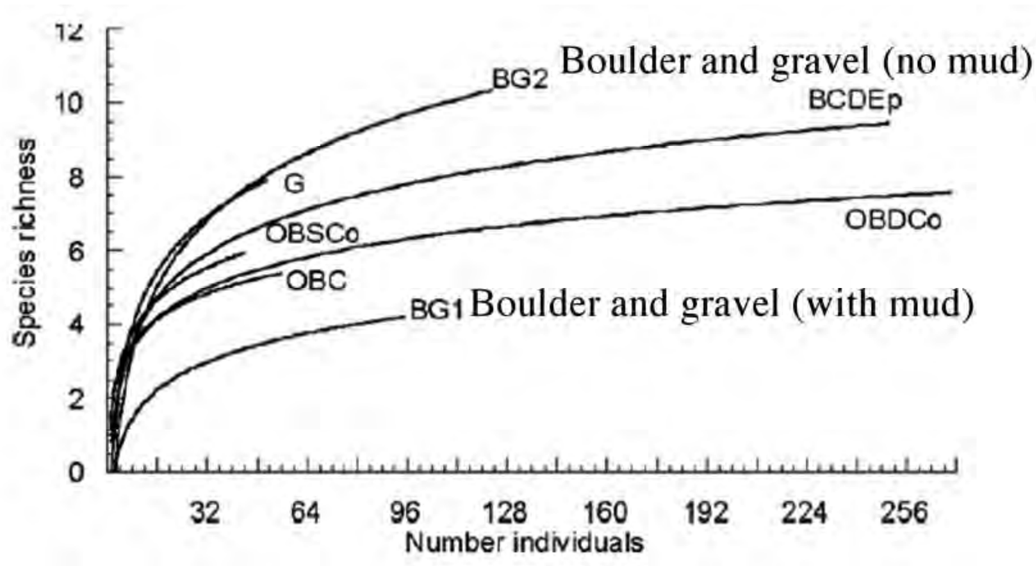

Figure 5-19: Deep-water coral species richness relative to the number of individuals encountered in the Gulf of Maine (modified from Auster, 2005)

Demersal faun – hard and soft substrata, R. Steneck

The raining of phytodetritus to the relatively shallow GoM maintains a relatively high carrying capacity for demersal fishes. Centuries of fishing have greatly reduced abundance of most fish stocks in the GoM (Jackson et al., 2001; Steneck and Carlton, 2001). Today, aggregate landings of groundfish constitute only 3% of all landed biomass in Maine (compared to 26% Atlantic herring and 35% American lobster; Maine DMR data for 2009).

Groundfish comprised fourteen of the 21 most abundant finfish species captured in Maine and New Hampshire's inshore spring and fall trawl surveys over the past decade. Of them, some species such as cod, haddock and winter flounder are primarily confined to the relatively shallow water of the northern coastal shelf and Georges Bank (Figure 5-20). On the other hand, silver hake, Acadian redfish, American plaice and witch flounder are most abundant in the central GoM physioregion (Figure 5-21).

Although no firm geographic boundary can be placed around any fish species, recent research suggests that many are more geographically confined than previously thought (reviewed in Steneck and Wilson 2010). Even in species such as Atlantic cod that undergo seasonal migrations, tagging information is emerging that indicates the "primary migration highways" are along the northern and southern coastal and Scotian shelves and Georges Bank (Figure 5-22; Tallack, 2009).

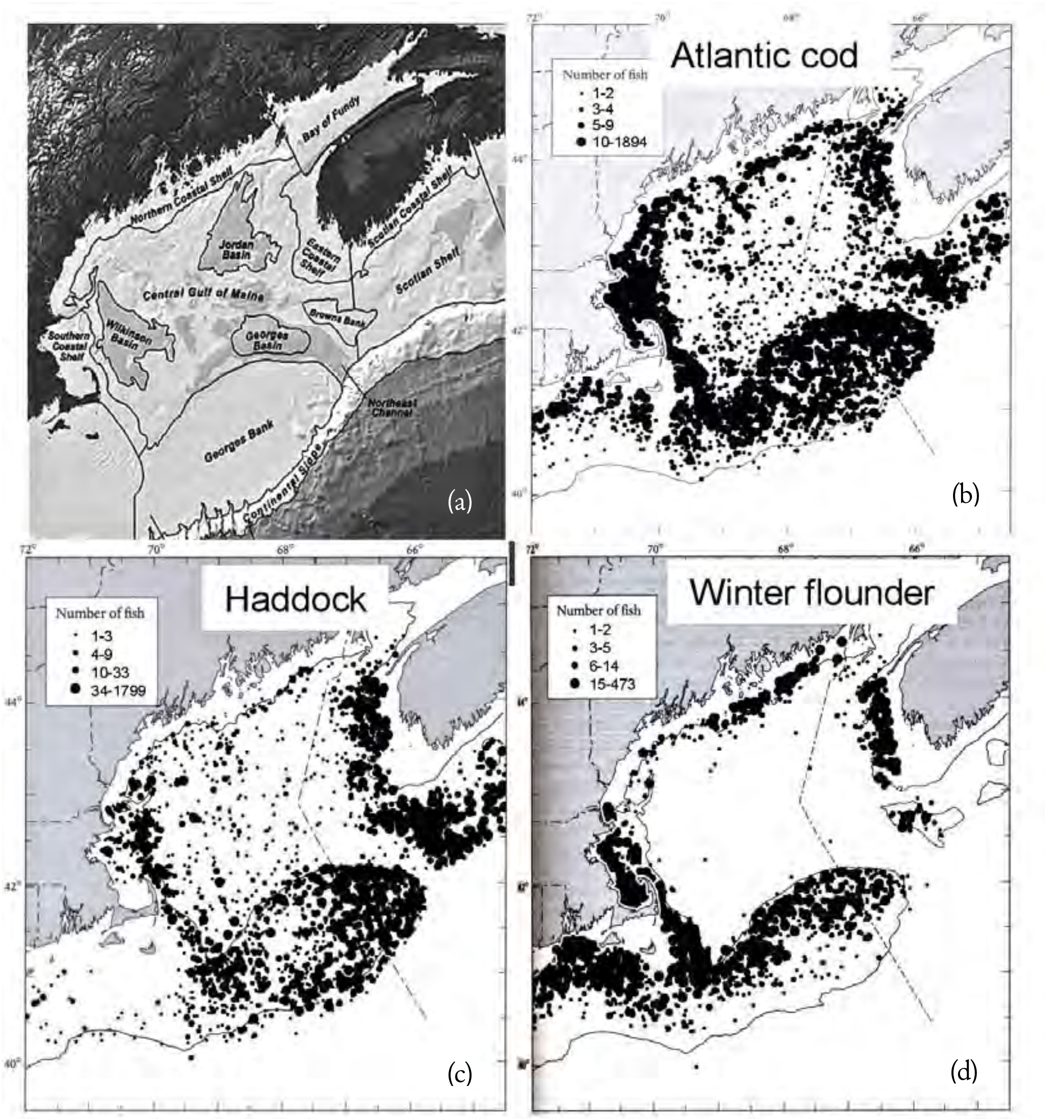

Figure 5-20: (panel a) The Gulf of Maine's physioregions (from the Gulf of Maine Census of Marine Life), and spatial distributions of groundfish species (panels b – d) with coastal shelf and Georges Bank physioregion association, as compiled from NEFSC bottom trawl surveys from 1968 – 1996 (compiled by Collette and Klein-MacPhee, 2002; after Steneck and Wilson, 2010)

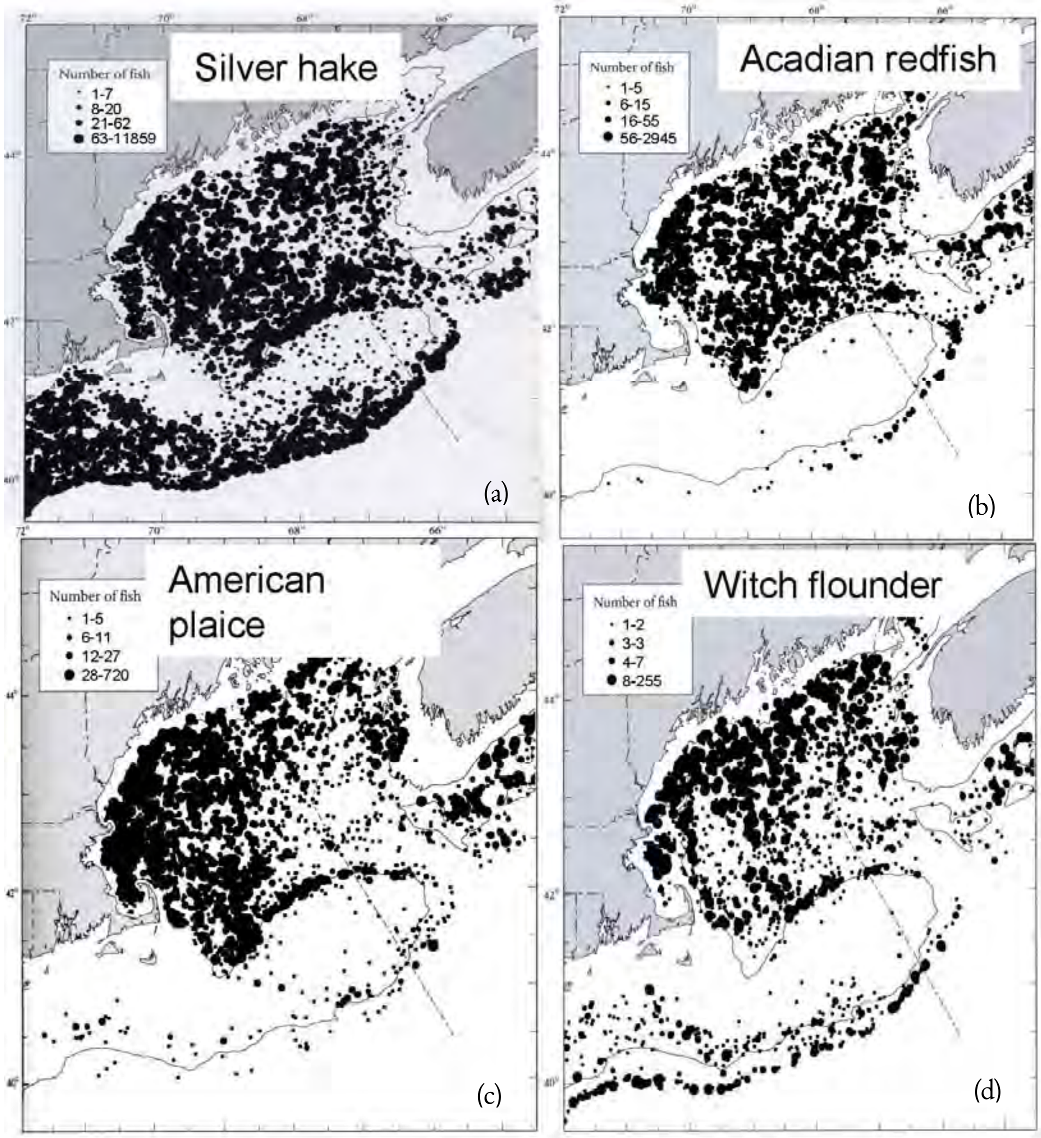

Figure 5-21: Spatial distributions of groundfish species (a – d) with affinities to the central Gulf of Maine physioregion (after Steneck and Wilson, 2010)

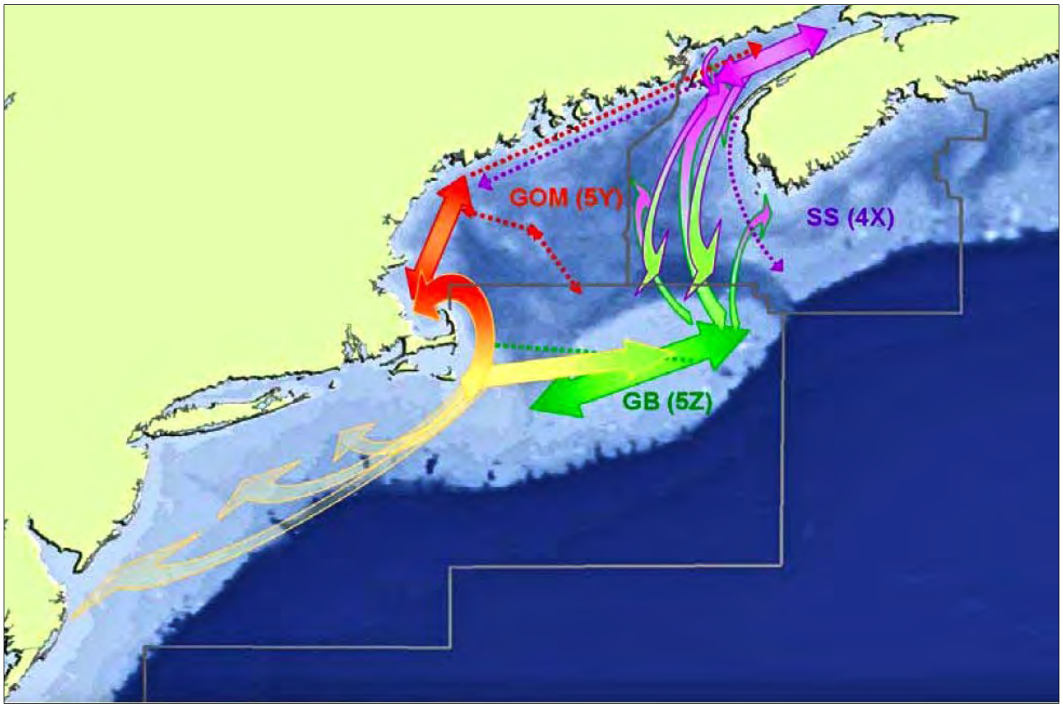

Figure 5-22: Summary results of Atlantic cod migrations in the Gulf of Maine for 2003 – 2007 (from Tallack, 2009)

Pelagic species, J. Stockwell
Species likely to be encountered greater than ten (10) nmi from shore and over 300 ft deep can be classified into pelagic and demersal/semi-pelagic groups. The pelagic group includes Atlantic mackerel (*Scomber scombrus*), Atlantic herring (*Clupea harengus*), Atlantic salmon (*Salmo salar*), bluefin tuna (*Thunnus thynnus*), northern shortfin squid (*Illex illecebrosus*), northern shrimp (*Pandalus borealis*), silver hake (*Merluccius bilinearis*), and pollock (*Pollachius virens*). The demersal/semi-pelagic group includes haddock (*Melanogrammus aeglefinus*), Atlantic cod (*Gadus morhua*), red hake (*Urophycis chuss*), white hake (*Urophycis tenuis*), Acadian redfish (*Sebastes fasciatus*), and spiny dogfish (*Squalus acanthias*).

Highly migratory species within these two groups include Atlantic mackerel, Atlantic herring, Atlantic salmon, bluefin tuna, northern shortfin squid, and spiny dogfish. Most of these species are seasonal, spending spring to fall in the GoM and then exiting to overwinter elsewhere. Some exceptions apply though, as larval and juvenile Atlantic herring do overwinter in the region, and Atlantic salmon are transient as they pass through the region quickly on their way to feeding grounds in the Northwest Atlantic as post-smolts (May-June) or to rivers to spawn as adults (summer and fall). Several of the demersal/semi-pelagic species have obligate pelagic larval/juvenile life-stages.

Species of particular concern include Atlantic salmon (endangered species listing), Atlantic sturgeon, and bluefin tuna because of depressed populations. Moreover, bluefin tuna (and other species) are known to aggregate around floating objects such as fish aggregating devices (FADs) (Freon and Dagorn, 2000; Josse et al., 2000; Relini et al., 2000; Castro et al., 2002; Addis et al., 2006), which will likely cause some degree of concern or expectation by the fishery (Fayram and Risi, 2007). River herring (alewife *Alosa pseudoharengus* and blueback herring *Alosa aestivalis*) are listed as species of concern by NOAA. However, the distance from shore makes them unlikely to be encountered

Available information sources relevant to pelagic fishes include:

- NMFS bottom trawl surveys done in spring and fall
- ME – NH inshore bottom trawl surveys (spring and fall – maximum depth sampled to the east and west of Monhegan Island was 162 m)
- NOAA Atlantic salmon post-smolt, pair-trawl survey (2001-2005). This was done inside and outside Penobscot Bay. It may contain some useful information. Trawling was done during the day at the surface, targeting post-smolts.
- Essential Fish Habitat Source Documents (NOAA Technical Memoranda) provide information on biology, habitat, behavior, and distribution of many species listed above. They include maps of bottom trawl catches, MARMAP catches, and other sources of data.
- Fishery-dependent data. There is enormous potential here if one can get access to VMS (Vessel Monitoring System) data, from systems that are installed on all vessels that participate in specific fisheries in federal waters, and fishery catch records. [National Marine Fisheries Service (NOAA Fisheries) collects VMS data. The Maine State Planning Office recently acquired a subset of the VMS database].

5.3.4 Physical Interaction with Turbines, Platforms, Cables and Anchors

Direct interactions of interest include strikes and effects of blade-induced pressure fluctuations on birds and bats in the turbine's vicinity. Birds are in principle less sensitive to pressure fluctuations because of the flow-through structure and function of the bird lung. Offshore wind platforms have the potential to disrupt movement patterns of animals, act as attractants to birds and fish (reef effect) and disrupt migratory patterns of seabirds, turtles and marine mammals.

Birds and bats
Perturbations of offshore wind construction and operation include, but are not restricted to, direct loss of nesting, resting, and feeding habitat caused by placement of

support structures related to construction, deployment and maintenance of onshore transmission lines as well as of the turbines. Birds are also subject to increased traffic to and from the sites.

Effects of wind farms on birds depend on the height of the hub, the rotor diameter, the distance between turbines (preferably 1 – 2 km), the total area of the wind park and the color and placement of the structures (Roth et al., 2004). Collision risks also correlate with weather conditions such as rain or fog. A Dutch publication (NL-012) on bird collisions calculates a maximum of one thousand to multiple thousands of extra mortalities per year, based on measurements on turbines on land for a wind farm area of 16 square kilometers (km^2) with 36 turbines.

Species with a high reproductive output and a correspondingly low annual survival rate will be less sensitive to added mortality than species with a high annual survival rate and a low reproductive output. The latter group typifies most marine-based species in the region. Flight altitude can vary significantly between species, time of year, and distance from the coastline. Assessment of collision risk during both day and night is greatly hampered by the lack of fundamental knowledge of the behavior of diverse species towards wind turbines and turbine arrays (see Roth et al., 2004).

Collision risk may be highest in connection with the annual migration between areas used for breeding and wintering. The frequency of collisions is expected to depend on ability of the birds to see the spar and blades and the bird's maneuverability, and is known to increase during periods of low visibility (precipitation, fog). Patterns of lighting (red versus white light, blinking or constant) will affect relative attraction to or avoidance of turbines by birds. Collision risk for birds and bats, and risks to bats of embolism from rapid pressure fluctuations near blades have been subjects of numerous terrestrial and nearshore marine turbine studies (e.g., Erickson et al., 2001), and collision risks depend very heavily and very locally on migration routes (e.g., Barrios and Rodríguez, 2004).

"Barrier effects" of wind farms have been found to vary across species, and, based on some European studies, to be important for Common scoters and eiders, which are numerous in the GoM. Reduced nocturnal flight activity near the wind farm and low number of flight movements through it, as documented in some radar studies offshore, indicate that turbine arrays function as a flight barrier. While collision risk is reduced, wind farm avoidance may impede birds from reaching critical foraging and resting areas and may increase interactions with commercial fisheries and other boat traffic. Few if any studies have measured these effects. Species presence or absence is not an adequate indicator of insignificant effects because individuals may be present in an area but fail to initiate or complete breeding. Monitoring impacts should include confirmation of effects, or lack thereof, on productivity for breeding birds in the area.

There is, therefore, a need to identify foraging areas of birds that rely on coastal and offshore environments at some stage of life and to identify temporal and spatial patterns of movement (flight paths, elevations, group sizes) for waterbirds (including seabirds, shorebirds, wading birds, and waterfowl) as well as landbirds (including songbirds and raptors). In addition to identifying which birds are likely to be present and when, differences in foraging behavior should also be taken into consideration with respect to turbine structures above and below the water (platforms, cables). Diving birds such as gannets and terns initiate dives well above the water surface, well within the rotor-swept zone of most commercial turbines, whereas deep-water divers, such as razorbills and puffins, initiate dives from the surface but dive much deeper. The proposed monitoring activities at potential wind energy sites should take into consideration direct and indirect effects on birds and bats during spring (April – June) and autumn (August – November) migration periods as well as throughout seabird breeding (May-August) and wintering (November – March), essentially throughout the year. Because of strong site and seasonal dependence of risk, NEPA compliance has tended toward acquiring two years of local migration or movement data prior to issuance of permits for installation to resolve site and seasonal dependence of risk.

Offshore migration patterns are poorly known because of range and resolution limitations of shore-mounted radar. Individual songbirds can be resolved only to distances of about 1.5 nmi or less [Mizrahi, pers. comm.]. Thus pre-installation radar data will be problematic to collect for offshore wind farms. The idea of using barge-based radar is problematic in many ways. It is impractical in heavy weather, and the small distance of the transducer above the waterline makes backscatter from waves a much bigger noise issue in extracting bird signals. Data processing and analysis is much more complex because the motion of the barge must be removed.

Long-range radar, such as WSR-57 weather station units, can be used to identify broad-scale flight patterns for flying vertebrates, but with multiple challenges and limitations. Only large flocks can be imaged, and it is difficult to distinguish bird targets from fog and precipitation. Nevertheless, a desktop analysis of broad-scale migration patterns in the northern GoM region, using multiple decades of available weather radar data, might be a helpful initial analysis to inform siting decisions (i.e., to determine areas and seasons frequented by large flocks).

Monitoring should include marine surveillance radar, using a horizontal and a vertical array. Analyses of such radar can reveal headings, tracks, altitudes, target sizes and target speeds, and provide information about movements and, in some cases identify, species or species group. Collectively, the two different orientations of units provide critical spatial information about where and how high animals are moving, and, depending on their placement, can be used to monitor behavior at the local (turbine site) as well as at the regional level. Ideally, one set of radar units would be placed within one to two (2) nmi of the test turbines.

Many birds call during flight, and acoustic monitoring helps identify many birds to species or species groups. Because radar data provide only a few clues to species identity, acoustic equipment should be used to sample at each radar site during key activity periods. It needs to be kept in mind that negative information is not useful in this mode; many species and individuals do not call. In addition, infrared cameras have been used to help identify bird and bat species and to record direct responses (avoidance behavior, physical impact, and ultimate trajectories of carcasses) to turbine blades, and such cameras would also be deployed at monitoring sites. In addition to pre-determined and planned visual surveys, these tools (surveillance radar, acoustic monitoring, and infrared photography) are commonly used in monitoring the impact of wind turbines on aerial animals. Standardized visual surveys should be established at key periods throughout the year to provide additional information on species identities and observable behaviors.

Tracking individuals via radio or satellite telemetry is critical in determining animal movement, particularly during the breeding period when individuals remain within the region but may change their spatial use of resources as they track the movement of fish stocks throughout the season. Terns (Common tern, *Sterna hirundo*, Arctic tern, *S. paradisaea*) and alcids (e.g., Atlantic puffin, *Fratercula artica*, Razorbill, *Alca torda*) would be fitted with radio transmitters, and two (2) to three (3) stationary receiver stations would be placed strategically to triangulate and determine coordinates. Birds would also be tracked from boats during other monitoring activities (e.g., buoy deployments, fish and mammal surveys).

Such proposed work takes into consideration direct effects, including primary (direct impact by the turbines) and secondary (avoidance response that may result in increased energy expenditure, predation risk) effects at the turbine site, but also indirect effects in how the food base and other resources in the ecosystem (plankton, fish, etc.) could change as a result of turbine structure and operation, including noise effects. While avoidance may reduce collision risk (direct effect) it may incur energetic costs that affect survival and reproduction (indirect effect). These latter costs have been little studied, but may influence population viability for many species.

Construction activities (e.g. transport, construction work) should be timed to avoid pre-breeding and breeding periods as well as the post-breeding period when young of the year are beginning to depart and adults are recovering (molting, regaining energy reserves) from breeding and preparing to leave for wintering areas.

Post-installation data on bird and bat collisions should be planned, probably with radar mounted on the wind platforms themselves, to assess behavioral amelioration of risk (e.g., bird avoidance of turbines cf. Desholm and Kahlert 2005). Direct studies of bird and bat injuries and mortalities due to turbine strike are complicated over water by collection difficulties.

Marine mammals
Whale entanglement with lobster trap lines and gillnets is an issue in this region (see Section 5.4), and this is a significant source of mortality in some species (Clapham et al., 1999, Johnson et al., 2005). The anchoring systems being considered for the floating turbines are superficially similar to these fixed-gear fisheries (a float connected to an anchor by a line or cable); however, there are significant differences that make entanglement in the turbine anchor system unlikely. For an animal to be entangled in a rope or cable, the rope or cable must be slack enough to form a loop around part of the animal. The rope used in the lobster fishery is thin, and the buoys are small. This means that the tension on the rope is low, especially relative to the inertia of a large whale. When a whale encounters and lifts the line, it is possible for the line to wrap around a portion of its body. The anchoring systems being considered for the floating turbines involve cables or chains much thicker than fishing rope and under much higher tensile loads, making it much harder hard to conceive of their curling around an animal. Because the platforms are stationary and will be making noise, the chance of a whale colliding with the platforms or their anchoring system is expected to be low, and any such interaction would be unlikely to result in serious injury. The risks would appear comparable to those of running into a large anchor chain or cable of an anchored vessel.

Seals are known to haul out on nearly any floating platform. Thus, the most common direct interaction between marine mammals and the turbines is likely to involve seals using new solid substrates above the water line. A seal hauling out on a turbine platform is unlikely to injure the seal; rather, it is more likely that seals could become a nuisance to operations and maintenance. True seals such as the ubiquitous harbor seal seem to be less of a nuisance than the sea lions that occur on the West Coast. It is likely that the turbine platforms could be "seal proofed" by limiting the horizontal surfaces, raising the platform deck to several feet above the water level, or by adding fences or other barriers.

Sea turtles
Risk of direct physical interaction between sea turtles and turbine system is predicted to be low based on the estimated infrequent use of the GoM by sea turtles and lack of any apparent mechanism for negative interaction.

Megafaunal species (including T&E and fishery resources – corals)
There is a minor risk to soft-bottom megabenthos from anchor installation and anchor cable movement. There is likely to be limited benthic habitat and species disturbance from cable installation and burial.

Demersal species and (including T&E and fishery resources)
Most demersal fish species are mobile and therefore at less risk than sedentary megafauna. Local attraction to anchors is expected for species that frequent hard substrata.

Pelagic species (including T&E and fishery resources), J. Stockwell
Very little is published on the effects of wind turbines, platforms, anchors, anchor lines, and cables on pelagic fish species. A number of studies have been conducted on the effects of wave and wind power foundations on fish and invertebrates. However, these studies necessarily focus on benthic and demersal species because of the shallow water depth (e.g., Wilhelmsson et al., 2006; Langhamer and Wilhelmsson, 2009; Andersson and Ohman, 2010). Direct physical damage to pelagic and demersal fishes from platforms, anchors, anchor lines, or cables is considered to be unlikely.

5.3.5 Alteration of Benthic, Demersal and Pelagic Habitats and Species

Direct alteration of benthic habitats
Below-water support structures for offshore wind turbines will differ substantially from the rigid structures used under nearshore wind platforms. All proposed designs use a small number of cables under tension loading from a buoyant surface structure to anchors at or in the seabed. In some designs the anchor is entirely buried in mud. Because of the limited surface area presented by these bottom structures and the generally slow currents at greater than 100 m depth, scour and alteration of depositional patterns should be much more limited than around nearshore wind platforms. It is also difficult to conceive of a mechanism for significant wave damping or focusing to reach the seabed in water depths greater than 100 m from an up to 30 MW wind farm. New habitat for fouling organisms is limited to the projecting portions of anchors, the cable and the area below the waterline on the buoyant platform. Thus a relatively small reef effect is expected, even in comparison to that of floating offshore oil platforms, because the latter present much more surface area below the waterline.

Many fish species have specific substrate and habitat requirements. Monkfish and many flatfish species such as American plaice, winter, witch and windowpane flounder prefer sediment habitats. Other species such as longhorn sculpin, Acadian redfish and Atlantic cod recruit to and often are associated with rocky habitats (Collette and Klein-MacPhee 2002). In some cases, organisms that recruit to hard substrates such as deep-water corals create preferred nursery habitats for recruiting groundfishes (Auster 2005).

Thus it is possible that the anchors and chains placed into soft-sediment habitats would diversify substrate heterogeneity that could increase the recruitment potential for some species of groundfish. Monitoring epifaunal succession on anchor-associated structures along with changes to the wind farm site benthos seems warranted. The development of benthic communities in largely untrawled wind farm sites could provide a means of assessing trawling effects on biogenic structure and the recruitment potential of undisturbed habitats along with assessing how trophic characteristics of these sites may change over time.

To determine impacts on megafauna from deploying offshore wind generators both the historical data, documenting species change with depth, distance from shore, and substrate type, as well as this habitat modification suggests that several sources of variance such as depth, physioregions, temperature and substrate will need to be controlled for statistically robust conclusions regarding turbine effects.

Indirect alteration of benthic habitat

Anticipated indirect effects can be separated conceptually into three modes: (1) reduction of trawling disturbance within the anchor field; (2) biodeposition from fouling organisms and attracted pelagic fauna; and (3) stimulation of local primary production through enhanced mixing and upwelling. Each of these effects can propagate through food webs, with additional consequences. Potential importance of these indirect effects varies greatly among the species groups. The last effect (benthic alteration due to increased primary productivity) is addressed below under pelagic habitats, where the effect begins.

In the depth ranges of the GoM where offshore wind devices are projected to anchor, trawling has substantially altered soft-bottom macrofaunal community structure. Under repeated trawling, structure-building animals, such as tube-building polychaetes, become conspicuously scarce. This trend has been most clearly documented by sampling programs that covered several years both inside and outside fishing closure areas in the western GoM in mud bottoms between 100 and 190 m deep (Grannis, 2005; Knight, 2005; Grizzle, 2008; Nenadovic 2009; Grizzle et al., 2009). Studies at least as deep as 232 m outside marine protected areas also indicate similar effects of trawling on community structure (Weissberger et al., 2008).

Anchors used for offshore wind platforms are incompatible with mobile fishing gear, so the area occupied by anchors will become a no-trawl zone. A reasonable hypothesis, but one that clearly merits testing, is that no-trawl zones created within wind farms will follow successional trajectories like those of marine protected areas at similar water depths. One caveat is that some mud bottoms in the region at depths of 84-102 m appear to be extensively affected by deep, biogenic sediment mixing (bioturbation) from benthic megafauna, and there the added effects of trawling, at least on the short term, are difficult to resolve (Simpson 2003; Simpson and Watling 2006). Where there is intensive habitat disturbance of this biogenic sort, trawling closure by anchor emplacements may have less effect on community structure.

Macrofaunas in water deeper than 100 m in this region depend on fluxes of particulate organic matter from above as a source of organic matter for growth. Biodeposition in the form of feces from fouling organisms and detaching fouling organisms (caused by weather events and predation attempts) can lead to local enrichment of organic matter under platforms with anticipated effects on growth rates and successional changes of the underlying community. The magnitude of fecal deposition can be estimated from filtering and other feeding rates of attached and attracted organisms. Biological interactions below a platform can be affected in unexpected ways, however. An oil platform off southern California, for example, was estimated to deliver an average of a cubic meter per day of mussels to the seabed, supporting extraordinary areal densities of sea stars on the bottom (Wolfson et al., 1979). This kind of effect should scale with the surface area on which fouling organisms will settle and the turnover rate for the attached community.

Direct alteration of pelagic habitat

Any structure in the offshore environment is expected to act as an attractant to fish and other marine species. The attraction of fish to wind turbine installations in shallow water has been documented to be similar to that for offshore oil platforms. Floating structures, called fish aggregation devices (FADs), can attract and retain fishes in localized areas. FADs are known to affect pelagic fishes, with most data coming from tropical regions (Dempster and Taquet 2004). FADs are particularly effective with mahi mahi, billfish and some species of tuna (i.e., yellowfin, skipjack and bigeye). It is expected that floating offshore wind platforms will act as FADs for multiple trophic levels (forage fish and predators). It is unknown whether this effect would lead to positive, negative, or no effects on pelagic species given the myriad potential effects on behavior, energetics and predator-prey interactions, as well as the degree of interaction with human systems (recreational and commercial fisheries, ecotourism, etc.). Avoidance of any physical structure, if it occurs, would likely result from other factors (e.g., noise, electromagnetic fields) other than the physical structure(s) itself. Note that direct attraction of fish and other species to platforms could attract larger predators, including seabirds and marine mammals.

Indirect alteration of pelagic and benthic habitat

Enrichment of organic matter delivered to the seabed may also occur if the turbine array enhances mixing or creates upwelling (Broström 2008). During nutrient-limited summer seasons, primary production may be increased in the wake of the wind farm. Delivery of this kind of input to the seabed will not be localized; slowly settling organic matter will travel farther than quickly settling organic matter. Most pelagic organic material that settles does so in the form of aggregates whose peak settling velocities are ≤ 100 m/d. Even at the high end of that velocity range, at the typical coastal current speed of 0.1 m/s, the aggregate would travel several kilometers, and more slowly settling particles would travel farther still. This simple calculation suggests that looking for a downstream organic enrichment effect on benthos is impractical before the existence, magnitude and geometry of any resulting phytoplankton bloom is measured more directly. In any case it is likely to be diffuse and diluted over a much larger region than the footprint of the anchor field. Enhanced primary productivity could contribute further to a species aggregation effect.

5.3.6 Acoustic Effects of Turbines and Other System Components

Acoustic interference can occur from offshore wind turbines above water, interrupting communication and navigation for birds and bats, as well as below water from turbine noise and strumming of anchor lines, potentially affecting communication and navigation of marine mammals and some fish species. Sea turtles may also be affected.

The mooring structure will also influence sound transmission from the turbine to the water. It seems reasonable that a moored structure of small cross section would transmit less sound energy to the water than a rigid structure of larger cross section, but resonance frequencies and intensities will also vary. Thus monitoring across the frequency ranges to which marine mammals and fishes are sensitive is prudent.

Wind turbines can generate significant noise, enough to irritate humans in the nearby area. The properties (volume and frequency) of the sound that will be transmitted by the turbines into the ocean will depend strongly on the design of the turbine blades and on the structure of the platform. However, given the important role that acoustic communication plays in the ecology and behavior of cetaceans, characterizing the acoustic "footprint" of floating wind turbines should be given high priority.

Measurements around bottom-mounted offshore wind structures suggest that, at frequencies used by baleen whales (20 Hz – 200 kHz), sound levels 100 m from a turbine near maximum power could exceed 100 decibels (dB) referenced to one micro-Pascal [1 μPa] (Betke 2006). These levels are not high enough directly to harm a whale, but they are likely to make it very difficult for whales to communicate within a few hundred meters of the turbines (Nowacek et al., 2007). Detailed measurements of the noise produced by the turbines and their anchoring system should be included in the study. They should characterize the sound produced under different operating conditions (wind speeds, wave heights) and different seasons (with different sound-speed profiles). Once the characteristics of an individual turbine and platform design are known, including its acoustic coupling to the water through the anchor lines and platform, then it should be possible to estimate the sound produced by a series of turbines.

Very little information is available on potential risks to pelagic species of turbine noise and strumming of anchor lines. At a rudimentary level, research on the reaction of fish to fishing vessels may be comparable in terms of reaction to a stimulus. Fish reaction to fishing vessels typically consists of diving or horizontal movement, although avoidance is highly variable both within and among species (Neproshin, 1979; Olsen et al., 1983; Ona and Godø, 1990; Fréon et al., 1990; Gerlotto and Fréon, 1992; Fernandes et al., 2000; Gerlotto et al., 2004). Presumably the avoidance, when it occurs, is a response to vessel noise, strumming of warp lines attached to the trawls, chemical cues from injured or stressed fish, visual cues of the net itself or behavior of other fish, or some combination. A review by Wahlberg and Westerberg (2005) on potential impacts of noise from nearshore wind farms on fish indicates that very little is known, and many of the effects will likely depend on individual site characteristics (number and arrangement of turbines, composition materials of turbines, wind speed, fish species, etc.). The authors estimate the detection range of three species of fishes (Atlantic salmon, goldfish, and cod) based on noise measurements of nearshore wind turbines in Sweden and modeling at distances of 0.4 to 25 km from the structures. However, these results have questionable relevance to the present water depths and mooring arrangements. A deep-water sound channel can be expected and would be expected to increase the propagation distance of low-frequency sound.

Acoustic effects on benthic macrofauna are poorly known. Some shallow-water benthic organisms respond to vibrational stimuli in wave swash (Ellers 1995), and pressure pulses recently have been shown to carry information on activities of neighboring infauna (Wethey and Woodin 2005), but substantial acoustic or pressure-pulse effects at water depths greater than 100 m seem unlikely.

Recommended acoustic studies include both monitoring and modeling to understand

- What sounds are produced by the turbine system (turbine, platform, anchor, cables);
- How turbine system sounds compare to ambient sounds;
- Propagation of the sound both above and below water;
- Implications for marine species, including marine mammals and fishery resources; and
- Implications for coastal residents or other activities near turbines (see Section 5.4 subsection on sound and aesthetic impacts).

Acoustic measurements can be undertaken via hydrophone systems deployed at regular intervals via ship-based surveys or via acoustic instruments mounted on oceanographic buoys or mounted on the turbine/platform/anchor system or on separate bottom tripods. Pilot studies are currently being undertaken by UMaine, led by Dr. Andrew Pershing, to document acoustic signatures of the 100 kW test turbine planned for deployment at the UMaine deepwater offshore wind testbed south of Monhegan Island. Resulting data will be analyzed from the perspective of potential impacts on marine mammals, particularly endangered large whale species through their use of sound. Additionally, the Department of Energy's (DOE's) Pacific Northwest National Laboratory (PNNL) is currently developing specialized methods for modeling noise propagation from offshore wind installations (contact: Andrea

Copping, Senior Program Manager for marine and coastal waters http://marine.pnl.gov/staff/staff_info.asp?staff_num=1094).

5.3.7 Electromagnetic Field Effects

Electromagnetic Field Effect (EMF) sources from offshore wind farms include potential leakage from cables connecting individual wind turbines, as well as electrical cables between wind farms and shore. The EMFs of concern in water are the magnetic field and the induced electrical field. Magnetic and induced electric fields will travel through the water. Wind turbines produce EMF at certain operational speeds, with the electrical field carrying farther in air. Living marine resources that may be affected by EMF include marine animals that navigate and hunt prey by magnetic field, including sharks and rays, as well as invertebrate species such as lobster. Air-borne EMF from turbines may have deleterious effects on birds and bats.

Cable burial in this region has been studied at these water depths. Non-electrical cables appear to present little long-term habitat change. Sharks, skates and rays are exceptionally sensitive to EMF, however, and fishermen have expressed concerns that seasonal migrants such as lobsters might be sensitive to EMF.

Underwater and laboratory EMF studies in seawater are logistically difficult and expensive. Recognizing that difficulty, Pacific Northwest National Laboratory (PNNL) has chosen to address EMF issues directly with rigorous laboratory and field tests. PNNL plans to complete initial laboratory sensitivity studies for American lobster by the end of 2011. These tests are designed to determine what EMF levels may impair feeding and migration behaviors for comparison against field strengths surrounding submarine cables.

5.3.8 Potential Risks and Recommended Studies

Direct physical interactions
A key site-selection criterion is to reduce potential for direct interaction by avoiding aggregation sites and transit routes of whales. Although the recommendation is the same for birds and bats, data on their transit and use of offshore habitats as functions of altitude and offshore location are scarce. As noted, radar ranges of less than or equal to two kilometers ($\leq$ 2 km) are needed to resolve individual passerines, and the need for a fixed or floating platform for radar will make pre-deployment data problematic to obtain. One adaptive management approach would be to use surveillance radar to detect and avoid flyways of large flocks, followed by studies after turbine deployment that mount radar units directly on the turbine platforms to evaluate flock and individual bird trajectories and behaviors.

Habitat modification

In terms of pelagic habitat modification, a before-after, control-impact (BACI) design is recommended to evaluate the impact of floating offshore wind platforms on pelagic fishes. Two sampling approaches should be used concurrently – one based on mobile acoustic surveys with biological verification and the other based on continuous stationary acoustic monitoring. Mobile sampling should be conducted day and night, twice per month during each of the new and full moons. Mobile acoustic units would consist of dual-frequency (38 and 120 kHz), downward-looking echosounders and a side-looking (fanned directly below boat to the surface), multi-beam sonar. The latter will enable sampling close to and under floating platforms from distances of hundreds of meters (dependent on frequency of the system). Mobile survey data will be used to quantify fish biomass and intensity of aggregation. Midwater fish trawling and MOCNESS will be used to verify pelagic acoustic targets and partition biomass and aggregation metrics into species and functional groups. Continuous stationary acoustic sampling will consist of a self-contained, seafloor-mounted, upward-looking acoustic system to sample the water column directly under and around floating platform(s) and at a control site. Data would be collected at a sampling rate of one ping per minute (for example). The unit would need to be retrieved, data downloaded, new battery installed, and then re-deployed at intervals dependent on sampling rate. Data would provide continuous diel and seasonal coverage to fill gaps between active surveys and will be highly informative for understanding development of and changes to pelagic community biomass and aggregation metrics after deployment. The system may also be able to monitor marine mammal use of the area (potentially continuously) depending on system configuration, sampling rate, frequencies, beam angles, etc.

Acoustic surveys, coupled with biological verification, are the optimal sampling strategy in deep-water habitat for pelagic species. Visual surveys (i.e., SCUBA) are not practical as in shallow-water assessments, ROVs are not effective for quantitative assessments of pelagic fishes, and reliance on trawl or gillnet sampling is limiting in spatial and temporal coverage compared to acoustics. Broadband sonar is a promising acoustic method. It would provide better spatial resolution, remote identification of species or functional groups across pelagic fish and large invertebrate (e.g., krill and northern shrimp) trophic levels, and perhaps reduce the need for biological sampling after sufficient calibration and validation compared to what is possible with standard narrowband echosounders.

Although scale of up to a 30 MW demonstration project is marginal with respect to induction of substantial upwelling (Broström 2009), it seems prudent to initiate studies at this scale to enable estimates of impacts from scaling up. A reasonable design would include an upstream buoy and a downstream buoy to achieve time resolution, with glider observations taken at the onset of stratification, at peak stratification in summer and during the fall decay of stratification. An effect during peak stratification would be a good indication of a larger effect from scaling up, whereas the greatest sensitivity of stratification to perturbation occurs during its onset and decay. This design would also reveal the magnitude and spatial extent of any resulting phytoplankton bloom (through optical sensors on the glider), informing potential concerns about increased phytodetrital fluxes to the seabed.

In terms of macrofaunal effects, recommended sampling design would employ BACI methodology on four stations, with two stations located randomly within the anchor footprint, one station 500 m upstream and the final station 500 m downstream of the nearest anchor with an approximate minimum of three cores or grabs from each of the four stations. Sampler designs that restrict bow waves are preferable, and samples should be sieved through a 0.3-mm sieve because many adult macrofauna in this depth range are small, and a 0.3-mm sieve has been widely used in East Coast environmental assessments. Expectation for macrofaunal abundance in a 0.02-m^2 sample is approximately 560 individuals (Weissberger et al., 2008), suggesting that a sample size smaller than the 0.1 m^2 traditionally used in studies of trawling impacts could be adequate. By far, the greatest expense is the time-consuming sorting of animals from sediments and identification of species. Because much community change depends on recruitment and many species recruit annually, before-after samples should be taken annually. Sampling each year in the same season will maximize power to detect control-treatment differences. Late summer or early fall is convenient both from the standpoint of avoiding both bad weather and taxonomic problems with recently settled juveniles. Experience with closure areas effectively doubles the statistical power by allowing a one-tailed alternative hypothesis against the null that structure-forming species will be unchanged or will decrease in abundance within the anchor footprint. That is, it is expected the effective closure to mobile gear to allow structure-forming species to recolonize. An enrichment effect from falling fragments and feces of fouling organisms is possible at the downstream station. Changes in composition and abundance of benthic and demersal megafauna can be assessed using a BACI design and a remotely-operated vehicle (ROV).

Acoustic Effects

Measurements of noise fields around wind turbines (levels, frequencies, ranges) are needed. Even with this information (which will not be possible prior to deployment), it will be difficult to recreate conditions in the laboratory to systematically test response(s) of fishes. A comparative field experiment using one 3 – 5 MW test turbine can be used to evaluate potential effects of noise from wind turbines on fish. Using a BACI design, continuous stationary (active and passive) acoustic monitoring can be deployed in control and experimental test sites at various distances to examine patterns in fish distributions as functions of environmental conditions (e.g., wind speed) and ambient noise levels. An iterative approach to modeling and measurement is recommended both above and below the water to maximize skill in prediction before scaling up further from the up to 30 MW farm occurs.

Electromagnetic Field Effects

We anticipate a better ability to design electromagnetic field (EMF) studies and a better articulation of the need for them after PNNL completes additional, rigorous studies on animal sensitivity across a range of species. Possibilities include field observations via ROV on American lobster behavior, when PNNL sensitivity tests reveal how far such effects might extend.

Existing resources for environmental data and monitoring:

- GoMOOS/NERACOOS regional buoy network observing system,
- ongoing regional environmental monitoring efforts,
- marine research universities, institutes, and consortia,
- state and federal resources,
- Maine Wind Industry Initiative (MWII) member organizations

5.4 ENVIRONMENTAL STAKEHOLDERS

This section is intended to identify those groups and individuals most directly affected by or potentially concerned with the assembly, installation, and operation of up to a 30 MW deepwater offshore wind project with connectivity to the State of Maine, as well as to outline their primary concerns, questions, and attitudes with respect to offshore wind energy. In particular, the section provides relevant information related to other installations or activities of significance in the regional analysis, including but not limited to shipping, fishing, recreational uses, and sites of military importance. Note that military sites have not been queried to date.

The Island Institute, in Rockland, Maine, is the primary author of Section 5.4. It is a membership-based community development organization focusing on the GoM, particularly Maine's island and remote coastal communities. The Institute is supportive of wind development that is appropriately sited with community input and balances impacts to ecological and human uses with community benefit. The organization played a key role in the development of the 4.5 MW community-owned Fox Islands Wind project on Vinalhaven Island, Maine, and supported the State of Maine's efforts to engage coastal stakeholders in the 2009 effort to designate ocean energy demonstration areas. The Institute's goal in developing this stakeholder section is to better inform the siting process and encourage community engagement in offshore wind siting and development.

5.4.1 Introduction to Environmental Stakeholders

This section represents a compilation of existing information about environmental stakeholders in the marine areas covered by the feasibility report, as well as information derived from the extensive experience of the authors working with priority environmental stakeholders, especially commercial fishermen, environmental non-governmental organizations (NGOs), and coastal residents. In addition, Island Institute staff organized a series of individual interviews with high-priority environmental stakeholders, eliciting information regarding their questions, concerns, and attitudes with respect to offshore wind development. These stakeholders include: mobile-gear fishermen, fixed-gear fishermen, tourism operators, coastal land trusts, environmental NGOs, and island electric utility representatives.

Previous Stakeholder Engagement on Offshore Wind
A wealth of valuable information about stakeholders interested in offshore wind has been gleaned from a public outreach process that was undertaken as part of the 2009 state-led effort to designate ocean energy demonstration areas in state waters. This outreach effort took place at the direction of LD 1465 and was led by the Maine State Planning Office (SPO) and the Maine Department of Conservation (MEDOC), in consultation with federal, state, and non-governmental (NGO) entities (See http://www.maine.gov/spo/specialprojects/OETF/index.htm). Its primary goals were to gauge the extent of human use and activities in each of the proposed areas and to document concerns and comments related to proposed sites. Public outreach included over 20 meetings ranging in scale from large regional public meetings to conversations with small groups or individuals representing environmental, economic, fisheries, or municipal interests.

As a result of the 2009 demonstration site outreach process, many of the individuals and groups interviewed for this section have been previously engaged in discussions pertaining to offshore wind development. It is useful to note, however, that these previous discussions were based on demonstration areas within three (3) nmi of land, for which the permitted sites, size, and activities differ significantly from current plans for an up to 30 MW commercial ocean energy project located ten (10) nmi from an inhabited area of the state. Nonetheless, many of the same questions, comments, and concerns remain relevant and are echoed in this section, including (1) the importance of siting to minimize adverse impacts to current ocean users; (2) the viability of emerging technology, and (3) access to compensation or community benefit.

Topics Addressed
This section builds on prior stakeholder engagement efforts by addressing areas that are at least ten (10) nmi offshore with a depth of at least 300 ft (90 m). To allow for the inclusion of regional detail where available, coastal waters are divided into the following areas: south of and including Casco Bay, between Casco Bay and Penobscot Bay, Penobscot Bay to Winter Harbor, and east of Winter Harbor.

Table 5-2: Stakeholder concerns, questions, and priorities as relating to deepwater offshore wind energy in Maine

Stakeholders contacted for this section raised a number of common concerns, questions, and priorities related to deepwater offshore wind energy, including: • **Will it benefit Maine people and how?** • **As a ratepayer, what will the costs be? Will the power be shipped to another state while we get stuck paying for it?** • **How will ocean energy development impact current users of the ocean, both from a pilot perspective and eventual build-out?** • **Which fisheries will be allowed amongst turbines in an array? Which will be completely excluded?** • **How will those individuals and/or communities negatively affected by ocean energy development be compensated?**

This section provides information pertaining to the following stakeholder groups:

- Commercial fishing
- Commercial shipping
- Recreational fishing
- Other boating (recreational, tourism businesses)
- Archaeological/cultural resources
- Aesthetic and sound concerns for people on water or nearby land masses
- Environmental/conservation concerns (e.g. NGOs)
- Island electric utilities

For each topic, this section provides:

- A description of each activity or resource in areas that meet the criteria of being at least ten (10) nmi offshore with a depth of at least 90 m and any associated vessel exclusion zones
- Economic value of activities and resources (as publicly available)
- Priority concerns, questions, and attitudes related to offshore wind energy
- Maps of where/when activities/resources occur
- Identification of and contact information for key industry groups, individuals, and NGOs (as publicly available)

To the extent that interviewees agreed to public dissemination of the spatial information they offered, maps detailing current uses of coastal waters are incorporated into this section. Information deemed to sensitive by interviewees for map display is summarized in the section text.

5.4.2 Summary of Major Current Human Uses

Commercial Fishing

Commercial fishing contributes significantly to both the culture and economy of Maine's coast. Well over 200 million pounds were landed in commercial fisheries in 2009, contributing nearly $325 million to Maine's economy (Figure 5-23). In island and coastal communities, commercial fisheries can account for more than 70% of employment (Island Institute, 2008). Commercial fisheries are managed by the Maine DMR in state waters (less than three (3) nmi from shore) and by NMFS in federal waters (greater than three (3) nmi from shore).

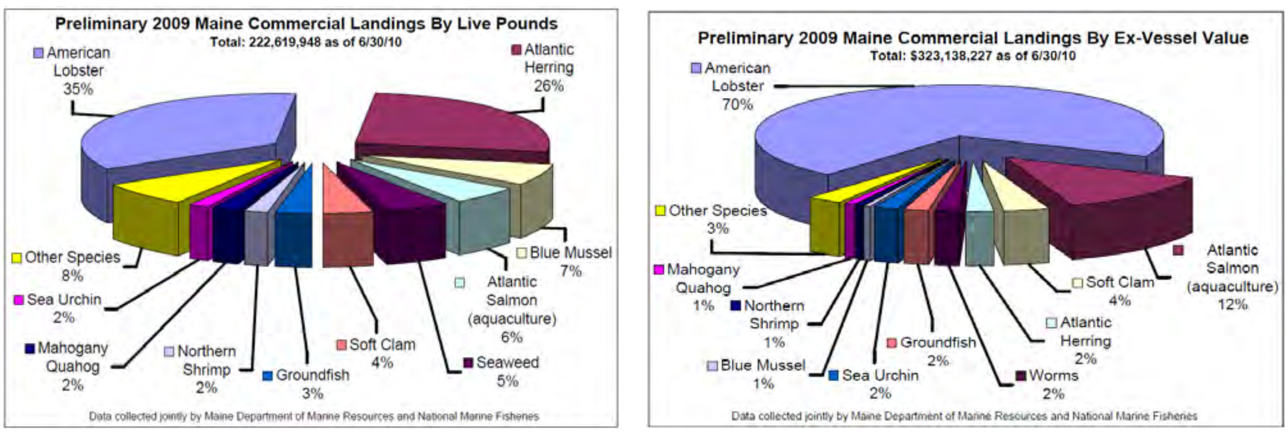

Figure 5-23: Preliminary Maine commercial fishery landings by weight (left) and by value (right). Source: Maine Department of Marine Resources, 2010.

Reliable digital information on the spatial distribution of commercial fishing occurring in state and federal waters is lacking. Data commonly used to show the extent of offshore fishing activity is that which is gathered by Vessel Monitoring Systems (VMS). However, since VMS is only required for certain fisheries, not including offshore lobster, VMS are only mounted on those boats that are also used for fisheries that require it. According to NMFS, only about 6.5% of lobstermen that hold federal permits report data via VMS.

The maps in Figure 5-24 through Figure 5-28 illustrate the extensive nature of fishing grounds off the coast of Maine as well as the complexity of fisheries and gear types across areas. It should be noted that these maps show areas fished by only those fishermen from selected harbors or regions, as they represent an incomplete 'snap-shot' from an ongoing project being undertaken by the Island Institute in partnership with commercial fishermen, entitled Mapping Working Waters (II-MWW).

This section focuses on major commercial fisheries occurring ten (10) nmi offshore and in over 300 ft water depth, including lobster, Northern shrimp and groundfish (suite of 17 species). In addition, the section also discusses other offshore fisheries, including small pelagics (herring, menhaden, sand eels), hagfish and ocean quahog. Information on major stakeholder groups for each fishery is highlighted below. In addition to these groups, a number of non-profit community organizations are actively involved in supporting commercial fisheries, including the Island Institute (Rockland), Penobscot East Resource Center (Stonington), and Cobscook Bay Resource Center (Eastport). Along with these groups, Maine Sea Grant (Orono and regional offices) and the Gulf of Maine Research Institute (Portland) provide research, education, and outreach services to the fishing industry and other marine users.

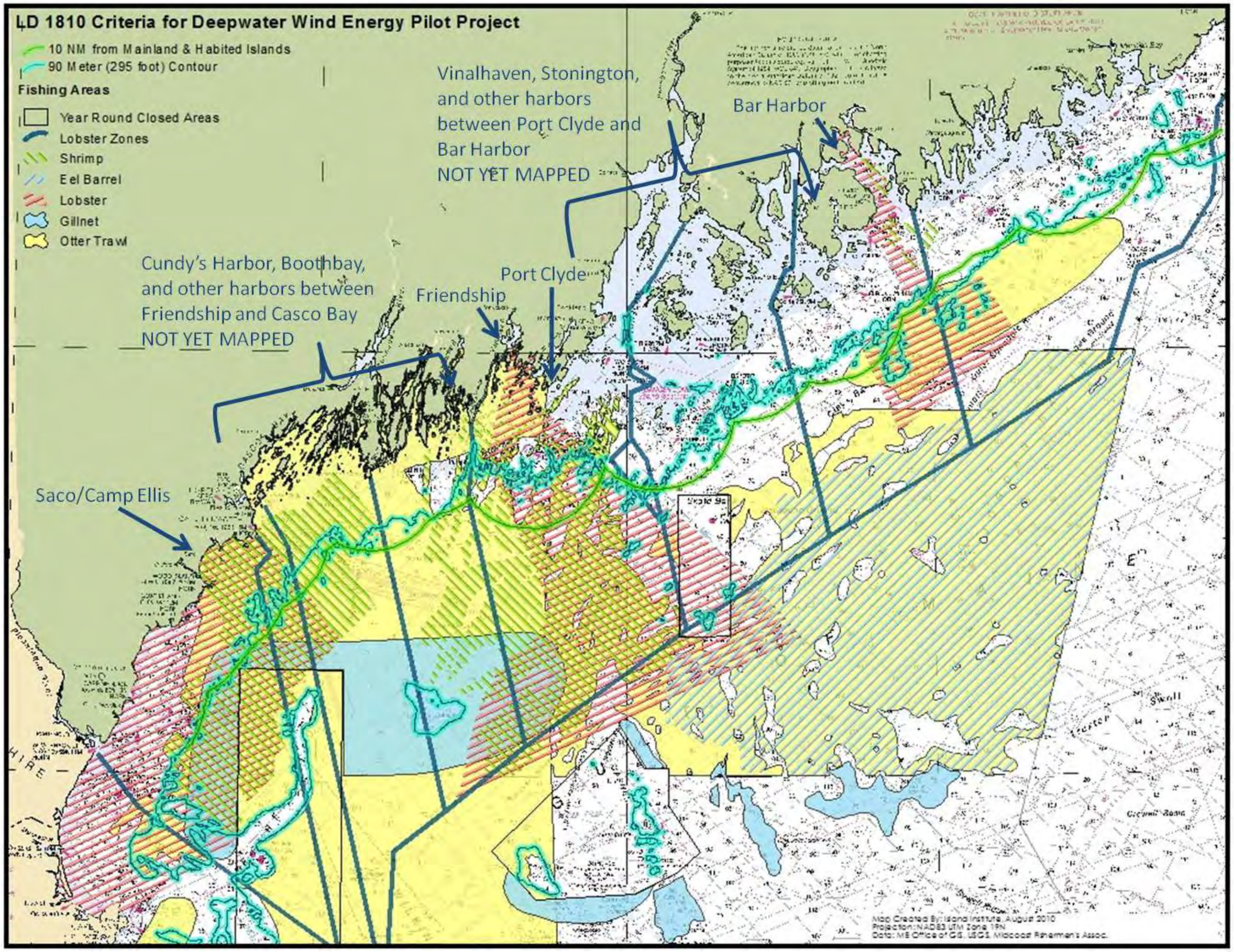

Figure 5-24: Commercial fishing areas identified through stakeholder interviews (groundfish trawl, shrimp trawl, lobster pot, hagfish barrel) from selected communities. Note major fishing harbors are currently not included on these maps. Information herein is proprietary; please request permission before duplicating or reproducing this material. (Source: Island Institute, Mapping Working Waters)

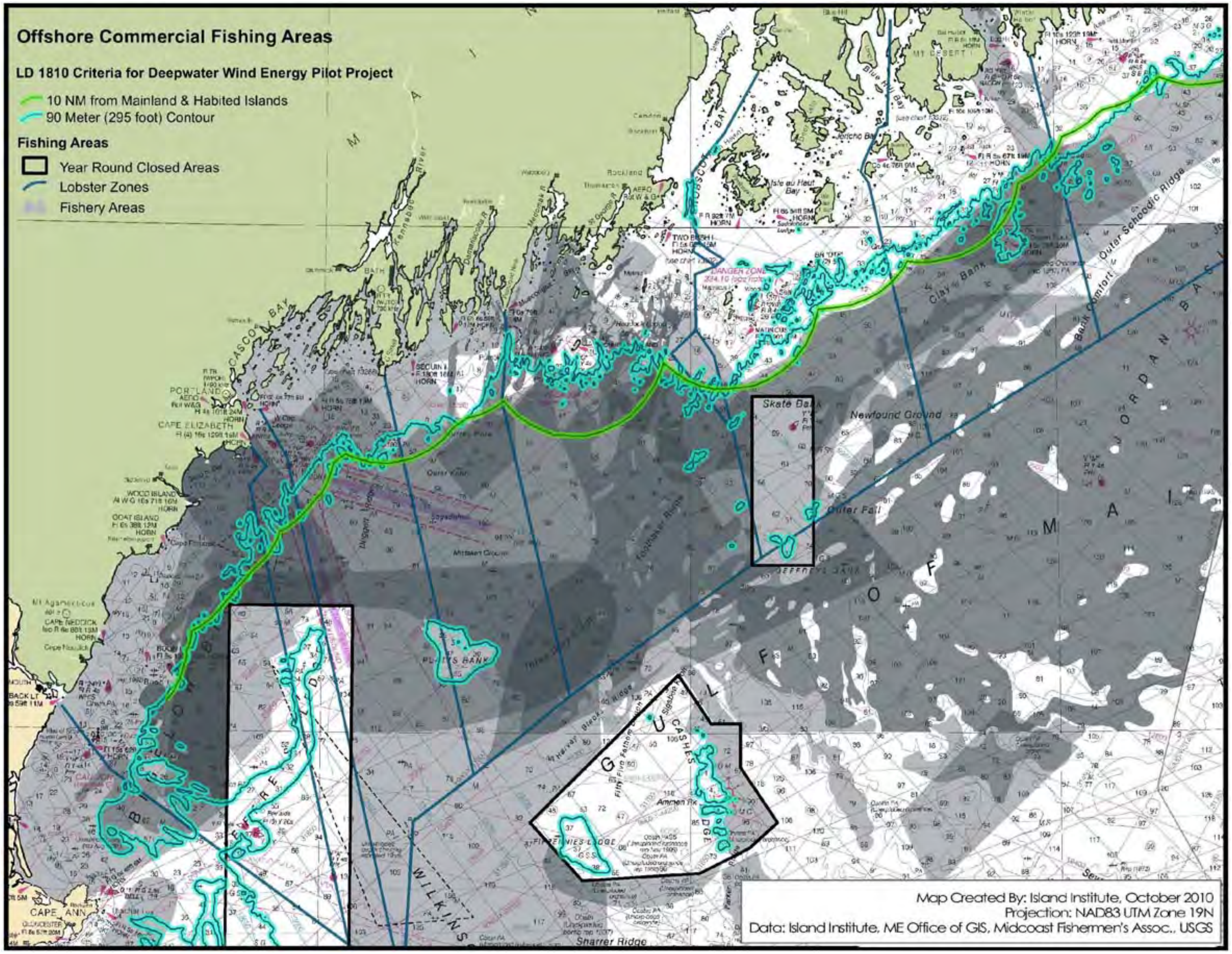

Figure 5-25: Commercial fishing areas identified through stakeholder interviews (groundfish trawl, shrimp trawl, lobster pot, hagfish barrel) from selected communities. Darker areas represent places where there are more types of active commercial fishing. Note major fishing harbors are currently not included on these maps. Information herein is proprietary; please request permission before duplicating or reproducing this material. (Source: Island Institute, Mapping Working Waters)

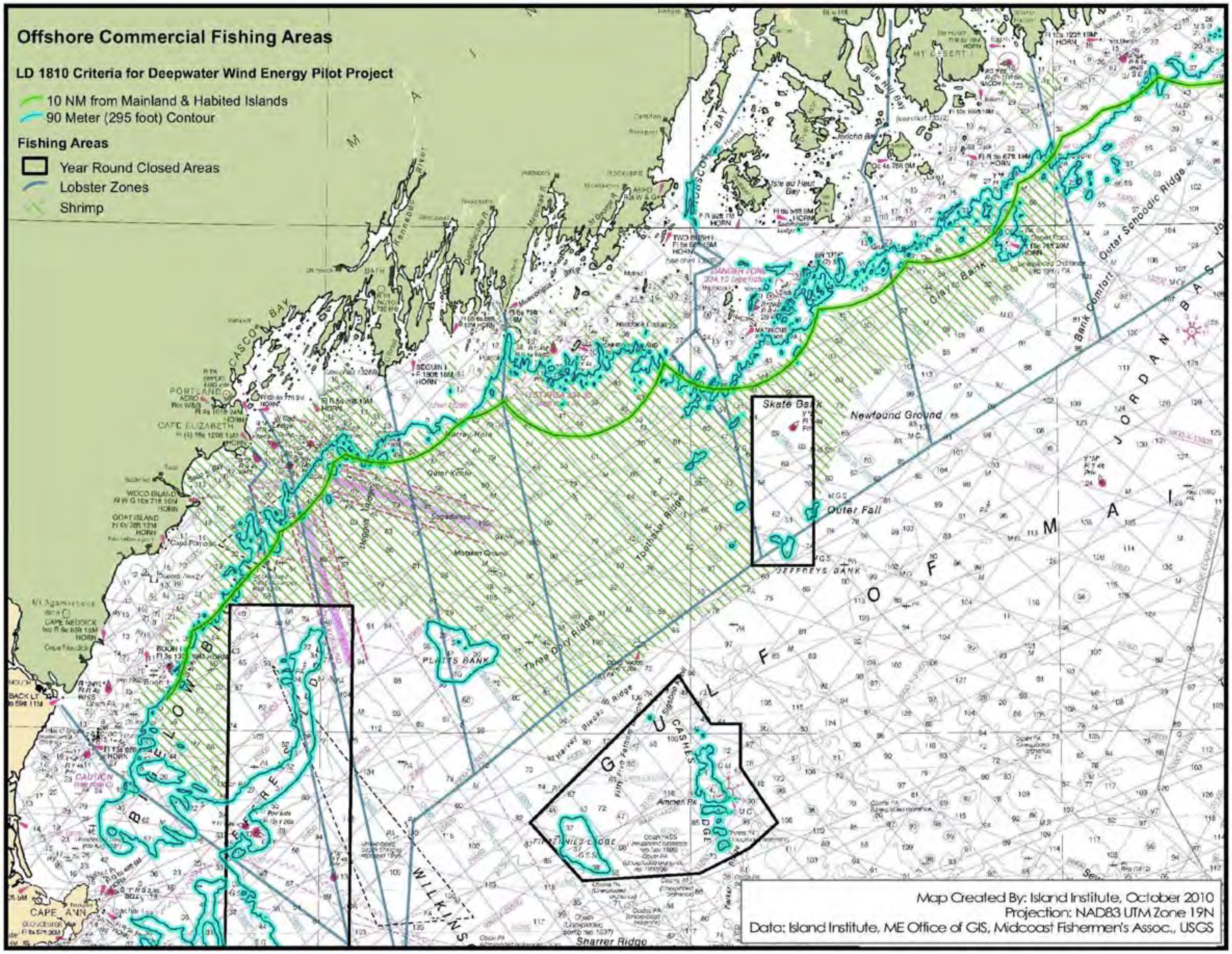

Figure 5-26: Commercial shrimp trawl areas identified through stakeholder interviews from selected communities. Note major fishing harbors are currently not included on these maps. Information herein is proprietary; please request permission before duplicating or reproducing this material. (Source: Island Institute, Mapping Working Waters)

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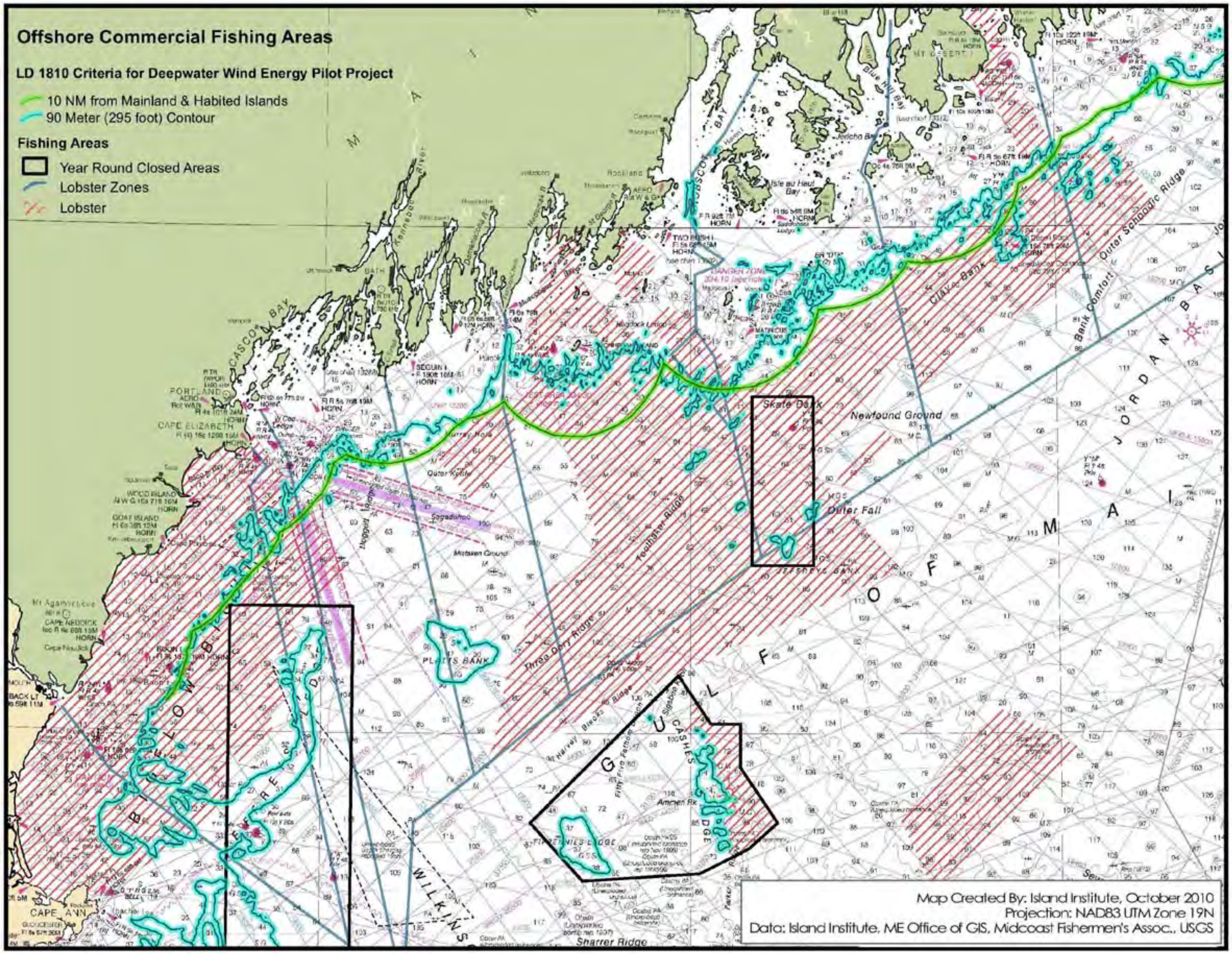


Figure 5-27: Commercial lobster pot fishing areas identified through stakeholder interviews from selected communities. Note major fishing harbors are currently not included on these maps. Information herein is proprietary; please request permission before duplicating or reproducing this material. (Source: Island Institute, Mapping Working Waters)

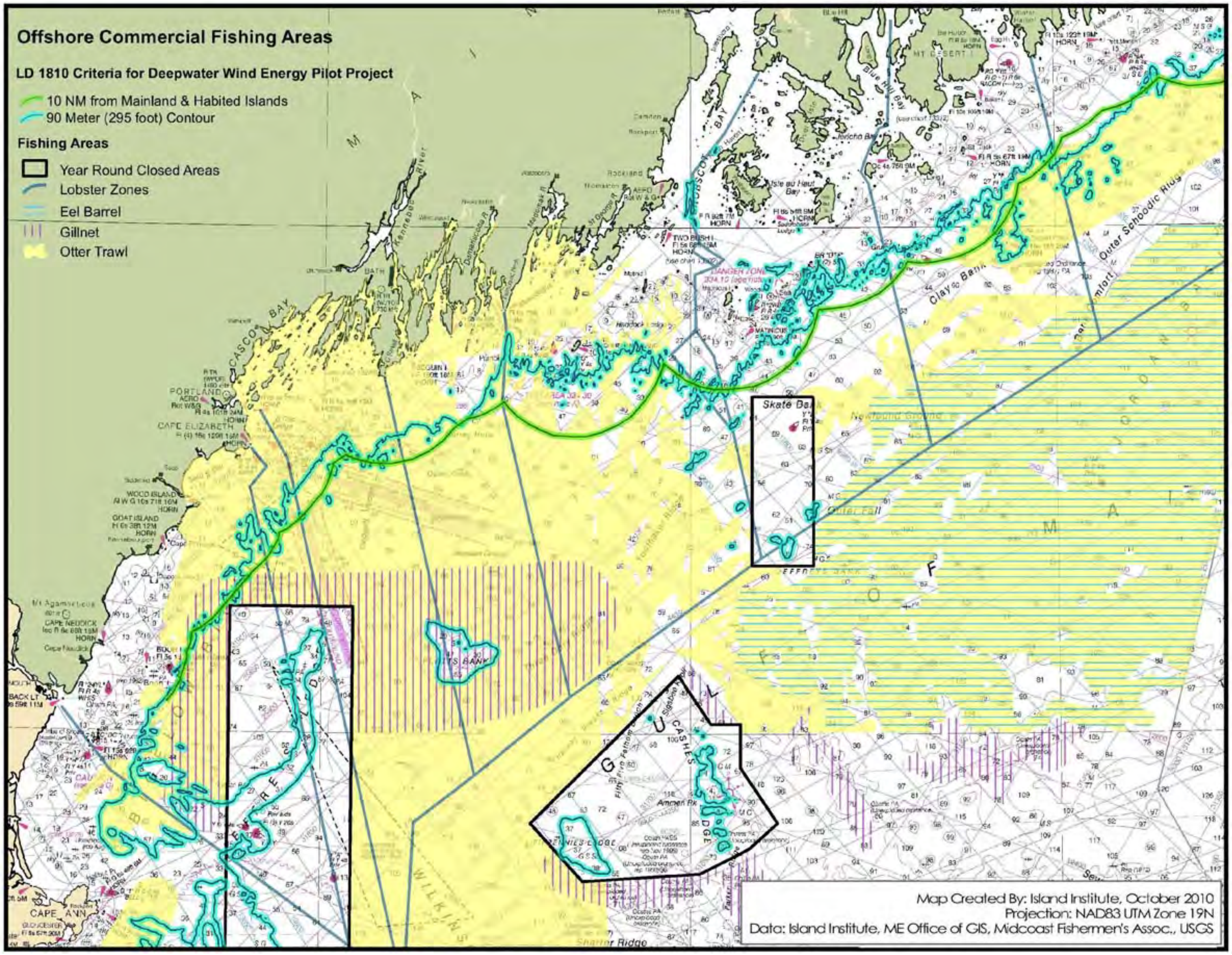


Figure 5-28: Commercial groundfish trawl and hagfish barrel fishing areas identified through stakeholder interviews from selected communities. Note major fishing harbors are currently not included on these maps. Information herein is proprietary; please request permission before duplicating or reproducing this material. (Source: Island Institute, Mapping Working Waters)

Lobster

In 2009, the lobster fishery was Maine's largest fishery, in terms of both pounds landed and revenue generated (Figure 5-23). Over the last five years, an average of 71.2 million pounds of lobster was landed each year, valuing on average $276.7 million per year (Maine DMR, 2010). In 2008, licenses in the Maine Lobster Fishery were used as follows (Deirdre Gilbert, Maine DMR, pers. comm.):

- 6,492 commercial licenses eligible for tags (distributed uses of total available)
  - 2,053 (32%) have no reported activity
  - 4,439 (68%) have at least one pound (1 lb) of landings
  - 2,703 (42%) landed less that 1,000 pounds (lbs)
  - 1,309 (20%) landed greater than 20,000 pounds (lbs)
  - 217 (3%) landed greater than 50,000 pounds (lbs)

Of the commercial lobster license holders in the state of Maine, about 2,000 actively fish in state waters and 1,300 hold federal lobster licenses (Patrice McCarron, MLA, pers. comm.).

Inside Maine state waters, lobster fishing is a trap fishery. In federal waters, lobsters can be caught in both traps and trawls, but only those caught in traps can be landed in Maine. Lobsters caught in trawls are landed in either New Hampshire (NH) or Massachusetts. Traps are set either singly or in strings of up to ten (10) or 20 traps. These longer strings of traps are used primarily offshore, and represent areas where there is gear coverage on more bottom area than is immediately apparent from the density of buoys on the surface. Both Maine-based and out-of-state vessels fish for lobster in the federal waters ten (10) nmi off Maine's coast.

While fishing effort and gear follow the lobsters' seasonal migration patterns, moving closer to shore in the summer and farther offshore in the winter, virtually all waters off the coast of Maine are spoken for in the sense that they are fished by individuals from a particular harbor, or in the case of overlapping areas, more. As such, any exclusion areas related to offshore wind development can be expected to displace some number of fishermen from their traditional fishing grounds. The intensity of lobster fishing is highest closest to shore in state waters, and decreases with distance from the coast. However, there is substantial offshore lobster fishing in federal waters, and a greater degree of mixing across communities as those who fish far offshore are more mobile and cover larger areas.

Maine's coastal waters are divided into lobster zone territories, which are managed by Zone Councils, composed of industry representatives, in conjunction with Maine's

DMR. Lobster zone boundaries are shown in Figure 5-29, below as given by the Maine DMR Regulations Chapter 25.94 (Image available at http://www.maine.gov/dmr/council/lobsterzonecouncils/Lobster%20Zones%20All%20Zones.jpg . In federal waters, the fishery is managed by the Atlantic States Marine Fisheries Commission (ASMFC), an inter-state management body. The major industry organization for the lobster fishery is the Maine Lobstermen's Association (MLA), see stakeholder contacts section. In addition to participation in the MLA, many lobster fishermen are actively involved with fisheries management, through participation in their regional Lobster Zone Councils, the Maine State Lobster Advisory Council (MSLAC), the Maine State Marine Resources Advisory Council (MSMRAC), and as advisors to the ASMFC.

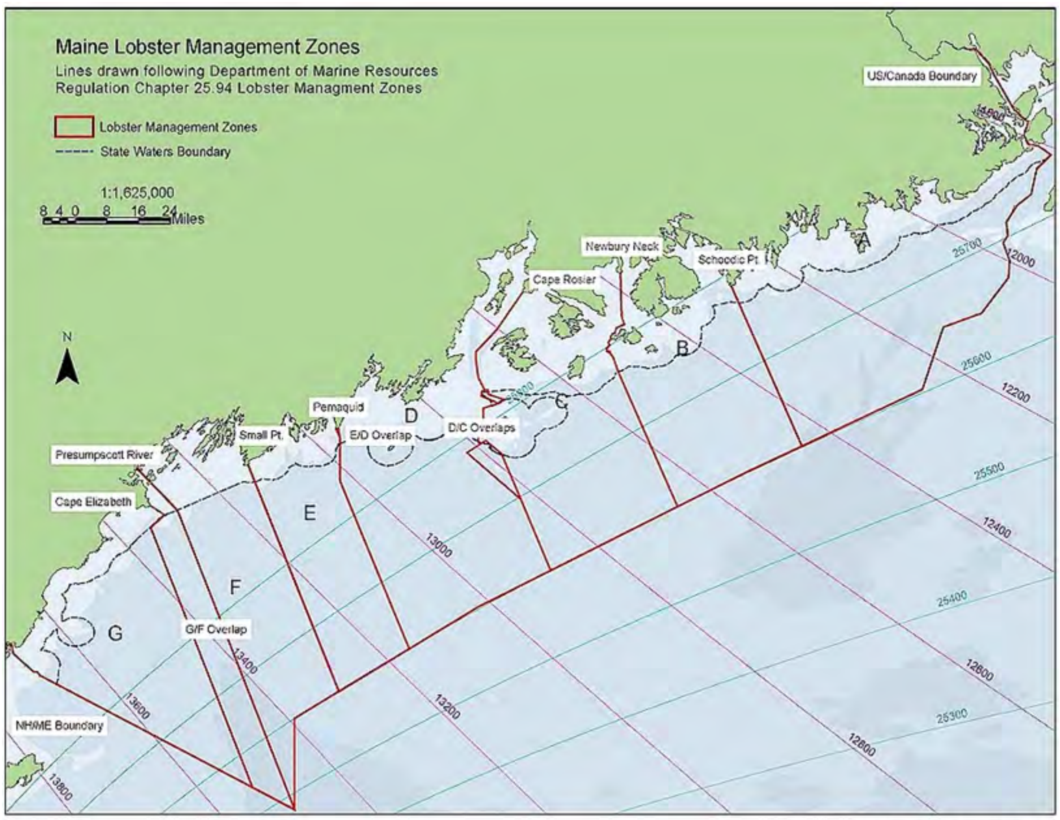


Figure 5-29: Maine's Lobster Management Zones

Northern Shrimp

Northern shrimp are caught in both trawls and traps in Maine state and federal waters, primarily during the winter months. Preliminary data for 2009 show nearly 4.8 million pounds of shrimp, valued at $1.92 million, were landed in Maine. The start date and length of the fishing season varies year to year, but in recent years has started in either November or December and ended in May. Maps of shrimp tows by region as well as names of draggers and operators can be found on the DMR website: http://www.maine.gov/dmr/rm/shrimp/shrimptow.htm. Shrimp tow areas offshore of ten (10) nmi are also shown in the overall fishery area map, in Figure 5-26, above.

The number of fishermen landing shrimp has varied widely over the past decade as the stock size has fluctuated dramatically. It was estimated that just over 200 boats from Maine participated in the fishery in the 2007 – 2008 season. It should also be noted that in the 2008 – 2009 season a number of boats from the lobster fishery rigged over to fish for shrimp in the winter months when the market for lobster was poor. Similarly, many lobstermen also participate in the spring halibut fishery in state waters, particularly in the Downeast region.

The GoM fishery for northern shrimp is managed across Maine, New Hampshire, and Massachusetts by the Interstate Fisheries Management Program (ISFMP) of the Atlantic States Marine Fisheries Commission (ASMFC). Maine members of the ASMFC Northern Shrimp Advisory Panel are listed in the contacts table at the end of this chapter. There is currently not an industry organization solely focused on the northern shrimp fishery, however the Midcoast Fishermen's Association includes many active shrimp fishermen and serves as a voice for the fishery. Glen Libby, President of the Midcoast Fishermen's Association, and other members of the association expressed a number of questions, priorities, and concerns related to shrimp fishing, which are highlighted below.

Groundfish

The groundfish fishery or the "Northeast multispecies fishery" is managed by the Northeast Fishery Management Council (NEFMC) and the federal NMFS. The groundfish fishery includes American Plaice, Atlantic Cod, Atlantic Halibut, Atlantic Wolffish, Haddock, Ocean Pout, Offshore Hake, Pollock, Red Hake, Redfish, Silver Hake, White Hake, Windowpane Flounder, Winter Flounder, Witch Flounder, and Yellowtail Flounder. Groundfish are caught in trawls, gillnets, and, to a lesser extent off the Maine coast, using long lines. Maine members of the NEFMC are listed in the stakeholder contacts at the end of this section.

While groundfish fishing decreased substantially after stocks plummeted following overfishing in the 1970's and 1980's, substantial efforts have been made to bring these fish back and there is currently a complex management plan in place to allow groundfish species to return to their once abundant levels on federally mandated rebuilding timetables. In Maine, fishermen belong to one of two groundfish sectors: the Port Clyde Community Groundfish Sector or the Sustainable Harvest Sector. Through sectors, a group is granted a total allowable catch (TAC) for each groundfish species that can be caught over the year at the sector's discretion with the understanding that once the TAC for one species in the allocation has been reached, sector members are no longer permitted to fish for any species. Those who do not belong to a sector fish under the Days At Sea allocation scheme and comprise what has come to be referred to as the "common pool". The Island Institute, The Nature Conservancy, and members of the Port Clyde Community Groundfish Sector are partnering on a series of fisheries capacity and sustainability projects. An additional sector, the Community Groundfish Sector, supported by the Penobscot East Resource Center, has been formed as a vehicle for re-building an active groundfishery east of Penobscot Bay.

Since 2007, all federally-permitted groundfish vessels have been required to operate a Vessel Monitoring System (VMS). State and federal agencies with access to VMS data are therefore able to produce maps showing groundfish fishing spatial distribution in recent years. Nonetheless, determining areas critical to the groundfish industry is more difficult than for some other fisheries, as there is an expectation that the industry will rebound over the next decade. While currently groundfishing is primarily an offshore industry, the expectation is that areas closer to shore will once again become productive and valuable to the fishery, as has occurred in recent years in the western GoM off the coast of New Hampshire and northern Massachusetts. In speaking with members of the fishery, this was among their primary concerns – that VMS data do not accurately depict the high historical value of areas that are currently sparsely fished due to limited groundfish resource, and that future access to fishing grounds not be limited to only those offshore areas currently used.

The Midcoast Fishermen's Association (Glen Libby, President) and Associated Fisheries of Maine (Maggie Raymond) are two key industry organizations representing groundfish fishermen in the State.

Small Pelagic

Small pelagics are caught using both mid-water trawls and weirs and include such species as herring, menhaden, and sand eels. Of these, Atlantic herring is the state's most important pelagic fishery, with nearly 58 million pounds landed in 2009 (Figure 5-23). Historically this catch fueled a large sardine canning industry in the State. While the last of these canneries closed in April 2010, herring is still a huge driver in the state's coastal economy as it is the primary bait used by the lobster fishery. The small pelagic fishery, generally termed the 'herring fishery' as a catch-all, is highly mobile and inter-annually variable in location. The herring fleet exploits different areas along Maine's coast during different years. The East Coast Pelagic Association (Mary Beth Tooley) is an important industry organization for this fishery. Figure 5-24 and Figure 5-28 includes a map showing areas of commercial pelagic fishing effort.

Hagfish

The fishery for hagfish has expanded across the northern GoM over the last decade, and is now undertaken across large areas, as shown in Figure 5-28. The fishery is known as the 'eel barrel' fishery and is managed by the NEFMC. Landings, total commercial value, and number of participants are not well known for this fishery; however, the fishery has expanded territory eastward over the last five years (Figure 5-28). There is not a currently active industry organization for hagfish in Maine. For an overview of the fishery, please see the following website article: http://www.workingwaterfront.com/articles/Unregulated-hagfish-industry-creates-conflict-and-opportunity/13890/.

Quahog

In eastern Maine, there is an ocean quahog fishery, which according to preliminary data for 2009, was valued at $1.82 million. Locally these small ocean quahogs are known as "mahogany quahogs" and are generally sold for the half-shell market. The fishery is managed by the NEFMC. There is not currently an active industry organization for the ocean quahogs fishery in Maine.

Commercial fisheries concerns, priorities, and questions:

- How could turbines be placed anywhere in waters off Maine's coast while the shore line to twenty miles off shore is where all major fishing efforts are conducted?
- At what distance will fishermen be allowed to fish around and between the turbines?
- Loss of access to fishing areas and concern about being cut-out from the fishery permanently as competing uses increase
- Concern about gear loss from increased traffic as well as entanglement with structures
- Interest in knowing about new employment opportunities for those who may be displaced
- If individuals are forced to give up fishing grounds, there isn't really room for them to relocate since nearly all coastal waters are already spoken for
- What opportunities exist to compensate for, or mitigate harm to, fishing communities?
- With respect to staging areas, there is the example of the Stella Firth ship repair during the summer of 2010 between Rockland and Vinalhaven. The vessel was there ten (10) days or so, not much of a problem for lobster fishery. However, no-fishing zones associated with turbine staging in Penobscot or Casco Bay for a longer period of time (one to three months) could cause major disruptions to the lobster fishery, especially in summer or autumn months when the majority of catch is landed.

- Concern about limiting future flexibility; even though an area might not be heavily used right now, if the resource shifts, they are potentially cut out if that becomes a site.

Table 5-3: Environmental Stakeholders – Commercial Fishing Contacts

COMMERCIAL FISHING CONTACTS		
Maine Lobstermen's Association	Patrice McCarron, Executive Director	(207) 967-4555 patrice@mainelobstermen.org
Port Clyde Community Groundfish Sector	Glen Libby, Sector President	(207) 701-7032
Offshore lobster	Jon Munsey	(207) 373-0701
ASMFC Northern Shrimp Advisory Panel	Terry Alexander, Chair	(207) 729-2538
East Coast Pelagic Association; Small Pelagic Group	Mary Beth Tooley	(207) 230-7088 mbtooley@roadrunner.com
Associated Fisheries of Maine	Maggie Raymond, Director	(207) 384-4854 maggieraymond@comcast.net

Commercial Shipping
In 2007, Maine ports collectively handled over 1.5 million tons of dry cargo, 41% of which was handled in Portland; 33% in the Penobscot River ports of Bangor, Bucksport, Rockland, and Searsport; and 26% in Eastport. Additionally, Portland and Searsport handle close to 125 million barrels of petroleum products. (Source: Maine DOT, Office of Freight Transportation web site: http://www.maine.gov/mdot/freight)

Pilots are often the best source of information regarding inshore commercial shipping lanes and approach routes, as they are employed to guide cargo ships through state waters to port. For state pilot information, contact the Maine Pilotage Commission web site: http://marinepilotage.com/.

In addition to large-scale commercial shipping, many of Maine's harbors also have some short-distance freight activity. Employed by local municipalities, harbormasters manage the multitude of activities that happen along waterfronts and, as such, are familiar with the barges that come and go from their particular harbor, their schedules and routes. A directory of a number of the State's harbormasters is maintained by the State of Maine Harbormasters' Association (http://www.maineharbormasters.org/). Contact information for harbormasters not listed on this site can be found through local municipal offices.

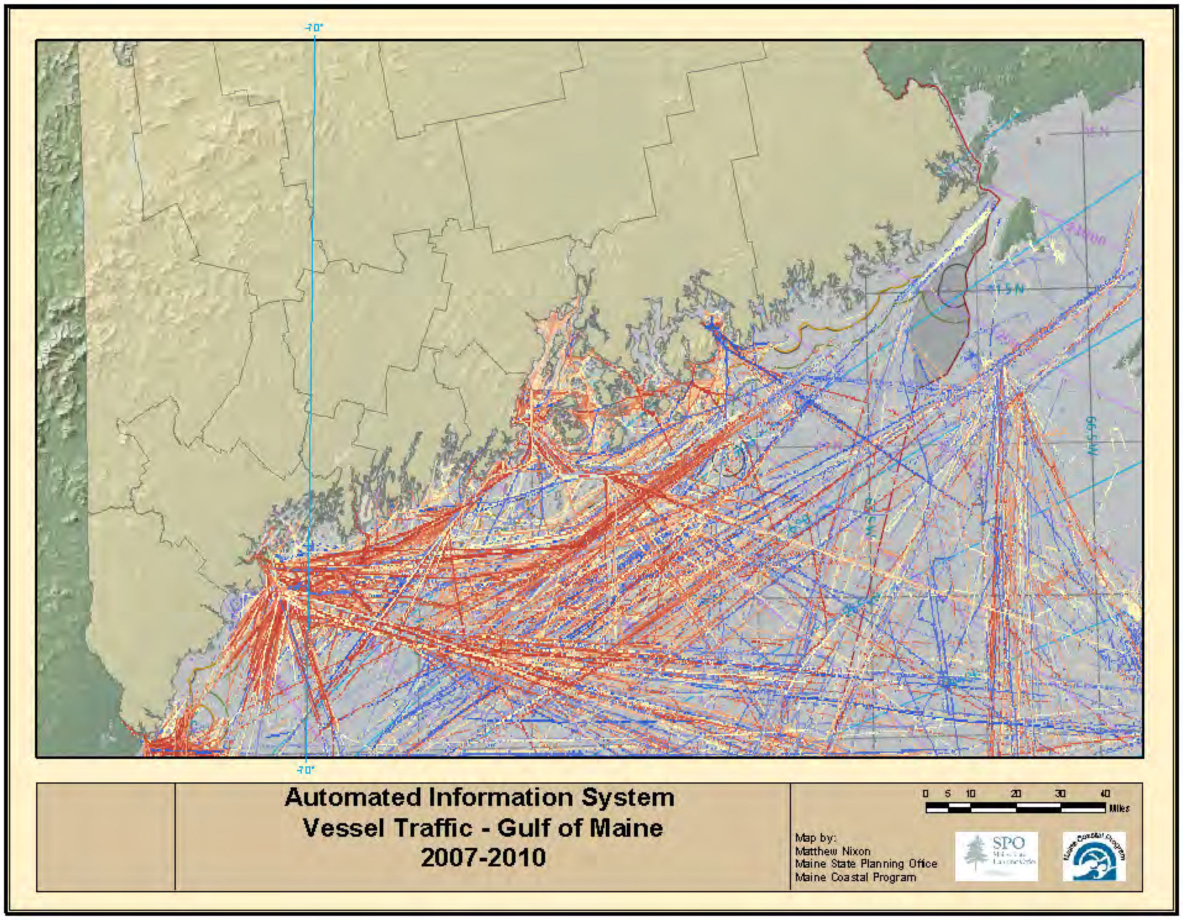


Figure 5-30: Gulf of Maine Automated Identifications System (AIS) Vessel Traffic. Vessel traffic data in GoM as reported by AIS; red lines depict routes of high-volume routes and blue lines depict low-volume traffic routes.

South of and including Casco Bay

Portland (http://portofportlandmaine.org/) is New England's largest tonnage seaport, the second largest oil port on the east coast, and the largest foreign inbound transit tonnage port in the United States. (Source: http://www.portlandmaine.com/index.php?sec=2)

Portland is also home to Portland Fish Exchange, a non-profit organization owned by the City of Portland where seafood is offloaded and auctioned. (http://pfex.org)

Between Casco Bay and Penobscot Bay

There are no ports located in this portion of the coast. The bathymetry in much of this area makes navigation very difficult.

Penobscot Bay to Winter Harbor

The Penobscot River is home to a series of ports – in Searsport, Bucksport, and Bangor/Brewer. Searsport is the primary port along the Penobscot River, and home to Mack Point Marine Intermodal Cargo Terminal. Mack Point has liquid and dry cargo piers as well as an intermodal rail yard operated by Montreal, Maine and Atlantic Railway. Both Sprague Energy and Irving Oil Corporation have processing facilities on site. Primary contacts and a map of the port's facilities can be found at http://www.mackpoint.com .

Other commercial shipping of note along the Penobscot River includes bulk liquid shipments at Webber Dock in Bucksport and barge shipments leaving the Cianbro Corporation site in Brewer (Source: http://penbaypilots.com/ports.html). Rockland sits along the western approach to Penobscot Bay and has regular marine and cement barge traffic. Tug service in Penobscot Bay is provided by Penobscot Bay Tractor Tug Company, which operates out of Belfast. For pilot contacts and information contact the Penobscot Bay and River Pilots Association: http://penbaypilots.com/.

East of Winter Harbor

Maine's third major port, and the easternmost port in the United States, is the Port of Eastport (http://www.portofeastport.org/), home to the Breakwater Terminal and Estes Head Cargo Terminal. The Port of Eastport works closely with DOMTAR Pulp & Paper, Grieg Star Shipping, ORPC, First Wind and GE Energy (Source: http://www.portofeastport.org/index.php). Pilotage services for the port are offered by Eastport Pilots USA (Captain Gerald Morrison) and Quoddy Pilots USA (Captain Robert Peacock).

Table 5-4: Environmental Stakeholders – Commercial Shipping Contacts

COMMERCIAL SHIPPING CONTACTS		
Penobscot Bay & Rivers Pilots Association		(207) 548-1077 pilots@penbaypilots.com
Maine Port Authority	John Henshaw, Executive Director	(207) 624-3564

Recreational Fishing

While recreational salt water fishing takes place along the entire coast of Maine, the majority of boats operate from Boothbay Harbor to the southern Maine border, with increasing prevalence the farther south one travels along the coast. Saltwater angling is primarily done through for-hire charter and head boats, charter boats being those that carry up to six passengers while head boats carry seven or more. A listing of charter and head boats by county is maintained by Maine DMR. Of the 117 vessels listed, 108 are charter boats of which 69 operate from either Cumberland or York counties. The nine head boats are distributed relatively evenly along the coast. The DMR list of charter and head boats can be found at the following website: http://www.maine.gov/dmr/recreational/forhirefleet/index.html.

Saltwater sport fishing tournaments occur in summer months, with the bulk of activity again located in Boothbay and south. A list of tournaments is maintained by DMR and can be found at the following web address: http://www.maine.gov/dmr/recreational/tournaments/index.html.

Recreational fishing concerns, priorities, and questions:

- Fisheries stakeholders note that the Western GoM Multispecies (Groundfish) Habitat Closure area (see Figure 5-25) is used by many recreational fishing vessels.
- Concerns from recreational fishermen would depend on whether they have access to the areas around the turbines, and whether it happens in western Maine.
- Recreational fishing contact information and licensed charterboat captains can be found through the Maine Association of Charterboat Captains (MACC). See http://mainechartercaptains.org for details.

Table 5-5: Environmental Stakeholders – Recreational Fishing Contacts

RECREATIONAL FISHING CONTACTS		
Recreational Fisheries Alliance	Barry Gibson, New England Regional Director	(207) 633-5929
Maine Association of Charterboat Captains	David Pecci, President	(207) 841-1444

Source: http://mainechartercaptains.org/

Other Boating (Recreational, Tourism Businesses)

Inshore Recreational Boating and Tourism Businesses

The majority of Maine's recreational boating occurs within a few miles of shore or in the bays between islands and the coast. While this makes these activities less of a concern for the siting of offshore wind platforms themselves, they still represent relevant stakeholders when potential staging areas and transportation routes are considered.

Figure 5-31 below shows typical cruising routes used by Maine Windjammer Cruises between May and October, and demonstrates the types of routes and areas most often utilized by other recreational vessels on the coast of Maine (Image available at http://www.mainewindjammercruises.com/cruisinggrounds.cfm.)

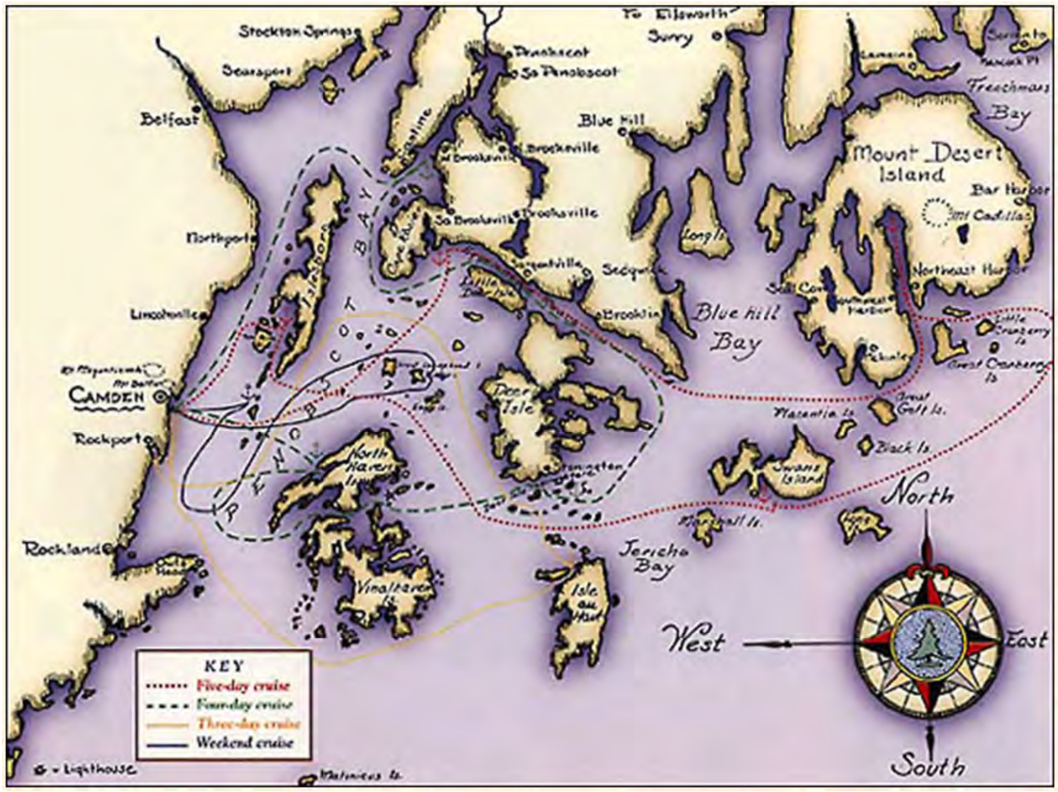


Figure 5-31: Maine Windjammer Cruises – Typical Cruising Routes

Primary types of inshore recreational boating include

- Kayaking – In addition to the numerous rental and guide companies along the coast, for an overall sense of kayaking routes and destinations, the Maine Island Trail Association (http://www.mita.org/), is a Portland-based organization that created and maintains a 375-mile water trail comprised of a chain of over 180 coastal islands and sites along the coast of Maine.
- Sailing – Charter sailboats operate either singly or as part of a local fleet. The largest fleet in the State is the Maine Windjammer Association (http://sailmainecoast.com/fleet.php; 800.807.9463) with 12 boats operating out of Camden and Rockland in Midcoast Maine.
- Lobster boat racing – A schedule listing race sites is on the following web site: http://lobsterboatracing.com/

A more detailed listing of recreational boating stakeholders by region can be found through the searchable list of marinas and boating activities maintained by the Maine Port Authority (MPA): http://maineports.com/pleasure-boating/marinas.

Offshore Cruising and Tourism Businesses

Yachts, cruise ships, whale-watching boats, and seabird tours represent the recreational boats most likely to be encountered in Maine's offshore waters.

Cruise Ships

The vast majority of cruise ship activity happens in Bar Harbor and, to a lesser extent, Portland. Other destinations include Rockland, Eastport, Freeport, Kennebunkport, Portland, Rockland, Bath, Boothbay Harbor, Camden, Belfast, Searsport, Bucksport, and Bangor. A list of cruise lines that visit Maine as well as the 2009 ship schedule by port can be found at http://www.cruisemaineusa.com .

Yachts

Local yacht clubs (http://www.yachtclub.com/usycs/maineyc.html) and cruising guides are the best resource for understanding which offshore routes are most heavily used. There are multiple annual yacht races along the Maine coast, including the Monhegan Island Race from Portland east around Monhegan and then returning. Another example is the Eggemoggin Reach Regatta (http://www.erregatta.com/), which includes a series of races within Penobscot Bay during August every year. The New York Yacht Club undertakes flotilla cruises along the Maine coast each summer, involving tens of yachts.

Whale-watching boats

The majority of Maine's whale-watching boats operate out of Casco Bay, Boothbay, and Bar Harbor. Tours are busiest through the summer tourist season. For example, Bar Harbor Whale Watch operates "four ships, two of which are for whale-watching and combined hold over 700 people per trip and they run three (3) trips a day from May – September". In addition to contributing to Maine's coastal tourism, whale-watching tour businesses are also are rich resources for whale data.

Seabird tours

Particularly due to efforts to restore Atlantic Puffins to Midcoast islands and the existing prevalence of seabirds on Downeast islands, these two regions are where most seabird tours operate. (Hardy Boat, Monhegan Boat Lines, Downeast: http://www.robertsonseatours.com/bird-watching.html)

Other boating concerns, priorities, and questions

- Would not want turbines located in summer feeding grounds where whales congregate
- Concern about potential increases in boat traffic running back and forth through whale feeding grounds
- See section on aesthetic and sound concerns, below

Archaeological and Cultural Resources

Submerged cultural resources will be in the form of historic shipwrecks and prehistoric archaeological sites. Shipwrecks will exist as features exposed, partially exposed, or buried on the ocean floor, and may be widely and randomly distributed. It is anticipated that most wrecks will have some surface expression on the ocean floor, but sediment-covered wrecks with a muted or absent surface appearance must also be anticipated. Prehistoric sites will be in the form of upland and coastal occupation, travel, and resource exploitation sites in areas that were subaerially exposed during the Late Pleistocene lowstand of sea level. These areas extend from the current coast to approximately 120 m of water depth (Kelley et al., 2010). This area will include development sites, as well as cable crossings, and staging areas.

Human occupation of these areas is established by the recovery of artifacts from Maine's nearshore region (Kelley et al., 2009; Price and Spiess, 2007; Crock et al., 2007). Because the size of these sites are anticipated to be of limited extent, and artifacts are too small to be resolved by any remote sensing techniques, recognition of these sites will be based on identification of landforms with high archaeological potential based on terrestrial site location models (Speiss et al., 1998, Kellogg, 1987), a newly developed marine site location model (Kelley et al., 2010), and detailed survey of areas of proposed bottom disturbance.

Initial survey for submerged cultural resources will require a number of geophysical techniques that will allow for the remote identification of high potential areas. These include multi-beam bathymetry and backscatter intensity data, side-scan sonar, and seismic reflection profiling, all combined with precise position data. Because offshore development requires some of the same information used in submerged cultural resource evaluation, advance planning can allow information for cultural resource assessment and development to be collected simultaneously.

If culturally sensitive areas are identified on the basis of the above techniques, more detailed surveys will be required if the resources are in areas of sea floor disturbance. For shipwrecks, this will entail more detailed mapping of the site, involving high-resolution geophysical techniques (side-scan sonar or multi-beam survey), investigation by remotely operated vehicle (ROV), or evaluation by submersible. Potential prehistoric cultural resources can be investigated in more detail through focused seismic reflection profiling studies, coring, and ROV or direct submersible investigation, if materials are exposed at the sea floor. Intensive studies of submerged cultural resources will be expensive, and developers may choose to avoid areas of potential, rather than carry out costly investigations.

Aesthetic and Sound Concerns

Millions of dollars pour into the state's coastal regions each year as tourists flock to the area to enjoy scenic vistas and natural landscapes. This subsection will briefly discuss how offshore wind development may affect both residents and visitor experiences along the coast in terms of aesthetic and sound impacts.

Aesthetic

While visual impact has played a significant role in some efforts to develop offshore wind in the United States (e.g., Cape Wind), the issue did not emerge as a critical concern during the 2009 efforts to site ocean energy demonstration sites (J. Atkinson, pers. comm.). Atkinson helped the State of Maine to facilitate public outreach during this siting process (see Introduction, above) and noted that reactions of stakeholders on visual impacts included:

- Concerns about "industrialization of a viewshed," particularly in the region around Acadia National Park;
- Questions and concerns about visibility of turbines in terms of marine safety purposes (e.g. commercial shipping and fishing); and
- Comments about turbines being visually pleasing

[N.B., these observations are from the oral comments given at various meetings and during public events that Atkinson planned for the State. Moreover, they do not reflect the content of any written comments the State received or phone conversations that may have taken place between stakeholders and agency personnel prior to or after these meetings.]

Atkinson noted that these reactions were in response to presentations on plans to site and test deepwater, floating wind turbines in state waters, the specifics of which vary significantly from the focus this section places on areas more than ten (10) nmi from shore. In addition, these reactions were based on plans for a limited number of turbines installed for a limited amount of time. Atkinson therefore stressed that the responses to larger, commercial projects sited farther from shore for longer periods of time may vary from those received during the outreach process for the demonstration areas.

While formal public opinion studies on the aesthetic impact of offshore wind in Maine have yet to be completed, the topic was brought up in some stakeholder interviews for this section. A statewide perspective was offered by Vaughn Stinson, Executive Director of the Maine Tourism Association. Stinson's comments do not represent the official stance of the organization, but are some initial thoughts in response to information about the up to 30 MW RFP released by the Maine PUC. He noted that the visibility of an offshore wind farm would not necessarily have an adverse impact on coastal tourism. Rather, public emphasis on the environmental benefits and carbon footprint reductions of a project may help the site become a tourism attraction. Stinson suggested that there are both costs and benefits to renewable energy development and that depending on where an offshore wind farm is sited, the benefits have the potential to outweigh the costs. Stinson had not previously been aware that turbines will be located at least ten (10) nmi from the nearest inhabited land, but gave his comments based on this information.

An example of a local perspective was given by Glenn Burdick, president of Monhegan Associates, a land trust that holds approximately two-thirds of Monhegan Island in conservation. The mission of the Associates is two-fold: (1) to protect the wildlands of Monhegan and its scenic vistas, and (2) to support the island's community. While the organization currently does not have an official stance on offshore wind, it is supportive of responsibly-sited renewable energy. However, Burdick did note that due to the organization's focus on the natural environment of the island and its surroundings, there would be great interest in the proper siting and development process of a large-scale, commercial offshore wind farm. Changes to the viewshed near some of Monhegan's most visited sites, such as the renowned cliffs on the eastern side of the island, may be of particular concern.

In regards to the second part of the organization's mission to support the island community, Burdick suggested that efforts to balance visual impacts by providing tangible benefits to the island community may help some of the organization's membership to accept an offshore wind project sited reasonably nearby. Burdick offered an example of how some form of transfer payments by a wind farm developer might help the municipal power company to finance a small-scale community-owned wind project as a way to lower the extremely high cost of energy on the island (see Island Electric Utilities, below).

Finally, reactions to the visual impact of terrestrial-sited wind power in Maine may help to inform those seeking to understand the potential response to offshore wind development. Reactions to onshore wind for the most part have been mixed, with a small but vocal group of activists contesting the development of wind in more rural, mountainous parts of the State. Information on these views can be found at http://www.windtaskforce.org and http://www.penbay.org. Ron Huber, of

Penobscot Bay Watch (http://www.penbay.org), is currently suing the State of Maine relating to the designation of the ocean energy demonstration areas in state waters.

Sound

A minimal amount of concern about the sound impacts of temporary test turbines was raised during the 2009 demonstration area siting process (J. Atkinson, pers. comm.). However, concerns over the sound impacts of land-based wind power have been featured prominently by both Maine-based and national media outlets in recent months. These concerns have ranged from general annoyance to concerns about human health effects to property value impacts. The concerns have been raised in response to large commercial-scale wind projects (e.g., First Wind's project in Mars Hill, Maine) as well as smaller, community-owned projects (e.g. Fox Islands Wind in Vinalhaven, Maine). Due to the relatively high visibility of these issues, the efforts of small but vocal group of anti-wind activists (again, see: http://www.windtaskforce.org and http://www.penbay.org), and the larger scale of commercial offshore wind projects, it is likely that some concerns about sound impacts will be raised in the development of offshore wind in Maine.

As suggested by Section 5.3.6 of this report, developers interested in siting wind farms in the GoM should be prepared to discuss the potential for sound propagation over water to impact residents on land. The results of sound modeling studies will likely be of interest to some stakeholders, but more experiential information such as sound recordings may prove to be more useful in helping them to understand the nature of the potential impact. Stakeholders interested in the well-being of various marine species will also be concerned with the potential for underwater impacts as also discussed in Section 5.3.6 and electromagnetic field effects discussed in Section 5.3.7. Developers should therefore be prepared to detail relevant ecological research and monitoring.

Aesthetic and sound concerns, priorities, and questions

- How far away will the offshore turbines be heard?
- Will sounds reach islands or mainland locations?
- How far away will turbines be visible?
- Will they be visible from island or mainland locations?

Environmental and Conservation Areas of Concern

National and regional environmental NGOs engaged in coastal and marine issues in Maine include National Audubon, The Nature Conservancy (TNC), Conservation Law Foundation (CLF), Environmental Defense Fund (EDF), and the Pew Environment Group. TNC and CLF are actively engaged in Maine fisheries issues and other marine issues. In addition, The Ocean Conservancy, the National Wildlife Federation (NWF), and Oceana are concerned with coastal and marine issues nationally and are engaged in discussions about offshore wind energy along the Atlantic seaboard.

These national environmental organizations tend to be supportive of renewable energy, in general, and of offshore wind development, in particular. Staff members interviewed for this section noted that their organizational support for particular deepwater offshore wind developments would hinge on site selection that avoids, minimizes, and mitigates local environmental impacts and impacts on current users to the greatest extent possible. Marine Spatial Planning (MSP) is an activity of particular interest to some environmental NGOs at this time, including TNC and CLF, which are active participants in the Northeast Regional Ocean Council (NROC), which will be implementing the National Oceans Policy for the GoM region. NROC has stated that siting of renewable energy projects will be one of its primary immediate objectives (http://collaborate.csc.noaa.gov/nroc/default.aspx .)

Environmental and conservation organizations with particular interest in issues of coastal and marine significance in Maine include the Maine Chapter of Audubon, National Resources Council of Maine, Environment Maine, Maine Coast Heritage Trust (MCHT), Friends of Maine Seabird Islands, and The Lobster Conservancy.

At regional and municipal levels, environmental interests are often represented by local land trusts, conservation commissions, soil and water conservation districts, and environmental education organizations. Though many of these groups are more traditionally focused on land issues rather than marine concerns, in coastal communities some are active in both areas. In addition to environmental and conservation organizations, Maine is also home to a number of non-profit organizations and networks with a statewide focus on renewable energy generation. They include the Ocean Energy Institute (OEI), the Maine Wind Industry Initiative (MWII), Maine Renewable Energy Association (MREA), and the Environmental and Energy Technology Council of Maine (E2Tech).

For those groups that work in the field of land conservation – primarily MCHT and local land trusts – the primary concerns will be the ways in which offshore wind intersects with the land and the public. There is an interest in knowing more about transmission lines and grid connections as well as shoreline staging areas. In addition, there is a strong interest in maintaining a very open public process around offshore wind development. There is preference for local efforts over large-scale industry and a sense that development should be structured to provide maximum benefit to "the many," rather than a small few. Environmental concerns voiced by land trusts included apprehension about storing excess energy as ammonia as well as possible interference with whale and bird migrations.

Also of particular relevance for offshore wind conservation considerations, are those species federally- or state-listed as endangered, threatened, or protected that utilize Maine's coastal waters, particularly whales and seabirds. See Section 5.3 for more detail on listed species considerations.

In the case of the North Atlantic right whale, efforts are being made to reduce entanglements including new federal regulations prohibiting lobstermen from using floating rope. These regulations, enacted in April 2009, required wholesale changes in gear for lobstermen and have raised awareness of right whale protection amongst coastal residents and fishermen. See Section 5.3 for more detail on marine mammal considerations.

Of the 4,600 coastal islands in Maine, 294 have been designated by the United States Fish and Wildlife Service (USFWS) as nationally significant seabird nesting islands. (Source: http://www.fws.gov/northeast/gulfofmaine/downloads/fact_sheets/nesting_islands_data.pdf). The Maine Coastal Islands National Wildlife Refuge contains more than 50 of these offshore islands and four coastal parcels, totaling more than 8,100 acres, spanning more than 250 miles of Maine coastline and including five national wildlife refuges – Petit Manan, Cross Island, Franklin Island, Seal Island, and Pond Island. (http://www.fws.gov/northeast/mainecoastal/). See Section 5.3 for more detail on bird and bat considerations.

Mount Desert Island is also of particular concern since it is home to most of Acadia National Park. The park also includes part of Isle au Haut and the Schoodic Peninsula. Acadia is the second most visited national park in the country, and therefore represents an important scenic, cultural and economic resource.

South of and including Casco Bay

Active marine environmental and research groups include Friends of Casco Bay and Gulf of Maine Research Institute (GMRI).

Between Casco Bay and Penobscot Bay

Located in Muscongus Bay, Eastern Egg Rock is designated as the Allan D. Cruickshank Wildlife Sanctuary and is the site of the National Audubon Seabird Restoration Program's Project Puffin, providing important habitat to Atlantic puffins and nearly 4,000 pairs of nesting terns, laughing gulls and eiders. (Source: http://www.projectpuffin.org/EasternEggRock.html)

Of the islands that make up the Maine Coastal Islands National Wildlife Refuge, two (e.g., Franklin Island and Pond Island) are located in the Midcoast. There are also a number of environmental education facilities located in the Midcoast, including Hurricane Island Outward Bound School, Kieve-Wavus, Inc., and the Hog Island Audubon Center. Active marine environmental groups include the Quebec-Labrador

Foundation's Marine Program (http://muscongusbay.org/) and the Island Institute (http://www.islandinstitute.org).

Penobscot Bay to Winter Harbor

Of the islands that make up the Maine Coastal Islands National Wildlife Refuge, Seal Island is located in Penobscot Bay. Also of particular significance to seabird nesting is Matinicus Rock. Sears Island, which was purchased by the state in 1997, falls in this area of the coast and is of note for the recent debate around its use between those interested in preserving the island and those who would like to build a cargo port on it. Ron Huber, of Penobscot Bay Watch, who is currently suing the state of Maine over the designation of the offshore wind demonstration sites, has been an active participant in this Sears Island controversy. For more information, see the following websites:
http://www.maine.gov/doc/initiatives/SearsIsland/press/OwnershipDebate.shtml
http://www.maine.gov/doc/initiatives/SearsIsland/DraftConcensusAgreement02012007.pdf

Active marine environmental and research groups in this region of the coast include the Island Institute, Marine Environmental Research Institute and Penobscot East Resource Center.

East of Winter Harbor

Active marine environmental and research groups include the Cobscook Bay Resource Center.

Environmental and conservation concerns, priorities, and questions

- How will offshore deepwater wind siting intersect with ongoing Marine Spatial Planning (MSP) efforts?
- How will we ensure that multiple spatial data collection efforts ongoing in the region inform each other?
- What environmental research is currently being undertaken to understand the impacts of offshore wind energy?
- How will turbine heights intersect with bird migration heights? Do the specific heights used by birds to migrate over land apply over water?
- How exactly will adaptive management work? In the past, for example in LD 1465, the feedback loops have not been specific enough on how new environmental impacts information would be looped back into decision-making; this is a disadvantage for developers and those with environmental concerns?

Table 5-6: Environmental Stakeholders – Environmental/Conservation Contacts

ENVIRONMENTAL / CONSERVATION CONTACTS		
Conservation Law Foundation	Sean Mahoney, VP and Director of CLF Maine	(207) 210-6439 x12 smahoney@clf.org
The Nature Conservancy	Barbara Vickery, Director of Conservation Program of TNC Maine	(207) 729-5181 x210 bvickery@tnc.org

Island Electric Utilities

The GoM is populated with 15 year-round island communities, the electricity needs of which are met in one of three ways: (1) via a submarine cable and island grid owned by one of Maine's investor-owned utilities (either Central Maine Power or Bangor Hydro Electric); (2) via a submarine cable and island grid publicly owned by an island electric cooperative or company; or (3) via on-island generation (primarily diesel) and an island grid publicly owned by a quasi-municipal power district or company. As the financial burden of the latter two options is distributed amongst a very small number of ratepayers (1,020 – 1,800), the islands that fall into these categories currently pay between 24 cents/kWh and 70 cents/kWh for their power, roughly two and one-half to seven times the United States national average.

Island communities in other States (e.g., Block Island, Rhode Island and Nantucket, Massachusetts) have been closely involved in the offshore wind development process through discussions on siting and cable interconnects, as well as scenic and human use impacts. Therefore, several Maine island stakeholders were interviewed in order to identify relevant questions, concerns and interests related to the potential for offshore wind development in their state. Although this section focuses on island leaders working on energy issues, discussion with a broader set of island residents is strongly suggested should there be an interest in a site proximate to a year-round island community.

In general, comments and questions from these island energy leaders focused on the potential to tap into any power produced by offshore projects in the GoM as a strategy to lower the high cost of electricity on islands. Questions reflected the high level of uncertainty as to whether such an option might even exist, and the types of infrastructure or agreements that would need to be put in place for such a concept to become reality. Also of potential interest to developers, these leaders offered first-hand knowledge on owning and maintaining submarine cables in the GoM.

Fox Islands Electric Cooperative, Vinalhaven and North Haven Islands, Maine

Key issues raised: operating and financing submarine cables in Penobscot Bay, available capacity in existing cable

Chip Farrington, General Manager of the Fox Islands Electric Cooperative (FIEC), was one of the island leaders interviewed for this section. FIEC is Maine's largest island electric cooperative, serving 1,800 members on the islands of Vinalhaven and North Haven in Penobscot Bay. Until late 2009, FIEC provided power to its members exclusively via an 11-mile submarine cable that connects to the ISO-NE grid in Rockport, Maine's Glen Cove.

In December 2009, the 4.5-MW Fox Islands Wind project (http://www.foxislandswind.com) entered into commercial operation, generating roughly the same amount of power used by the islands over the course of the year. However, due to intermittency of wind, the submarine cable continues to be used extensively in order to buy or sell power at any given moment. Fox Islands Wind, developed and owned by FIEC with assistance from the non-profit Island Institute, is the largest community-owned wind project on the East Coast of the United States. It has been met with considerable local support, particularly in light of its ability to lower and stabilize electric rates on the Fox Islands. It is considered by many to be Maine's first foray into offshore wind, in spite of its terrestrial location.

While the vast majority of the island communities continue to support the wind project, concerns from a few neighbors over turbine noise have been broadly covered by local and regional media. As a result, and as detailed in the preceding Aesthetics and Sound Concerns section, some coastal residents may express concerns about noise impacts from proposed offshore project in spite of their sizable distance from shore.

Based on FIEC's experience, Farrington expressed concerns about the cost of financing, owning and maintaining submarine cables in the GoM. Prior to 2005, four single-phase cables powered the Fox Islands. According to Farrington, those cables began to wear away as sizeable tidal shifts dragged them over the rocky ocean bottom, causing the lines to fault ten years earlier than their anticipated end of life. Farrington recalled how FIEC struggled to secure funds to replace the cables and bury them in order to reduce the number of future faults. With the help of United States Senator Olympia Snowe's office, the Cooperative secured a multi-million dollar grant in 2005 to help cover the cost of the project that, at the time, was in excess of $6 million. Recognizing how the price of copper and other metals has since increased, Farrington estimated that the per-mile cost of new, buried cables would now be significantly higher.

Due to these costs, Farrington initially expressed doubt that a developer would consider a diversion from its straight path to a mainland interconnect in order to lay a cable "through" a Maine island. However, he suspected (the issue has not been formally discussed by FIEC's board) that the Cooperative would be "very interested" in the prospect of helping to site an on-island substation or leasing unused capacity in its existing submarine cable (10 – 14 MW of capacity are available, according to unofficial estimates). Farrington explained that the FIEC board has previously shown interest in finding advantageous uses for that unused capacity, most recently as they approved a deal with Time Warner Cable (TWC) to lease fiber for that company's high-speed internet service.

Matinicus Plantation Electric Company, Matinicus Island, Maine

Key issues raised: potential impact to fishing community, potential for power off-take to lower local energy costs

The Matinicus Plantation Electric Company (MPE) is a municipal utility that serves approximately 100 ratepayers on Maine's most remote inhabited island. At a distance of 22 miles from the mainland, Matinicus relies on diesel power at a cost of roughly 50 cents/kWh rather than a submarine cable connecting them to the ISO New England grid. MPE sells approximately 300,000 kWh to its customers each year.

Paul Murray, MPE's long-time plant manager, was interviewed for this section. Murray stated that while MPE's Board of Directors does not have an official stance on the potential for offshore wind development, he stressed that the first issue of concern for the Matinicus community would be the potential impact to commercial fishing, particularly in federal waters. The Matinicus economy is almost solely dependent upon the lobster industry, so exclusions and setbacks would likely be the issues of greatest concern to the community, even more so than energy issues. Murray therefore sees the potential development of offshore wind as a community issue and one that developers should discuss directly with island leaders should they have an interest in waters in the area.

In regards to power, Murray felt that there would likely be some interest in the potential for power off-take from an offshore wind project but that the current state of the island grid would likely challenge the ability of the community to do so for the time being. Murray was aware of a designated cable right of way between Matinicus and the mainland but questioned how development of that right of way might impact fishing, as well as, if cabling in the area could be economic due to the rough ocean bottom. Finally, Murray questioned whether a nearby offshore wind project would create any electrical interference with power, microwave phone or internet service on the island.

Monhegan Plantation Power District, Monhegan Island, Maine

Key issue raised: Potential for power off-take to lower local energy costs

The quasi-municipal Monhegan Plantation Power District (MPPD) serves approximately 120 ratepayers on Monhegan Island, located 11 miles from the tip of the St. George Peninsula in Midcoast Maine. Due to the island's distance from the mainland and its relatively small number of customers, the 11-year old centralized utility has, to date, been unable to finance a submarine cable that can provide power from the mainland. Island residents are aware of the fact that a cable right of way had been permitted to provide telephone service to the United States Coast Guard station on nearby Manana Island, but that the Coast Guard's permit has since expired.

Lacking a connection to the mainland grid, Monhegan instead depends on 70 cents/kWh diesel-generated power to meet its load. Feasibility work on a small (100 kW) community-owned wind project began in September 2008 as MPPD and the Island Institute worked to explore options that would lower the high economic and environmental costs of island power. With the December 2009 designation of a demonstration area just a few miles to the southwest of the island, Monhegan residents are now watching the development of offshore wind with great interest, many with hopes that a nearby commercial project might somehow help to lower the high cost of local electricity.

Mathew Thomson, President of the MPPD Board of Trustees, and Chris Smith, Manager of the Monhegan Power Station, were interviewed for this section. Thomson expressed a strong interest in the potential for power off-take from an offshore project if a submarine cable were to be permitted in nearby waters and a power purchase agreement could result in lower electric rates on Monhegan. However, both Thomson and Smith raised several questions about the on-island infrastructure that would be needed to facilitate such a connection. The two expressed doubts that the current Monhegan grid is "shovel ready" in terms of connecting to a cable, but stated an interest in learning how future island grid upgrades might be done in a manner that made a cable interconnect a viable option.

Based on past efforts to site transformers and other electric infrastructure on the island, Smith noted that any discussion of siting new infrastructure to facilitate a cable interconnect (e.g., an electrical substation) might be met with concerns about aesthetics, fire, noise and ability to obtain necessary easements. Thomson and Smith both wondered if the established cable right of way that runs from Monhegan to the St. George Peninsula would be of interest to potential developers, with Smith questioning if the grid in that area would be able to support the output of a 25 MW offshore wind project.

Island electric utility concerns, priorities, and questions

- Is there potential to tap into any power produced by offshore projects in the GoM as a strategy to lower the high cost of electricity on islands?
- What types of infrastructure or agreements would need to be put in place for such a concept to become reality?

5.4.3 Common Priority Questions, Concerns and Attitudes across Key Stakeholder Groups

Turbine sites

- How large an area and where?
- When would build-out to larger number of turbines occur?
- How large would the exclusion areas be for all vessels?
- How large will the exclusion areas be for mobile (trawl) gear?
- Would fixed gear be allowed within the exclusion area for mobile gear?
- What will be the effects of mooring cables, electrical cables, platforms and turbines on fishery resources?
- Concern that the scope of the project not be expanded too much, so that 25 MW turns to 100 to 500 MW, etc at the expense of stakeholders
- Concerns about how species habitat will be affected
- Concern that turbines cannot be built to withstand winter weather and extreme storms.
- Concern with how operations and maintenance will access turbines when the conditions are very rough? How?
- How will turbines be anchored?
- Comments that the turbines should be placed on Jeffreys Ledge Multispecies Habitat Closure where it is closed to fishing already (western GoM).
- Comments that the turbines should be placed on Jeffreys Bank Multispecies Habitat Closure where it is closed to fishing already (north-central GoM, south of Matinicus Island).

Staging areas in rivers or bays and tow routes between staging areas and turbine site

- Questions about where they will be staging from on the main land
- How large an area will be closed to fishing during staging and towing? Where?
- How long will the areas be used?

- During which seasons?
- Number of vessels involved in staging and towing? (concern that lobster fishing gear will be caught and destroyed by large vessels inshore)
- Comments that there should be one common route back and forth to the turbines for operations and maintenance to minimize disturbance to fishing gear.

Cables

- Questions about how habitat will respond to electricity being emitted from cables
- Concern with respect to cables and EMF emissions. High priority on requiring the highest level of shielding in the cables and burial of cables to make sure to minimize any impacts of EMF on living resources.
- What kind of magnetic field is emitted from the cables that are carrying the electricity and what kind of effect does it have on habitat on the bottom?

Cost to the public

- Why should the public pay for the development of this technology? In addition, will we see benefits in Maine or are we giving up our territory for wind projects that send power to Massachusetts?
- Will this make electricity less expensive in the short term or even in the long term?
- What efforts will be made to mitigate financial harm borne by communities near development sites?
- How open and publically accessible will the development process be?

6.0 Construction and Assembly

6.1 SUMMARY

The Maine Midcoast/Penobscot Bay area has the facilities and capabilities for the development of an early stage floating offshore wind farm. While there is no current activity in the region specifically related to off shore wind, there are existing industry resources and infrastructure with similar experience. There is also a valuable workforce with valuable experience working on complex maritime projects available. The current infrastructure is appropriate to support a project of limited size; however, additional investment will need to be made with in facility infrastructure and equipment for larger commercial scale projects exceeding ten (10) – 20 turbines.

6.1.1 Facilities

The Searsport Terminal at Mack Point located at the upper regions of Penobscot Bay has port space and support infrastructure available for an assembly and staging area. Nearby Sears Island has additional space available that could be developed for larger future projects. There is also additional port infrastructure and industrial water front real estate farther up the Penobscot River and in the surrounding Penobscot Bay area.

6.1.2 Assembly and Deployment

There is a deep-water area in the upper east side of Penobscot Bay that enjoys relative protection from larger sea states. This is an area that has been identified as a potential option to serve as a wet assembly and ballast area. There is also a nearby deepwater route that would allow deployment access out of the Bay. Junkins Ledge to the southwest of Vinalhaven Island represents concern due to the water depth and narrowness of the channel. Detailed studies of the subsea topography and consultation with local pilots would be required to ensure safe passage through this area if selected.

6.1.3 Companies with Expertise

Construction firms with local offices have appropriate experience and interests. One firm has manufacturing facilities in the upper Penobscot River/Bay system. These firms operate throughout the United States eastern seaboard; have experience with onshore wind power installation, marine construction, construction of offshore oil platforms and subsea cable installation. There are also moderately sized marine construction firms located in Penobscot Bay that may play a significant role in support services.

6.1.4 Equipment

Currently cranes exist in Maine with the capabilities to install turbines and blades at tower height. These may be mounted on barges for offshore work, or crane and barge equipment can be found readily in neighboring northeastern states. There are many more mid-sized and smaller cranes available to provide support services. Additional cranes for either requirement can be leased with in the northeast region with an expected lead time of two (2) to three (3) months. Local construction firms have existing relationships with the crane and equipment supply companies.

Barges currently located within the region are available for support, transportation, and midsized crane operations. However, larger barges required for turbine installation would need to be leased within the greater northeast region with an expected lead-time of three (3) months. Again, the local construction firms have existing relationships with the crane and equipment supply companies.

6.1.5 Maritime Skills and Heritage

The Maine Midcoast region has a strong shipbuilding heritage, including existing firms that build complex large navy craft, advanced tug boat builders and shipyards with experience building and repairing steel ferries and barges. These firms may be able to provide component fabrication and support services. Penobscot Bay is also home to Maine Maritime Academy. Many technically proficient graduates reside in the surrounding area.

6.1.6 Support Industries

In the region there are a number of medium and small steel fabrication companies with experience in providing services for marine infrastructure, power industries, bridge, and general construction. A number of large and small precision machining companies in Maine have extensive experience in providing services for power generation, defense and paper industries. The area also hosts an advance composite manufacturing sector that may play a role in providing repair services for blades and light weight corrosion resistant components. (Appendix D.1 (Section 10.4.1)).

6.2 LANDSIDE STORAGE AND ASSEMBLY FACILITIES/SITES

6.2.1 Searsport Terminal at Mack Point

The approach channel depth for Mack Point/Searsport is 33.2 ft. The guidelines for under keel clearance in Penobscot Bay are three (3) ft under keel in the bay, two (2) ft in the approach channel and one foot alongside the berth. The tide range in Searsport is ten (10) ft. Good anchorage is located about one mile southwest of Mack Point with good holding ground in about 50 ft of water.

The Searsport Terminal is 7.6 miles (10.5 km) to the north of the proposed wet storage/marine assembly area.

Tidal Range: ten (10) ft

Approach Channel and Turning Basin -35ft depth from mean low water (MLW)

Dry Cargo Pier

- 100 ft x 560 ft working surface
- Deck Load Capacity 1,000 psf
- Berth #1 (Eastern Side) 800+ ft long, -40 ft MLW
- Berth #2 (Western Side) 800+ ft long, -32 ft MLW

Intermodal Truck to Rail Facility

- Served by Montreal, Maine and Atlantic
- Over 6,500 ft of on-site rail siding interconnected with Canadian Pacific for double stack service to United States Midwest, central Canada, and Vancouver
- Double stack clearance
- Track Mobile to index and ship cars within the terminal

Storage Areas

- Outside Storage: 310,000 sq. ft (28,800 sq. m)
    - 7 pads
    - truck and rail loading racks
- Inside Storage: 101,000 sq. ft (9,400 sq. m)
    - 3 buildings, rail capable
- 70 plus acres for development
- 100 plus acres of additional industrial lay down area available with rail and road access within 1.5 mi of Searsport Terminal.

Equipment

- 2 Crawler Cranes 125T, 175T
- New High Capacity Mobile Harbor Crane: 120-140 ton

- Specialized trailers and heavy equipment transporters available
- Spreader bars
- Truck scales
- Lift trucks
- Specialized electrical hookup

People

- Full Service private stevedores
- 24 hour x 7 days x 365 days
- Multiple years heavy lift experience

6.2.2 Sears Island

Sears Island is owned by the State of Maine, with 330 acres (134 hectares) available for potential development directly adjacent to the terminal at Mack Point. The site includes:

- Causeway access to road
- Rail connections on the mainland
- Breakwater and dredged berth
- Direct access to the channel

6.2.3 Brewer, Eastern Manufacturing Facility

The Eastern Manufacturing facility is owned and operated by Cianbro Corporation. The facility is located on the Penobscot River: 36.25 miles (50 kilometers) from Searsport Terminal; one mile (1 mi) to the Interstate; half-mile (0.5 mi) to the Rail Terminal; and 5.4 miles to Bangor International Airport.

- 41 acres
- Administrative Space: 30,000 sq ft
- Warehousing space: 40,000 sq ft onsite 200,000 sq ft offsite.
- Engineered site for module, and large structure assembly with heavy haul road, and construction pad, 20,000 ton + capacity
- Bulkhead Capacity: 12,000 tons
- Pier/Moring Facilities: 122 m (400 ft) x 31 m (100 ft) x 5 m (16 ft) depth
- Mobile Cranes from 30 to 440 ton capacity
- Floating Crane capacity can be arranged per project requirements

6.2.4 Belfast

City Facilities: 13 ft draft, vessels up to 200 ft, 100 amp power. Channel dredged to 15 ft MLW and is home of Penobscot Bay Tractor Tug Company:

- FOURNIER TRACTOR is a 3,500 hp ASD tractor tug,
- MACK POINT is a 2,000 hp single screw tug with an 800 hp stern thruster
- CAPE ROSIER is a 1,800 hp single screw diesel electric tug.

6.2.5 Bucksport

The Webber pier is located in Bucksport on the Penobscot River and can accommodate vessels up to 700 ft length, 106 ft beam and a maximum draft of 35 ft (brackish) for docking at high water. At low water slack, the maximum draft is 28 ft (based on a 0 ft tide). The tide range in Bucksport is 11 ft. There are two bridges over the Penobscot River below Bucksport and the vertical clearance of the lower bridge is 135 ft.

6.2.6 Rockland Harbor

Rockland Harbor is near the mouth of Penobscot Bay and is protected by a breakwater. The harbor is approximately three (3) km diameter with depths at the center of the harbor at 20 m, five (5) m channels and commercial dockage MLW. Rockland Harbor provides commercial marine support services to the region.

- Prock (Full equipment and capabilities list with company profile)
    - Approximately three acres staging area
    - 200 ft of seawall wharf, 14 ft at low tide.
    - Room for temporary office trailers
- Available structures for interior storage and/or work
- Rockland Marine Corp. is a full service marine vessel repair yard with a marine railway able to carry vessels up to 60 m specializing in steel vessel repair and fabrication. Services include full machine shop, welding and fabricating, complete interior and exterior paint application, sandblasting and many other services.
- Access to rail through Maine Eastern Railroad: Bill Phillips 973-267-4300
- Marine Railway repair and new build yard for vessel up to 60 m

6.2.7 Other coastal support facilities

- Boothbay: Marine Railway repair and new build yard for vessels up to 60 m

- Bath: Drydock and full service repair and new build yard for vessels up to 250 m
- Portland: Drydock for vessels up to 55 m
    - Pier side repair for vessels up to 275 m

6.3 MARINE ASSEMBLY AREA

There is a marine and wet storage assembly area located approximately 0.9 nmi from Hewes Point, Islesboro Island that could be used as necessary. Consultation with Penobscot Bay Pilots was conducted prior to selection of this site. Shipping traffic can use the east passage of Penobscot Bay with no issue or impact.

- Assembly area assumed to be 500 m x 500 m
- Wet storage is assumed to be 1000 m x 1000 m in addition.
- 87.78 m MLW (288 ft)
- Duration of Use 40 days to 180 days
- Distance to Deployment Site 32 km (82 mi)
- Distance from Staging Site (Searsport) 10.5 km (7.6 mi)
- Distance from Eastern Manufacturing Facility, (Brewer) 60.5 km (37.6 mi)

6.4 COMMUNITY, SOCIAL, AND ENVIRONMENTAL PARTNERS

Island Institute is a partner in local community communication and relationship building.

Supporting the year-round island and working-waterfront communities of the GoM requires knowledge of many different topics. Over the past quarter-century, the Island Institute has collaborated with constituents on a wide variety of projects. While each project has included unique challenges, and each coastal community has its individual identity, the Institute has identified priorities to address needs shared by multiple communities.

The Island Institute has been paramount in the development of wind resources for local island communities. Past successes such as the Fox Island Wind Project have included a valuable partnership with the Institute.

The Island Institute will be an important partner in the social relations efforts related to any offshore development project.

6.5 LOCAL SERVICE PROVIDER CAPABILITIES

6.5.1 CIANBRO

Cianbro is an employee owned construction and fabrication company providing services throughout the United States serving a number of industries including energy, marine, civil and transportation. The 2,000 multi-skilled team members of Cianbro include qualified technicians in the following fields:

- Mechanical and Structural Trades
- Civil Trades
- Coatings Specialists
- Equipment Operators and Support
- Project Management, Engineering and Administrative Support Staff

Cianbro Eastern Manufacturing Facility Brewer
The facility is located on the Penobscot River: 36.25 miles (50 kilometers) from Searsport Terminal; one mile (1 mi) to the Interstate; half-mile (0.5 mi) to the Rail Terminal; 5.4 miles to Bangor International Airport.

Working and Storage Area

- 41 acres
- Administrative Space: 30,000 sq. ft
- Warehousing space: 40,000 sq. ft onsite; 200,000 offsite.
- Engineered site for module, and large structure assembly with heavy haul road, and construction pad; 20,000 ton + capacity

Pier and Waterfront Capacity

- Bulkhead Capacity: 12,000 tons
- Pier/Moring Facilities: 122 m (400 ft) x 31 m (100 ft) x 5 m (16 ft) depth
- Bulkhead/Barge Berth: 600 ft x 150 ft x 24 ft

Equipment

- Mobile Cranes from 30 to 440 ton capacity that can be used onsite Brewer or in Support operations at other locations.
- Turbine Installation:
- Manitowoc M18000 – 120 m Height; 60 Mt Capacity
- Manitowoc 1600 Series 3

- 400 tons @ 30 m; 46 tons @ 96 m
- With MAX-Er Attachment: 380 tons @ 42m; 67 tons @ 120m
- Cianbro cranes on barge
- Manitowoc M18000; 100 mt @ 91 m height above water
- Manitowoc 4100 – 222 mt @ 50 m height above water
- Additional cranes on barge can be arranged per project requirements using existing east coast resources
- 907 mt @ 64 m height above water
- 453 mt @ 60 m height above water
- Multi-wheeled transporter equipment available for use at the facility

Access to Vessels and specialized equipment, local labor with worldwide industrial partnerships:

- Existing relationships and access to United States Flag Vessels readily available on East Coast US – ABS classed ocean-going barge 76 m to 120 m Loa. Common sizes in New England area 45 m to 76 m range. Can be secured for scheduling purposes within a 3-month lead-time.
- Support Vessels
    - Area tug boat resources include several tractor tugs with 3000 to 6000 HP
        - Conventional Twin Screw tugboats are available throughout the area most in the 2500 to 4000 HP range.
    - Crew boats in the 32 m range are available in the area within 1 day mobilization
- Anchor Handling Capacity
    - Anchor handling can be completed on a small scale in a project area with available equipment. Large scale anchor handling with anchor handling boats in the 60 to 80 m range will most likely require the mobilization of a United States flag AHTS vessel from the Gulf of Mexico.
    - Area companies are willing and committed to developing these capabilities or relocating boats and trained personnel to support large scale operations

Fabrication Capabilities

- Coating Capabilities with Sophisticated Paint Endorsements SPE P2

- Steel Fabrication through two facilities both AISC, ASME certified
- CNC Equipment, 3D Modeling
- Pipe Fabrication and Coating
- 250+ Pipe Fabricators/Welders
- Application of New Technology
    - 3D Laser Scanning and Surveying,
    - 3D Work Packaging and Construction Sequencing.
    - PMI – Positive Materials Identification and Tracking
    - Electronic Crane Setup and Rigging Planning
    - Automated Pipe and Preparation Welding

Qualified Processes and Certifications

- Top 100 United States Equipment Owner
- QU/QC Program Based on ISO 9001
- Quality Workforce and Systems
- ASME Certifications – U, S
- AISC Certifications – STD, SBR, CBR
- SSPC Certifications – QP-1 and QP-2
- CWI/NACE QA/QC Inspectors
- ABS/DNV/Lloyds Class Compliant

Compatible Management Philosophies

- Safety
    - American College of Occupational and Environmental Medicine (ACOEM) – Healthiest and Safest Company in America
    - Wellness Council of America (WELCOA) Wellness Program Best in the United States
    - 2008 Gold S.T.E.P. Award
    - 2008 ABC Best of the Best Safety Award
    - 2008 OSHA Safety and Health Achievement Program (SHARP) Safety Award

- 2009 Wellness Council of America – Platinum Award
- Quality and Production Efficiency
  - BC Contractor of the Year
  - ABC Excellence in Construction Award
  - Washington Building Congress Craftsmanship Award
  - American Society of Civil Engineers Outstanding Civil Engineering Achievement Award
  - American Council of Engineering Companies Engineering Excellence Award.
  - ABC Build American Award
- Schedule Reliability
  - Motiva Oil Refinery
    - One of three (3) chosen companies from a field of 30 worldwide competitors.
    - Produced and delivered under budget and under time.

6.5.2 GENERAL DYNAMICS Bath Iron Works

Shore support facilities
Bath Iron Works has approximately 25 acres available for working and staging.

Pier facilities

- Pier 4, 800 ft, 55 ft draft
- Pier 3N, 626 ft, 38 ft draft
- Pier 2N, 405 ft, 25 ft draft
- Pier 1S, 573 ft 32 ft draft

Working Facilities

- Blast and paint, three (3) buildings: 8,800 sq ft, 19,000 sq ft, 14,300 sq ft
- Calibration Laboratory: 640 sq ft
- Carpenter Shop: 14,280 sq ft
- Electrical: 5,929 sq ft
- Fabrication: 233,000 sq ft
- Industrial: 22,000 sq ft

- Machine Shop: 52,224 sq ft
- Mold Loft: 67,500 sq ft
- Office Space: 241,644 sq ft
- Paint: 5,000 sq ft
- Pipe: 42,148 sq ft
- Plate: 42148 sq ft
- Sheet Metal: 34,320 sq ft
- Sub-Assembly: 255,950 sq ft
- Ultra Hall: 66,804 sq ft
- Warehouse: 160,000

Floating Drydock

- Length: 750 ft
- Maximum Depth over Blocks: 42 ft
- Width: 140 ft
- Lift Capacity: 28,000 LT

Cranes: all on site, no offshore capability

- Bridge, 100 T
- Level Luffing: 300 T
- Level Luffing: 220 T
- Level Luffing: 50 T
- Level Luffing: 25 T
- Level Luffing: 25 T
- Level Luffing: 90 T
- Level Luffing: 60 T
- Level Luffing: 150 T
- Level Luffing: 300 T
- Mobile: 300 T
- Mobile: 100 T

Barges and Support Vessels: Provided by Winslow Marine (See Support Services)

6.5.3

Equipment list

- Cranes 2 – 440 tons, 97 m
    - 25 additional support cranes up to 250 ton capacity
- Barges
    - 5 barges capable of handling smaller capacity cranes
    - Barges available for lease for the 440 ton, readily available with limited lead time
- Support Vessels
    - 2 – 600 HP push boats
- Shore support facilities
- Dock yard facility 145 x 170 ft concrete pier 20 ft deep, Kennebec River, Woolwich
- 2 – Launching weights – 500 ton each
- Experienced with installing larger diameter pipelines in open ocean

6.5.4

Equipment list

- Cranes
    - 518 Linkbelt, 418 Linkbelt, 110 and 150 ton capacities.
    - 12 additional Cranes available for support less than 100 tons
- Barges
    - Three 48 ft x 140 ft crane barges capable of carrying 120 ton/37 m or 150 ton/46 m cranes.
- Support Vessels
    - Tugs, 2-twin screw 1000 HP, 1-single screw 650 HP, 1-300 HP push
    - 42 ft crew boat, 20 person capacity
- Resources and availability of additional equipment (rental)
    - Baldwin Crane & Equipment Corp. Availability usually within 2-3 months

        - Crawler cranes up to 500-ton: Manitowoc 888s, 999s and 2250s with heavy lift and extension attachments available.
    - Hughes Barges, for use with larger cranes, Readily available with short lead times.
- Shore support facilities
    - Approximately three (3) acres staging area
    - 200 ft of seawall wharf, 14 ft at low tide
    - Room for temporary office trailers
- Experienced as contractor with installation of USGC Buoys and offshore equipment
- Experienced with installation of submarine cables and pipelines

6.6 ADDITIONAL CRANE SOURCES AND AVAILABILITY

- Baldwin Crane & Equipment Corp. Availability usually within 2-3 months
    - Crawler cranes up to 500-ton: Manitowoc 888s, 999s and 2250s with heavy lift and extension attachments available.
- WH Green & Sons, Augusta, Maine
    - 22.5 ton – 450 ton Cranes, Max lift 105 m (5 tons at max extension)
        - Access to 500 ton capacity cranes through industry partnerships with two (2) month expected lead times.
- Marino Crane, Middletown, CT (Division of Barnhart, wind experience)
    - 11 crawler cranes from 100-300 ton capacity maximum 90 m

6.6.1 Additional Barge, Vessel and Tug Sources and Availability

- Penobscot Bay Tractor Tug Company, Belfast Maine:
    - FOURNIER TRACTOR is a 3,500 HP ASD tractor tug,
    - MACK POINT is a 2,000 HP single screw tug with an 800 HP stern thruster
    - CAPE ROSIER is a 1,800 HP single screw diesel electric tug.
- Winslow Marine, Falmouth Maine,
    - Tugs: Alice Winslow: twin screw, 3500 HP; Peggy Winslow, twin screw 2000HP; Patricia Winslow, twin screw 2000 HP; Charles Winslow, twin screw 800 HP; Elliott Winslow, single screw 2500 HP, Margery Winslow, single screw 1750 HP; 26 ft push boat 300 HP

- Barges: Deck Barge, 150 X 54 X 10 ft, 2000 lb/sq ft; Crane Barge, 130 X 50 X 10 ft; Material/Crane Barge, 110 X 42 X 9 ft; Deck Barge, 60 X 30 X 4 ft; Deck Barge, 50 X 30 X 4 ft

- Hughes Barges, Edison, NJ. Capable of carrying larger cranes, readily available with short lead times.
- Atlantic Towing Limited, St. John, NB
  - Barge Charter
  - Coastal Towage
  - Deep Sea Anchor Handling
  - Offshore Support

6.6.2 Special Requirement Vessels and Equipment

Anchor Hauling, Mooring installation
Limited mooring equipment may be installed using local contractors with existing equipment. However, larger permanent moorings for the offshore platforms will require support form vessels from the United States Gulf Coast, or Atlantic Canada. Local companies are willing to obtain and operate such equipment when the market demand for these types of services matures with further development.

Mooring systems
- Yale Cordage
  - Capable of designing and manufacturing synthetic mooring system/pennant for offshore wind installation.
  - Provider of deep sea synthetic mooring pennant systems to NOAA, Woods Hole and other clients for accurate placement of offshore weather buoys in waters as deep as 2,000 m for periods exceeding three (3) years. Systems installed by SAIC Contractors.
  - Experience in designing mooring systems for offshore oil.

7.0 Economics and Policy

7.1 MAINE PUBLIC UTILITIES COMMISSION REQUEST FOR PROPOSALS

The following discussion relates to the current Request for Proposals (RFP) that was posted September 1, 2010 and has a response date of May 1, 2010. The text, where applicable, was taken directly from the public documents discussing the RFP and actual government documents are included as attachments.

During its second regular session (2010), the 124th Maine Legislature enacted ***An Act To Implement the Recommendations of the Governor's Ocean Energy Task Force*** (Act). P.L. 2009, ch. 615. (See Appendix E.1) Section A-6 of the Act directs the Maine Public Utilities Commission (PUC), in accordance with the Maine Revised Statutes, Title35-A, section 3210-C, to conduct a competitive solicitation for proposals for long-term contracts to supply installed capacity and associated renewable energy and renewable energy credits (RECs) from one or more deep-water offshore wind energy pilot projects or tidal energy demonstration projects. The Act requires the Commission to initiate the solicitation by September 1, 2010.

The PUC issued the above referenced RFP on September 1, 2010. The complete RFP is included as Appendix E.2. The RFP is very prescriptive in its requirements. Initial proposals responding to the RFP are due to the PUC by May 1, 2010.

The documents included in this report corresponding to the RFP are included for reference only. Parties interested in responding to the RFP are encouraged to visit the PUC internet site at

http://www.maine.gov/mpuc/electricity/rfps/standard_offer/deepwater2010/

All inquiries about the RFP should directed to the PUC contact:

Mitchell Tannenbaum
mitchell.tannenbaum@maine.gov
Phone: (207) 287-1391
Fax: (207) 287-1039

Additional information regarding the RFP has subsequently been posted to the PUC site and includes:

- Rate Impact Limitation (Added 09/16/10) (see Appendix E.3)
- Experience Requirement-Supplemental Explanation (Added 12/03/10) (see Appendix E.4)
- Proposal Security Deposits will be held by the utility that bidder proposes as the long-term contract counterparty (Contact Information & Detail on Security Deposit Process- see Appendix E.5)

7.1.1 Basic Requirements of RFP and Subsequent Power Purchase Contract

For purposes of the RFP, "deep-water offshore wind energy pilot project" means a wind energy development that is connected to the electrical transmission system located in the State and employs one or more floating wind energy turbines in the Gulf of Maine at a location 300 feet or greater in water depth no less than ten (10) nautical miles from any land area of the State other than coastal wetlands or an uninhabited island.

As specified in the RFP, the PUC may authorize one or more long-term contracts for an aggregate total of no more than 30 Megawatts (MW) of installed capacity and associated renewable energy and RECs from deep-water offshore wind energy pilot projects or tidal energy demonstration projects as long as no more than 5 MW of the total is supplied by tidal energy demonstration projects.

Proposal qualification, evaluation and acceptance or rejection will be determined by the PUC consistent with applicable laws and rules, the provisions of the RFP, and the PUC's statutory public interest obligations. In making its determinations, the PUC will consult with other state entities, which may include Maine's transmission and distribution utilities, Office of Public Advocate (OPA), Department of Environmental Protection (DEP), State Planning Office (SPO), Department of Economic and Community Development (DECD), and the University of Maine (UMaine). To the extent that proposals contain confidential or proprietary information, they will be provided to other entities subject to protective order.

The PUC may accept or reject any proposal, or it may reject all proposals, based on its assessment of the proposals, including but not limited to, (1) whether a proposal meets the requirements of the RFP; (2) satisfies the policies and objectives of the Act; (3) is within the contracting authority of the PUC; and (4) conforms with generally accepted business practices. As noted above, the PUC cannot authorize proposals that in the aggregate would exceed 30 MW of installed capacity. There is no minimum or required level of installed capacity. However, a condition of the RFP is that applicants' proposals include a long-term plans to install capacity of 100 MW.

7.1.2 Price Mitigation and Rate Impact Limitation

As provided in the Act and the RFP, the long-term power contract that results from this process allows for the utilities to purchase the power output from the offshore energy projects at above market costs. As provided in Section 2.2 of the RFP, the PUC may not approve any long-term contract pursuant to the RFP that would result in an increase in electric rates in any customer class that is greater than the amount of the assessment charged under Title 35-A, section 10110, subsection 4 at the time that the contract is entered. The amount of the assessment under section 10110, subsection 4 is fixed at a rate of $1.45 per megawatt-hour.

For purposes of estimating the total limit on rate impacts resulting from any above-market costs associated with long-term contracts awarded pursuant to this RFP, the PUC has interpreted this provision to mean that only distribution level customers of the transmission and distribution (T&D) utilities (Central Maine Power, Bangor Hydro Electric and Maine Public Service) may have a rate impact up to 0.145 cent/kWh.

Recall that the PUC may approve multiple projects and the amount of funds available to purchase power from these projects would be distributed across the output from multiple projects and thus would effect the price per kilowatt hour accordingly. Per the Act and the RFP, the funds may be used to purchase power from the maximum or aggregate installed power generating capacity of 30 MW of which no more than 5 MW can be tidal power.

Finally, it is important to note that the May 1, 2010 response date is described as an "initial response". In personal interviews with PUC staff member Mitchell Tannenbaum, the PUC expects the process to be iterative, recognizing the long lead time for site identification and permitting. The RPF requires the project to be generating within five (5) years of power purchase contract completion. All potential applicants are strongly urged to meet with the PUC prior to proposal submission.

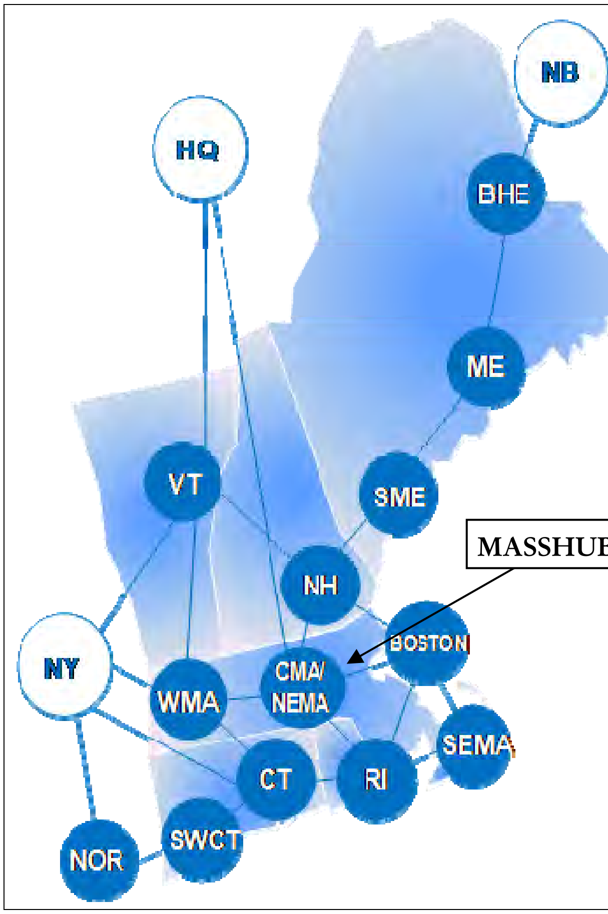
7.2 OVERVIEW OF NEW ENGLAND ENERGY MARKETS

7.2.1 Market Overview

Northeast Power Markets

The Northeast power market footprint is comprised of several different balancing authorities located in the United States and Canada. The Northeast market is generally defined to include ISO – New England (ISO-NE), New York ISO (NYISO), Ontario Independent System Operator (IESO), Hydro Quebec, and the Maritimes.[88] These interconnected balancing authority control areas are connected by an expansive transmission system that allows for the transfer of power between regions.

Figure 7-1 depicts the geographic footprint of the ISO-NE. Each circle represents a load zone that is limited by transmission constraint. The ISO-NE administers a nodal market, which clears a locational marginal price (LMP) at each node on the transmission network. Each load zone represents an aggregation of all the nodes located in the load zone and may have hundreds of nodes.



Subarea Designation	Region or State
BHE	Northeastern Maine
ME	Western and Central Maine/ Saco Valley, New Hampshire
SME	Southeastern Maine
NH	Northern, eastern, and central New Hampshire/eastern Vermont and southwestern Maine
VT	Vermont/southwestern New Hampshire
BOSTON	Greater Boston, including the North Shore
CMA/NEMA	Central Massachusetts/ Northeastern Massachusetts
WMA	Western Massachusetts
SEMA	Southeastern Massachusetts/ Newport, Rhode Island
RI	Rhode Island/bordering Massachusetts
CT	Northern and Eastern Connecticut
SWCT	Southwestern Connecticut
NOR	Norwalk/Stamford, Connecticut
NB, HQ, and NY	New Brunswick (Maritimes), Hydro-Québec, and New York external balancing authority areas

Figure 7-1: ISO - New England Geographic Footprint (Source: ISO-NE)

[88] In addition, the Northern Maine Independent System Administrator (NMISA) is responsible for the administration of the northern Maine transmission system and electric power markets in Aroostook and Washington counties, with a load of approximately 130 MW.

ISO – New England Market Outlook

New England's bulk electric power system is designed and operated to meet reliably the electricity needs of the region in accordance with established industry criteria. The system is comprised of more than 8,000 miles of high voltage transmission lines and several hundred generating facilities, of which more than 300 units are under the direct control of ISO NE.

There are also several interconnecting transmission lines to bulk power transmission systems in New York and the Canadian provinces of Quebec and New Brunswick. The interconnections with neighboring systems allow for the transfer of electricity between regional power systems. These interconnections are used for reliability purposes as well as for the economy sales and purchases of electricity between regions.

The ISO-NE power market is currently experiencing a surplus of generating resource that has been exacerbated by decreased power demand caused by current downturn in the United States economy. The supply curve in Figure 7-2 illustrates the surplus in resources that the ISO-NE is currently experiencing. While Black & Veatch forecasts the 2011 summer peak load to be around 27,000 MW there are approximately 35,000 MW of resources available to meet the peak load. The installed capacity requirement (ICR) determined by ISO-NE is about 32,000 MW which means that there is still about 3,000 MW of excess capacity on the ISO-NE system.

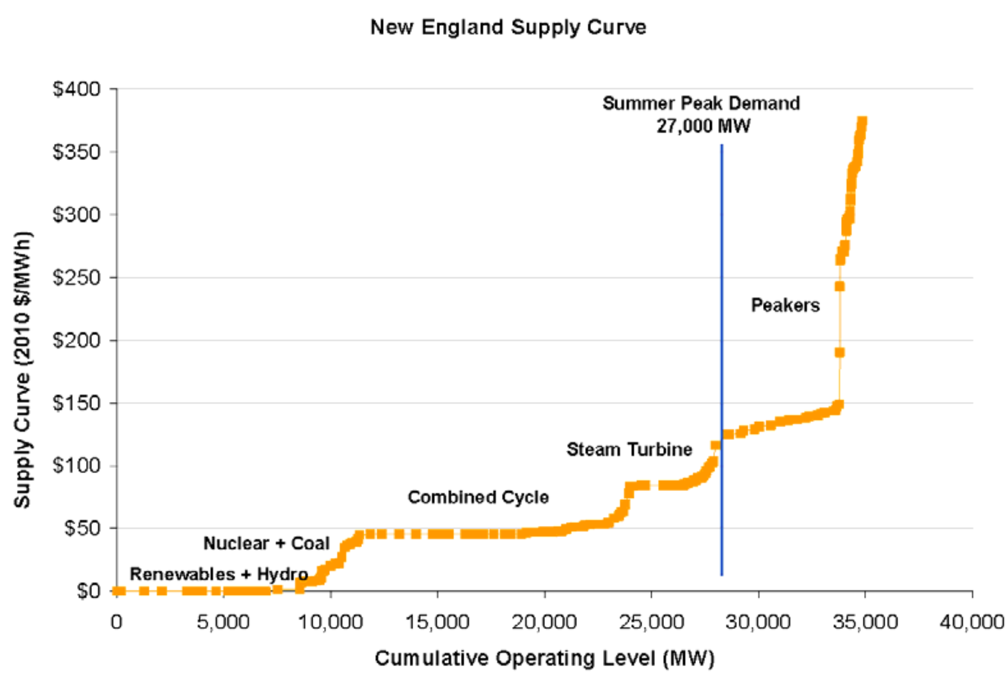


Figure 7-2: ISO-New England 2011 Supply Curve (Source: Black & Veatch)

As a result of the surplus capacity on the system Black & Veatch predicts that very few thermal generating resources will be built in the next ten years. Instead, most new units will be renewable resources built to meet state level Renewable Portfolio Standards (RPS).

The resource capacity mix in New England is made up of approximately 60% (percent) natural gas resources, which makes natural gas the marginal fuel during on peak demand periods. During off peak hours other fuels such as hydro, coal, nuclear, and hydro imports from Quebec are the marginal fuel. Figure 7-3 is a side-by-side comparison of the installed capacity mix in ISO-NE broken out by fuel in 2011 and the forecasted resource mix in 2035.[89]

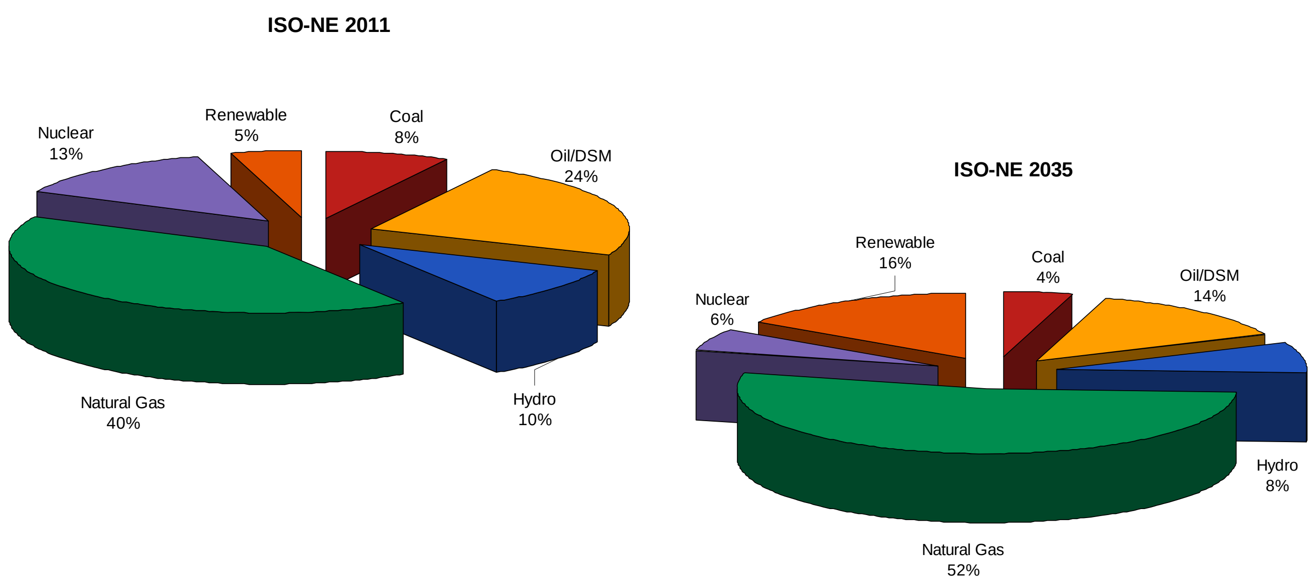


Figure 7-3: ISO -New England 2011 and 2035 Capacity Mix by Fuel (Source: Black & Veatch)

Approximately 40% (percent) of the capacity in Maine today uses natural gas, and Maine is a net exporter of power to the rest of the ISO-NE. The State of Maine has an abundant wind resource, and in the EMP Base Case Black & Veatch assumes that this resource will be extensively developed in the future, and much of this will be exported

[89] Except where otherwise noted, forecasts in this report are drawn from the Fall 2010 Black & Veatch Northeast Energy Market Perspective ("EMP"), discussed in more detail in Section 5.1.

to neighboring states.[90] Black & Veatch forecasts the mix of renewable capacity to grow from 16% (percent) in 2011 to 57% (percent) in 2035. Figure 7-4 illustrates the relative growth of all resource types in Maine over the next 25 years as compared with current values.

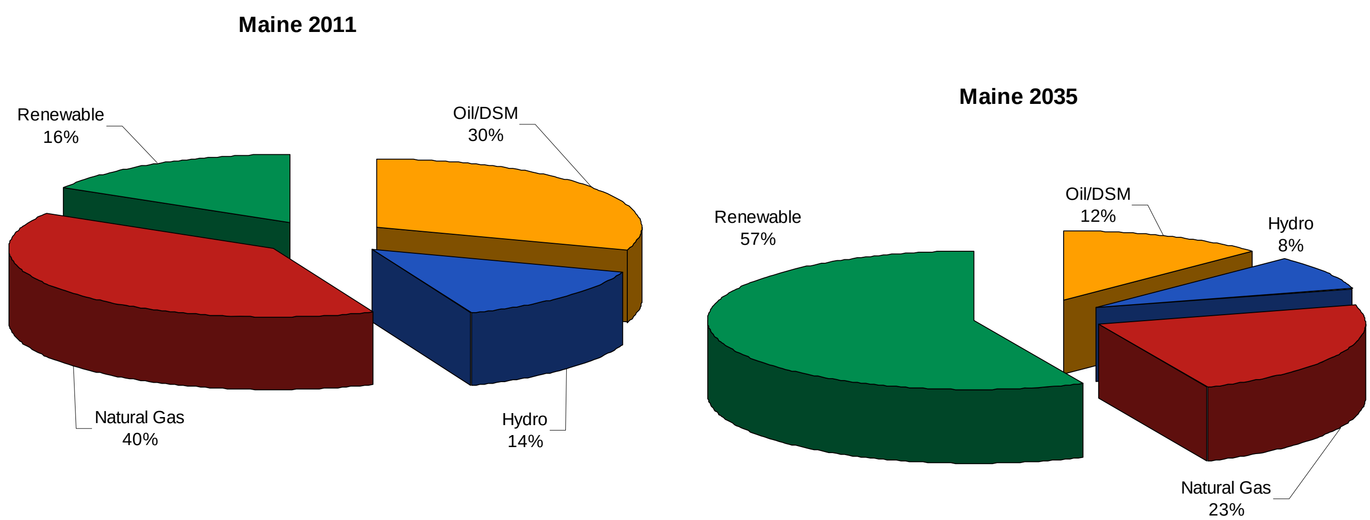


Figure 7-4: Maine 2011 and 2035 Capacity Mix by Fuel (Source: Black & Veatch)

Except for instances where transmission limits the flow of power within the ISO-NE electricity grid, power generally flows from north to south in New England, towards the load centers in Massachusetts and Connecticut. Electricity prices are typically lower in Maine compared to the rest of the ISO-NE due to lower cost resources and proximity to Canada.

Figure 7-5 shows a picture depicting an example of the price differential between Maine and the rest of the states in New England. In addition to having lower annual

[90] For example, see "Report of the Governor's Task Force on Wind Power Development: Finding Common Ground For a Common Purpose," February 2008, page 5, which called for the development of 3,000 MW of wind in Maine by 2020, including 300 MW offshore.

electricity prices, the State of Maine also has much higher renewable resource potential compared to states such as Connecticut and Massachusetts.

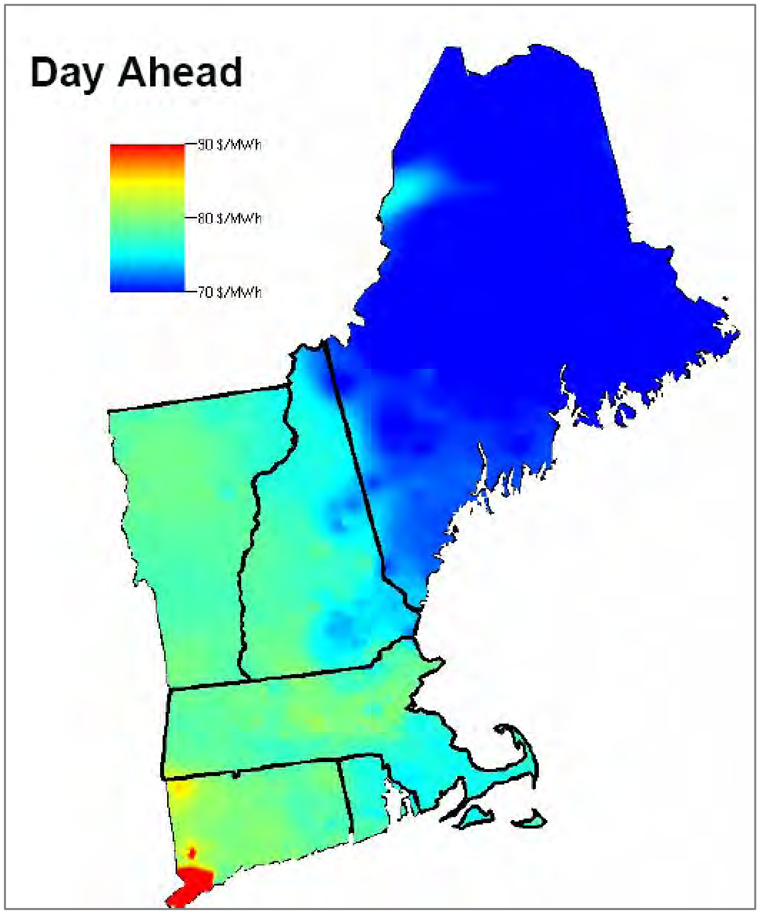


Figure 7-5: ISO-New England Electricity Price Map (Source: ISO-NE)

Figure 7-6 shows the generation dispatch from the Black & Veatch Energy Market Perspective. In 2011, natural gas is forecasted to account for about 46% (percent) of the total generation, by 2035 the percentage of natural gas increases to about 58% (percent). In that same period the amount of renewable generation is forecasted to more than double from nine percent (9%) to around 16% (percent) of the resource mix.

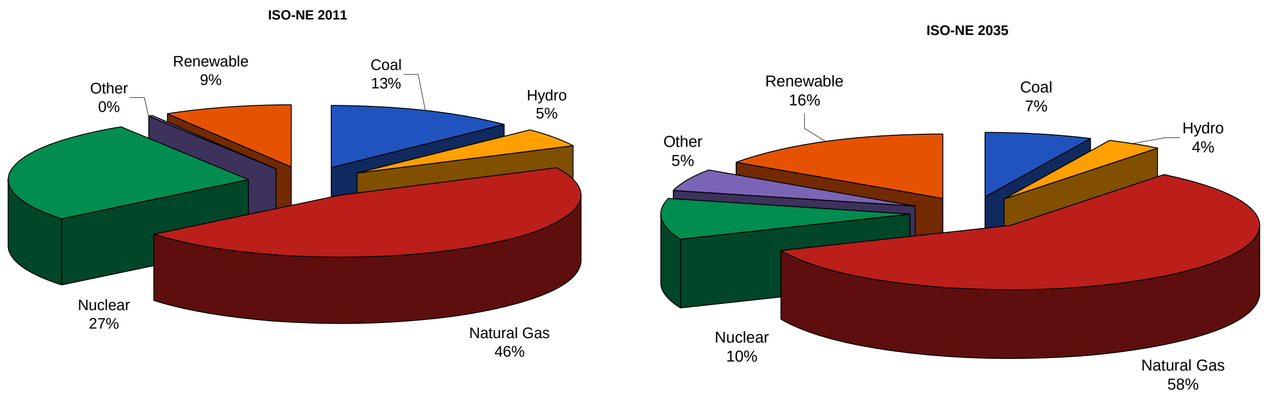


Figure 7-6: ISO-New England 2011 and 2035 Generation Mix by Fuel (Source: Black & Veatch)

The generation mix in ISO-NE over the next 20 years will also be affected by aggressive plans to build additional transmission from Quebec to Northeast markets, which will allow more hydro and renewable generation to flow from eastern Canada into ISO-NE.

Electricity Consumption

The New England region has not been immune to the effects of the recession. In addition to reduced electricity consumption caused by the recession market participants in the New England electricity market have invested heavily in demand response, energy efficiency, and smart grid. Regional Energy Efficiency (EE) initiatives will have a profound effect on load growth over the next decade.

The net impact of DSM/EE and smart grid investments has been incorporated into the demand forecasts that Black & Veatch has compiled from load serving entities and uses as the basis for the EMP long-term power demand view. The long-term energy forecast demand is expected to be around one percent (1.0%) in ISO-NE over the 25-year study period. Table 7-1 summarizes the ISO-NE historical and weather normalized forecasted demand from 2000 to 2030.

Table 7-1: ISO-New England Historical and Weather Normalized Forecasted Demand (Source: Black & Veatch)

Forecast Period	Year	ISO - NE			
		Peak (MW)	Energy (GWh)	Peak %	Energy %
Historical	2000	21,919	124,885		
	2001	24,967	125,976	13.9%	0.9%
	2002	25,348	127,455	1.5%	1.2%
	2003	24,685	130,776	-2.6%	2.6%
	2004	24,116	132,517	-2.3%	1.3%
	2005	26,885	136,355	11.5%	2.9%
	2006	28,130	132,087	4.6%	-3.1%
	2007	26,145	134,466	-7.1%	1.8%
	2008	26,111	131,743	-0.1%	-2.0%
	2009	25,081	126,842	-3.9%	-3.7%
Forecast	2010	27,121	131,302	8.1%	3.5%
	2011	27,591	132,372	1.7%	0.8%
	2012	28,099	134,006	1.8%	1.2%
	2013	28,497	134,658	1.4%	0.5%
	2014	28,960	136,064	1.6%	1.0%
	2015	29,379	137,287	1.4%	0.9%
	2016	29,709	138,504	1.1%	0.9%
	2017	30,038	139,823	1.1%	1.0%
	2018	30,355	141,191	1.1%	1.0%
	2019	30,657	142,541	1.0%	1.0%
	2020	30,878	143,916	0.7%	1.0%
	2021	31,100	145,303	0.7%	1.0%
	2022	31,325	146,706	0.7%	1.0%
	2023	31,553	148,123	0.7%	1.0%
	2024	31,784	149,553	0.7%	1.0%
	2025	32,017	150,997	0.7%	1.0%
	2026	32,249	152,455	0.7%	1.0%
	2027	32,484	153,928	0.7%	1.0%
	2028	32,721	155,415	0.7%	1.0%
	2029	32,959	156,906	0.7%	1.0%
	2030	33,196	158,414	0.7%	1.0%

7.2.2 Energy and Capacity Markets

ISO – New England Electricity Market

The ISO-NE operates a wholesale electricity market utilizing locational marginal pricing (LMP) to manage transmission congestion. LMP is a market-pricing approach used to manage the efficient use of the transmission system when congestion occurs on the bulk power grid as calculated at three types of locations: the node, the load zone and the hub. LMP includes the cost of supplying the more expensive electricity in those locations, thus providing a precise, market-based method for pricing energy that includes the "cost of congestion." Offers and bids are submitted, markets settle, and LMPs are calculated at these locations. While there are approximately 900 pricing nodes in the ISO-NE market, the Black & Veatch representation of the ISO-NE electricity market is aggregated into nine distinct load zones, which provide sufficient detail to capture long term regional transmission congestion issues.

The ISO-NE energy market has two different settlement periods: Day-Ahead and Real-Time. The day-ahead energy market clears energy supply bids against forecasted demand in the day ahead of delivery. The real time market clears energy supply bids every against actual demand every five minutes to true-up supply and demand imbalances. The hourly real time price is calculated by using a load-weighted average of the five-minute LMP prices.

ISO – New England Forward Capacity Market

The ISO-NE Forward Capacity Market (FCM) allows LSEs to procure capacity three years in advance of delivery. Existing generators in New England are automatically included in the FCM unless a de-list bid is submitted to the ISO-NE. The FCM uses a downward descending clock auction format to clear enough capacity to meet forecasted capacity requirements needed to meet reliability requirements. Existing generators act as price takers in the FCM and the clearing price is set by new generators based upon the cost of new entry (CONE) of a peaking gas unit. The FCM is structured so that the CONE will reflect the true long run costs of an efficient resource over time. The ISO-NE also employs the use of peak energy rents (PER) to limit the amount of market power that can be exerted in the energy market.

Table 7-2 shows the capacity supply obligation (CSO) prices[91] for the Rest of Pool zone in ISO-NE from the first four FCM auctions, as well as during the three-year transition period that preceded the first auction, for which the prices were set administratively. Capacity prices from the first four (4) cleared auctions cleared at the administrative floor price due to an oversupply of capacity and have not experienced price separation into different capacity clearing zones.

[91] The capacity supply obligation price is adjusted from the capacity clearing price to account for the clearing of excess supply in the FCA.

Table 7-2: ISO-NE (Rest of Pool) Cleared Forward Capacity Market Prices (Source: ISO-NE)

FORWARD CAPACITY AUCTION	START DATE	END DATE	CAPACITY SUPPLY OBLIGATION (CSO) [$/kW-mn]
Transition Period	June 1, 2007	May 31, 2008	$3.05 USD
	June 1, 2008	May 31, 2009	$3.75 USD
	June 1, 2009	May 31, 2010	$4.10 USD
1st Auction	June 1, 2010	May 31, 2011	$4.50 USD
2nd Auction	June 1, 2011	May 31, 2012	$3.12 USD
3rd Auction	June 1, 2012	May 31, 2013	$2.54 USD
4th Auction	June 1, 2013	May 31, 2014	$2.52 USD

*United States Dollar (USD)

The surplus of capacity is caused by a combination of reduced electricity consumption caused by the economic downturn and the presence of "out of market" OOM resources. Current market rules allow for OOM resources to bid below costs into the auction.

Black & Veatch's approach to forecasting the capacity prices in the ISO-NE is to examine the profitability of a new combined cycle plant in New England. Black & Veatch believes that combined cycle plants may be more valuable in the ISO-NE market because of the uniform capacity price auction structure. Combined cycles will get paid the same capacity payment as a lower capital cost peaking gas turbine, but have the potential to earn significantly higher levels of energy revenue. In order for a new combined cycle unit to economically enter the market the combination of energy, ancillary, and capacity prices needs to be sufficient to cover the long run fixed and amortized capital investment costs of a new combined cycle unit.

Capacity prices are volatile in nature because they are based upon a delicate balance between supply and demand. In a capacity overbuild environment such as the current ISO-NE market today, capacity prices tend to be relatively depressed because new capacity is not required. The amount of capacity a generator can count as dependable for the sale of capacity is determined by the Seasonal Claimed Capability (SCC) rating of each unit. The SCC is used to determine how much capacity can be counted on during the peak hours during the summer and winter seasons. The same SCC is also used to determine how much each generator may receive in terms of capacity payments.

There are three different methods used to determine SCC for generators participating in the ISO-NE market.

Method 1: Twice a Year Audit Obligation
Non-Intermittent generator assets that are not net-metered are required to audit twice a year, once during the summer demonstration period (June 1 through September 15) and once during the winter demonstration period (November 1 through April 15).

Method 2: Average of Monthly Hydrology Ratings
Non-Intermittent daily cycle hydro generator asset's SCC-S is calculated from the average of the four summer monthly ratings (June - Sept.) and the SCC-W is calculated using the average of the eight winter monthly ratings (October – May). These monthly SCC ratings are the lower of the 20-year hydrology study or what is claimed on the respective registration form.

Method 3: Median Reliability Hours Calculation
The SCC of Intermittent Power Resources generator assets will be determined using the median of net output from the most recently completed Summer Capability and Winter Capability Periods across the Summer (HE 14 - 18) and Winter (HE 18 - 19) Intermittent Reliability Hours, respectively.[92]

Method 1 will generally apply to thermal units burning natural gas, coal, or oil. Method 2 will apply to hydro units and Method 3 will apply to intermittent resource such as wind and solar.

7.2.3 Transmission

Transmissions Capability
ISO-NE is interconnected to Hydro Quebec, New Brunswick, and New York. While ISO-NE can import a maximum of 4,100 MW from these interconnections, the ability to transfer up to the full import capability is very dependent on transmission line loading levels, power transfers across internal and external transmission interfaces and generation dispatch.

Table 7-3 shows the current import capability from existing interfaces to ISO-NE today. As future transmission projects are built, the import capability should increase over time.

[92] Source: ISO-NE Website, "Seasonal Claimed Capability (SCC) Report - November 2010."

Table 7-3: ISO-New England Import Capability (Source: ISO-NE)

INTERFACE	MAXIMUM TRANSFER CAPACITY
Hydro-Québec (Phase 2 HVDC)	1,400 MW
Hydro-Québec (Highgate)	200 MW
New Brunswick	1,000 MW
New York	1,500 MW
Total Import Capability	**4,100 MW**

The New Brunswick transmission interface allows for up to 1,000 MW of import capability into Maine. During the peak load the New Brunswick interface is constrained by 350 MW, allowing only 650 MW of power to be imported in Maine due to transmission limitations. Factoring other transmission limitations and reliability requirements, the total import capability that ISO-NE can count on is approximately 2,400 MW.

Transmission Projects

Over the past several years the ISO-NE has taken an aggressive approach to strengthening the transmission system by approving and building many new major transmission projects (Figure 7-7). The cost of transmission is currently socialized amongst ISO-NE market participants; that is, all participants pay the same price for a given level of service. Over the past several years congestion on the transmission system has been minimal and therefore has led to smaller price differentials between loads zones.

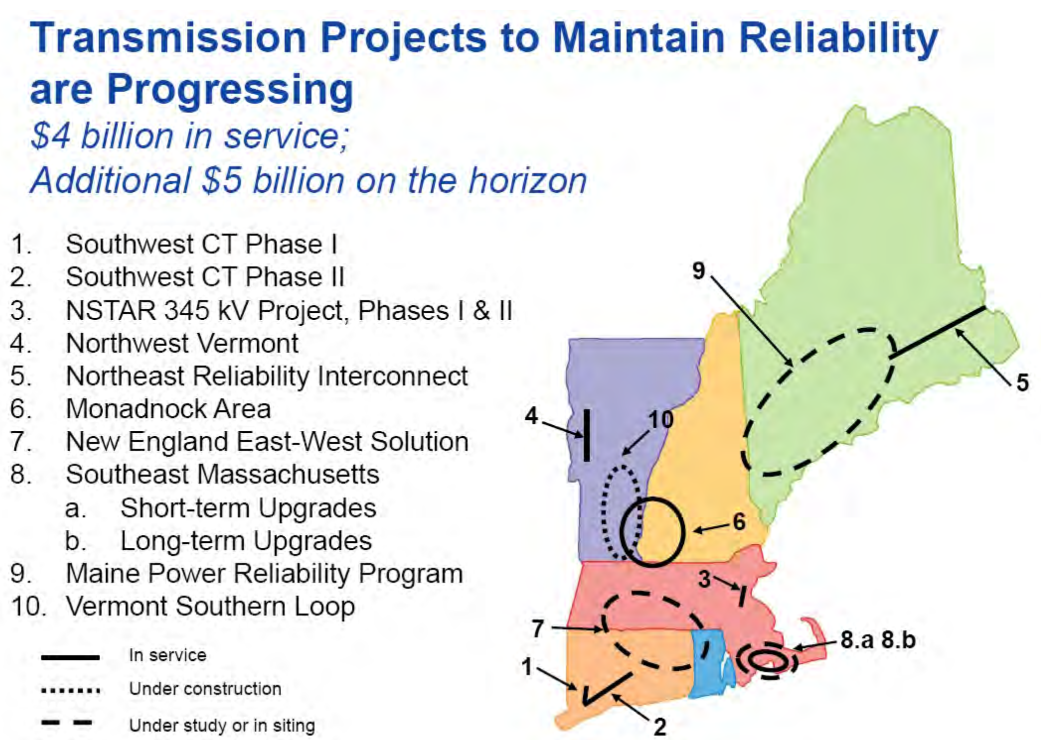


Figure 7-7: New England Transmission Projects

Of importance in Maine are the Northeast Reliability Interconnect (NRI) and the Maine Power Reliability Program (MPRP). The NRI transmission project was completed in 2007 and created a second interconnection to New Brunswick allowing up to 1,000 MW of power to be imported into Maine. The MPRP transmission project is currently undergoing construction and will solve the transmission issues in southern Maine but more importantly will allow for stronger transmission capability into New Hampshire. The MPRP project is estimated to be completed in 2013 and will allow about 1,500 MW of power to be exported from Maine into New Hampshire. The completion of the MPRP should allow for additional renewable projects to be developed in Maine and for the power to be exported out of Maine.

Renewable Energy Transmission

Compared to some other parts of the United States, the majority of the New England states with the exception of Maine are not particularly rich in renewable resource potential. Although high population states such as Connecticut and Massachusetts have established renewable portfolio standards (RPS), these states will have trouble meeting those goals with resources located in state. To solve this problem NSTAR and Northeast utilities have teamed up to build a proposed 1,200 MW high voltage direct current (HVDC) transmission line from Quebec to New Hampshire as a renewable energy highway to import renewable resources developed in Quebec into the ISO-NE. To date this project, currently called the Northern Pass Transmission line, has received preliminary approvals and is forecasted to start construction in 2013 and be completed in 2015. Black & Veatch has assumed the Northern Pass line will be completed and will be operational in 2017 to meet the renewable goals of the New England states.

Wind Integration

The ISO-NE system today only has about 200 MW of wind to integrate into the system, which currently does not pose any significant operational or reliability issues. Over time, Black & Veatch forecasts that over 4,000 MW of wind will be built and will need to be integrated into the system. While it is unlikely that all the wind plants across New England will collectively start or stop producing energy at any one moment, anecdotal evidence of significant wind penetration amounts has raised concerns that large amounts of wind can create significant reliability problems due to the intermittency of the resource. The New England Wind Integration Study (NEWIS) commissioned by ISO-NE examined the issue of integrating large amounts of wind resources and came up with the following high level observations:[93]

- Large-scale wind integration is achievable under certain conditions
- Wind resources would reduce fossil-fueled generation as an energy resource in New England
- Region needs to maintain a flexible system
- Regulation and operating reserve requirements would increase
- Major transmission expansion would be required
- ISO would need to develop wind power forecasting capability
- Technical requirements for wind interconnections must be implemented

The conclusions from the NEWIS study are similar to conclusions of other wind integration studies perform by the California ISO and NYISO. It appears that with sufficient transmission planning, flexible generation, and accurate wind forecasting services large amounts of wind can be reliably integrated into the ISO-NE system.

7.2.4 Renewable Portfolio Standards

New England Renewable Portfolio Standards

All but one of the New England states (Vermont) has embraced some type of renewable portfolio standard (RPS) with mandatory targets. The mandatory targets are tied to retail electricity sales for each state and typically increases at a rate of one

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[93] New England Wind Integration Study, November 2010.

percent (1%) or higher per year. The RPS targets vary from state to state, with many states creating multiple "classes" of renewable energy targets to accommodate new generation, existing generation, solar, and energy efficiency.

As an alternative to procuring renewable power, entities can make Alternative Compliance Payments (ACP). These payments are typically $55 – $60 USD per Megawatt-hour (MWh), and may be indexed to inflation. In mandatory programs, utilities that do not meet their targets through procurement or ACP payments face penalties for non-compliance. These can be fines that are higher than the ACP. Vermont is the only exception to the compliance requirement, since it has a voluntary goal and its utilities are not penalized for not meeting intermediate goals. However, if by 2012 the state's utilities do not meet the goal, the goal becomes a mandatory RPS with associated requirements and penalties.

New England states are all part of the ISO-NE power system; their respective RPS programs allow for renewable energy generated in or delivered into ISO-NE to qualify. The Renewable Energy Certificates (RECs) associated with the renewable energy must be tracked and recorded in the NEPOOL Generation Information System (NEPOOL GIS). RECs are the mechanism for utilities and retail energy providers to demonstrate compliance with their state's RPS program. The exception is Vermont who allows its utilities to sell RECs from renewable power used to meet the voluntary RPS to other states. The projected Gigawatt-hour (GWh) demand for renewable energy and RECs in New England by state through 2025 can be seen in Figure 7-8.

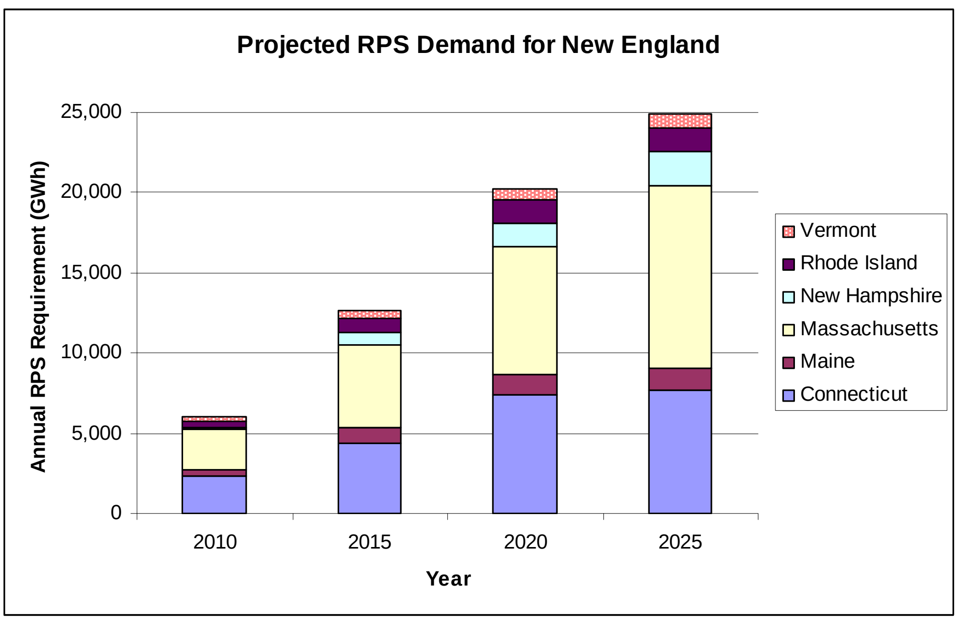

Figure 7-8: Project Renewable Portfolio Standards Demand (Source: Black & Veatch)

Table 7-4 provides a brief summary of each New England state's RPS program[94].

Table 7-4: Renewable Portfolio Standards New England States Summary (Source: Black & Veatch)

STATE	RPS TARGETS AND YEAR (MAIN TIER/CLASS I ONLY)	MANDATORY OR GOAL (INCLUDES ACP AND ESCALATION)	REC DELIVERY REQUIREMENTS	RENEWABLE ENERGY ELIGIBILITY REQUIREMENTS	SPECIAL CONSIDERATIONS (E.G. CARVEOUTS, OTHER TIERS, IN STATE CONTRACTS, ETC.)
Maine	1% by 2008 Increases 1% per year until 10% by 2017	Mandatory ACP is inflation adjusted, $60.93 in 2010	Generated in or delivered to ISO-NE (Tracked in NEPOOL GenIS)	Class I: Online after September 1, 2005 Projects less than 100 MW	Original target was 30%, which has already been met with pre-2005 projects. 10% target is in addition to this original target. 1.5 multiplier for community-based projects (< 10 MW)
New Hampshire	1% by 2010 Increase 1% per year until 16% by 2025	Mandatory ACP is inflation adjusted, (2010) Class I = $60.93 Class II = $160.01 Class III = $29.87 Class IV = $29.87	Generated in or delivered to ISO-NE (Tracked in NEPOOL GenIS)	Classes I & II: online after January 1, 2006 Class II include solar, solar hot water, incremental biomass/hydro Classes III (existing biomass) and Class IV (existing hydropower) with online dates prior to January 1, 2006.	Class I: 16% by 2025 Class II: 0.3% by 2014 Class III: 6.5% by 2011 Class IV: 1% by 2009 **Total:** 23.8% by 2025

*Kilowatt-hour (kWh)

**Note that NEPOOL General Information System is abbreviated as NEPOOL GenIS to distinguish it from the GIS acronym used herein to represent Geographic Information System(s), such as the Offshore Wind Energy Geographic Information System (OWEGIS).

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94 In addition to other sources cited in this report, the North Carolina State University Solar Center, Database of State Incentives for Renewables and Efficiency (DSIRE) was utilized as a source for the information summarized herein: http://www.dsireusa.org/ Last accessed November 15, 2010.

Table 7-4 continued

STATE	RPS TARGETS AND YEAR (MAIN TIER/CLASS I ONLY)	MANDATORY OR GOAL (INCLUDES ACP AND ESCALATION)	REC DELIVERY REQUIREMENTS	RENEWABLE ENERGY ELIGIBILITY REQUIREMENTS	SPECIAL CONSIDERATIONS (E.G. CARVEOUTS, OTHER TIERS, IN STATE CONTRACTS, ETC.)
Massachusetts	1% by 2003 4% by 2009 Increase 1% per year until 15% by 2020 plus 1% per year thereafter	Mandatory ACP is inflation adjusted. (2010) Class I: $60.93 Class II: $25 Class II WTE: $10 Solar: $600	Generated in or delivered to ISO-NE (Tracked in NEPOOL GenIS)	On-line after December 31, 1997 Small hydro and strict biomass requirements For renewable energy imported from outside of ISO-NE, the qualifying amount during each hour is limited to the lesser of the amount actually produced by the Unit or actually scheduled and delivered into the ISO-NE Control Area.	The solar carveout of Class I requirements is 0.0679% in 2010, increasing by ~30% annually Carve-out applies up to 400 MWdc Class II (Existing Resources): 7.1% in 2009 and thereafter (3.6% renewables and 3.5% waste-to-energy)
Vermont[95]	All new generation between 2005 – 2012 must come from renewables Goal of 20% by 2017	Goals: Minimum 5% of 2005 load from renewables and load growth each year is met with new renewable generation. Must exceed 10% of 2005 load by 2012 to be considered "successful" No ACP	Utilities are required to purchase renewable energy generation but are not required to purchase RECS Therefore RECs generated in VT can be traded on the open market outside of VT	Only for NEW generation: on-line after December 31, 2004 Must be in VT, produced using renewables or qualifying CHP No form of solid waste, other than agricultural or silvicultural waste, shall be considered renewable Hydroelectric facilities ≤ 200 MW are considered to be renewable (until July 1, 2012)	VT program is not a mandatory RPS. It is a voluntary program called SPEED. If RPS goal is not met by 2012, then a mandatory RPS will be implemented in 2013. Mandatory RPS would require renewables target to be met through using renewables, purchasing RECs, or paying alternative compliance payment.

[95] A separate target of 25% of energy consumed from renewables by 2025 was passed in March 2008 (SB 209), but has no apparent enforcement of target. Main driver is to enhance energy production from Vermont farms and forestland.

Table 7-4 continued

STATE	RPS TARGETS AND YEAR (MAIN TIER/CLASS I ONLY)	MANDATORY OR GOAL (INCLUDES ACP AND ESCALATION)	REC DELIVERY REQUIREMENTS	RENEWABLE ENERGY ELIGIBILITY REQUIREMENTS	SPECIAL CONSIDERATIONS (E.G. CARVEOUTS, OTHER TIERS, IN STATE CONTRACTS, ETC.)
Rhode Island	4.5% by 2010 16% by 2019	Mandatory ACP is inflation adjusted (2010) $60.93	Generated in or delivered to ISO-NE (Tracked in NEPOOL GenIS)	Hydro: ≤ 30 MW Biomass only from eligible fuels and meeting air quality standards	Existing generation (online prior to December 31, 1997) are allowed to count towards up to 2% of annual RES targets
Connecticut	1.5% by 2005 7% by 2010 20% by 2020	Mandatory ACP fixed $55 (does not escalate with inflation)	Must be procured in ISO New England territory or NY, PA, NJ, MD, DE, (tracked in NEPOOL GenIS)	Class I: Hydro must be run of river <5 MW, online after July 1, 2003 Biomass must be sustainably harvested, average emission rate of equal to or less than .075 lbs of NOx per MMBTU of heat input All other renewable generation do not have an online date requirement. Class II: Hydro (same as Class I) online before July 1 ,2003 Biomass online before July 1, 1998 (subject to less stringent air quality requirements than Class I)	Class I: 20% by 2020 Class I or Class II: 3% by 2010 Class III: 4% by 2010 **Total:** 27% by 2020 Compliance payment of $0.055/kWh

Each state approaches eligibility requirements for renewable energy somewhat differently, such as different on-line date requirements or certain restrictions on hydro and biomass. Hydro and biomass requirements vary quite significantly. For example, Maine allows any new hydro (after September 1, 2005) that is less than 100 MW to qualify for Class I, while Connecticut only allows projects less than 5 MW. For biomass, there are different eligibility issues, from having language stating the material must be sustainability harvested to limitations on emissions associated with the biomass facility.

In general, new renewable generation such as wind, solar, tidal/wave, and landfill gas all qualify for all the RPS programs in the region. Solar does get special treatment through carveouts, such as in Massachusetts, or a separate class, such as in New Hampshire. The associated ACP is much higher for solar than for other Class I resources — $600 per MWh in Massachusetts and $160 per MWh in New Hampshire.

These differences in eligibility requirements create a patchwork of rules in the region and limits or expands the availability of REC supply to each state. Historically, the RPS programs were being met by biomass, landfill gas, and some small wind projects in the region. More recently, new wind farms in Maine and Vermont, as well as larger wind projects in Canada and New York, have been helping the New England states meet their growing RPS targets. Going forward, on-shore wind projects are likely to satisfy a majority of the RPS demand in New England, due to the fact that the projects are generally lower cost than other options and can be developed in a number of places in and adjacent to New England. With the limitations on hydro and biomass, there are limited opportunities for their development. Solar projects are much smaller in scale and will not be able to address the overall targets for these states at a competitive cost.

Offshore wind may play a role in helping the states meet their RPS requirements in the long term, once on-shore wind projects become more difficult to permit and build due to NIMBY issues or lack of transmission to bring the wind to load. However, the high cost of offshore wind may limit its use. Recent evidence from proposed contracts for offshore wind projects, such as Cape Wind and Block Island, show that the costs are significantly higher for offshore wind projects than for onshore wind projects. Proposed contract prices for the two projects are 20.7¢/kWh (escalating at 3.5% per year) and 24.4¢/kWh (escalating at 3.5% per year) respectively.[96] Typical onshore wind projects in New England have contract prices that range from 8¢/kWh to 12¢/kWh, and do not escalate at high rates per year. Thus, the role of offshore wind in each state's RPS program may require policymakers to incorporate broader policy goals, beyond cost, for their development until offshore wind costs decline.

[96] New England Wind Forum, September 2010.

New England Renewable Energy Credit Markets

The New England REC market is considered one of the most "liquid" REC markets in the United States because of the opportunity for most renewable generators to sell their RECs to any state in New England, as long as the energy is generated in or delivered to ISO-NE. In general, since most RECs from new renewable energy projects can qualify for any of the RPS programs in New England, the RPS demand in the market is the sum of all of the mandatory RPS programs.

These RECs are created and tracked through the NEPOOL GIS.[97] The NEPOOL GIS, however, is not a marketplace or clearinghouse for RECs. Buyers, sellers, and brokers operate commercially outside of the NEPOOL GIS through direct transactions. Thus, market prices and volumes are often not transparent. Historical and forward REC prices are available through brokers who track these transactions and can be purchased for a fee. As an example, REC prices from 2003 to 2008 for Massachusetts, Connecticut, and Rhode Island can be seen in Figure 7-9.

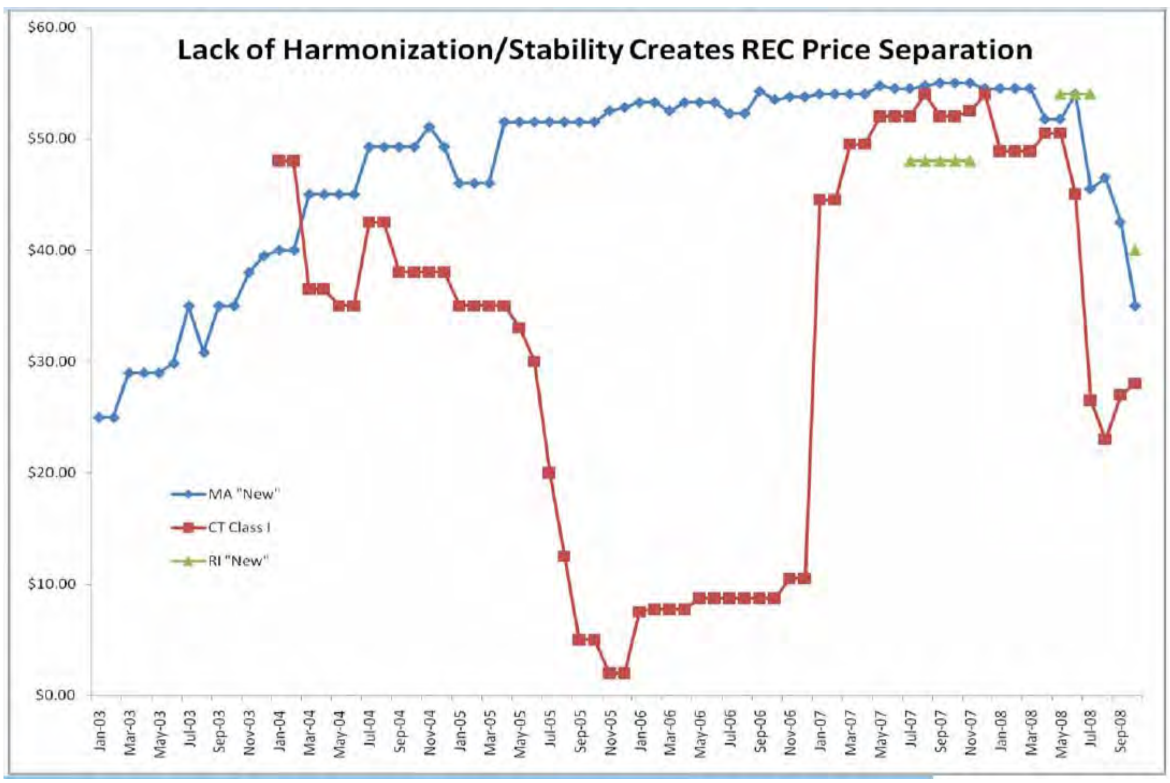

Figure 7-9: Historical Renewable Energy Credit Prices (Source: Sustainable Energy Advantage)

97 http://www.nepoolgis.com/

Historically, REC prices have been high in New England, especially in the initial years of the RPS regulations where there was an insufficient REC supply in the market to meet annual RPS targets. Massachusetts was one of the earliest RPS programs in the country and the state saw high REC prices, close to its ACP levels for multiple years due to the lack of supply. Then, in mid-2008, a number of Canadian and New York wind projects began delivering their wind energy to New England, increasing the REC supply in the region and causing REC prices to fall to more "balanced" levels.

During the same period that Massachusetts was experiencing high prices, Connecticut saw a crash in REC prices for over a year. In 2005, several biomass projects became eligible to supply RECs to Connecticut, creating a surplus of REC supply for the state. This was due to the fact that Connecticut's RPS is different from other states in the region. There is no restriction on the age of eligible renewable energy projects, as long as certain emissions requirements are met. Furthermore, Connecticut does not allow banking of RECs, meaning any surplus in one year could not be "banked" and applied to later year requirements. Since the biomass projects did not qualify for other states' RPS programs, the surplus in RECs from these projects crashed the Connecticut REC market for over a year, until the RPS target increased in 2007. These market examples in Massachusetts and Connecticut demonstrate the volatility of the New England market as result of supply/demand imbalances. Since 2008, the New England market has been more in balance; REC prices have been around $25-$35 per MWh.

One important note is that most of the utilities in the region are deregulated and purchase a majority of their RECs on an annual basis to meet their annual RPS requirements. These annual procurements cause volatility in the market as market participants respond to annual supply and demand balances. To address these uncertainties, some of the states now allow or require their utilities to sign long-term contracts for renewable energy to satisfy a portion of their RPS requirement. This effectively removes some supply and demand from the short-term REC market.

While it is challenging to predict the timing of supply/demand imbalances, it is important to understand the market drivers in the region and the bounds of potential REC prices. As the RPS requirements grow over the next 10-15 years, the differences in eligibility rules for the states will have less influence on market prices, as all of the states will need to compete for new generation to meet their growing demand. This will likely result in a more cohesive market with prices that converge around the value for new renewable generation relative to non-renewable power.

Towards a National Renewable Portfolio Standard

Various legislative proposals have been introduced in the United States House and Senate this decade to establish a Federal Renewable Portfolio Standard (RPS). Aspects of each have varied considerably, including the targets, timing, eligible resources, efficiency allowances, and alternative compliance payments. The recent piece of legislation that received the greatest support was H.R.2454, the American Clean Energy and Security Act of 2009, introduced by Representatives Waxman and Markey. This piece of legislation was passed by the House in June 2009, although no corresponding legislation was ever passed in the Senate. More recently, Senators Bingaman and Brownback introduced the Renewable Energy Promotion Act of 2010 (S.3813), which set less aggressive targets.

Each bill targets 15% to 20% (percent) renewable energy; as a point of comparison, the current level of non-hydro renewable energy output in the United States totaled about four percent (4 %) of the national supply. The actual amount of renewable energy likely to be implemented by each bill is somewhat lower than the stated target due to efficiency allowances and various exclusions. Key aspects of each bill are highlighted below in Table 7-5. Both would start in 2012.

Table 7-5: Federal Renewable Portfolio Standards (Source: Black & Veatch)

FEDERAL RENEWABLE PORTFOLIO STANDARDS POLICY EXAMPLES				
Policy	**Target**	**Compliance Waivers**	**Alternative Payment**	**Efficiency Allowance**
S.3813	15% by 2021[1]	Yes[2]	2.1 ¢/kWh	26.67%
H.R.2454	20% by 2023[3]	Very Limited	2.5 ¢/kWh	20%[4]

Notes:

[1]Interim goals: 3% by 2012, 6% by 2014, 9% by 2017, and 12% by 2019

[2]Due to rate impacts (> 4% per year), transmission constraints, or force majeure

[3]Interim goals: 6% by 2012, 9.5% by 2014, 13% by 2016, and 16.5% by 2018

[4]Could be raised to up to 40% with states requests and federal approval

There are a number of similarities between the bills. The definition of renewable energy is similar: solar, wind, geothermal, biomass, incremental hydropower,[98] ocean/tidal, and qualified waste-to-energy. With very few exceptions, there is no size limit or in-service date requirements to be considered eligible. Existing hydropower, incremental or new nuclear (depending on the bill), and fossil technology using carbon

[98] Expansion of existing facilities or addition of power generation on an existing dam previously without power generation

capture is subtracted from the utility's load when calculating the renewable target. The size of the utility that must comply, all with sales greater than four (4) million MWh/year, is similar. An alternative payment option is available for compliance instead of having to procure renewable energy. Money paid under this option typically goes to the state where the utility is located to support renewable energy programs.

The penalty for non-compliance is the same for both bills — 200% (percent) of the value of the alternative payment for every kilowatt-hour short of the goal. That is, if a utility is negligent in meeting their targets or making alternative payments when a shortfall can be foreseen, the penalty is twice the alternative payment for every kilowatt-hour short of compliance.

Most proposed federal RPS policies establish a federal trading system that allows utilities short of their goals to acquire federal RECs from any other utilities in the country that have a surplus. While the rules are not entirely clear, it appears that there will be separate state and federal REC markets. That is, a kilowatt-hour of electricity will have both a state and federal credit associated with it in states where a state RPS already exists. For states that have a target more stringent than the federal policy, the federal credits generated by meeting state targets could likely be sold to other utilities. This mechanism could effectively offset the cost of state RECs for those states that are ahead of the federal targets, creating an additional revenue stream for renewable energy projects.

H.R.2454 failed to garner support in the Senate not due to the RPS provisions, but rather due to the more contentious greenhouse gas (GHG) cap-and-trade program that was part of the bill. S.3813 has taken a more narrow approach by focusing solely on a federal RPS program without enacting a specific federal GHG management program.

Having a bill focused only on RPS provisions ultimately has a much better chance of federal enactment relative to a broader energy bill. RPS laws can be more easily linked to issues that resonate more with voters and lawmakers such as jobs and economic growth. States that may have the most to economically gain from a federal RPS are those with the best renewable energy resources, namely Western and Midwestern states. Lawmakers in these regions have realized the benefit of a federal RPS, as shown by the support of Republican co-authors to S.3813 in Kansas, Nevada, and Iowa.

S.3813 represents a compromise renewable energy bill that would have had a reasonable chance of success if introduced earlier in 2010. However, the very short time remaining in the 111th Congress, coupled with competing RPS-like bills (S.20, the "Clean Energy Standard" introduced by Senator Graham which includes new nuclear and fossil fuels with carbon capture to count toward targets) and legislative priorities other than energy make the chances of success for Federal RPS policies in the next two years low. Federal renewable energy policy is not a priority for the Republican controlled House. RPS legislation that would be of interest to the House in 2011 and 2012 would likely need to have additional provisions related to nuclear and fossil energy to attract the necessary votes. This implies that there likely will not be any new major federal drivers for renewable energy from an RPS-like bill until after 2012 at the earliest.

7.2.5 Power Market Forecast and Key Drivers

This section summarizes the input assumptions used to produce the electricity price forecast in the Fall 2010 vintage of the Black & Veatch Northeast Energy Market Perspective, as well as the forecast itself.[99] The input assumptions used in the electricity price forecast is intended to produce a baseline view of the Northeast and ISO-NE electricity market. While the future may play out differently, the Black & Veatch Energy Market Perspective provides a sound Base Case or "middle of the road" view of the power markets, with the understanding that different input assumptions can produce dramatically different outcomes.

Northeast Energy Market Perspective Framework

The Black & Veatch Northeast Energy Market Perspective is a 25-year forecast of electric, natural gas, and carbon allowance prices. The Northeast Energy Market Perspective is the end product of an integrated market modeling process (IMM), (see Figure 7-10), which utilizes multiple models to converge upon a optimized forecast using feedback loops between models. Black & Veatch draws from a number of commercial data sources and supplements them with its own view on a number of key market drivers, for example, power plant capital costs, environmental and regulatory policy, fuel basin exploration and development costs, and gas pipeline expansion.

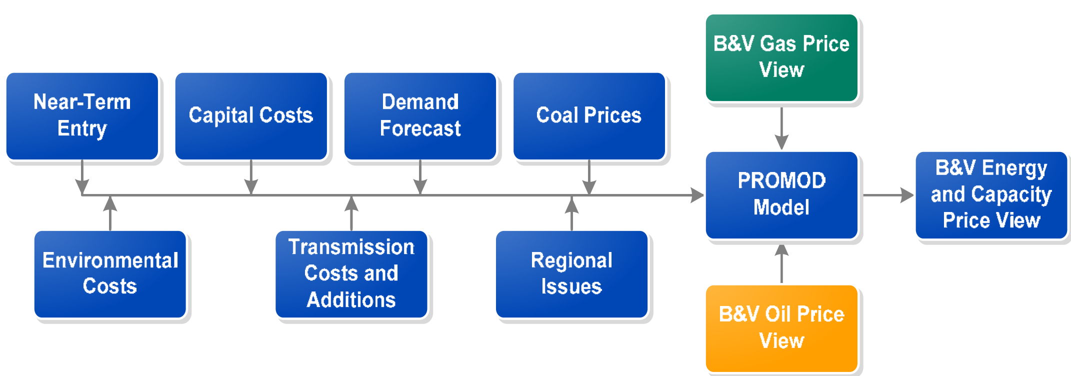

Figure 7-10: Black & Veatch Integrated Market Model Process (Source: Black & Veatch)

99 All forecast prices are presented in this section of the report are in constant 2010 USD.

Natural Gas Price

Natural gas is an important source of fuel for many generating units in the ISO-NE system. Today nearly half of the electricity produced in ISO-NE comes from natural gas fired generation. During the on peak hours[100] natural gas is typically the marginal fuel, which in turn sets the market clearing price of electricity. This makes the price of natural gas a key driver of electricity prices in ISO-NE, as well as in much of the rest of the United States. See Table 7-6 for natural gas price forecasts projected out to 2035.

Table 7-6: Natural Gas Price Forecast (Source: Black & Veatch)

Year	Dracut (2010 $/mmBtu)
2011	$5.12
2012	$5.16
2013	$5.43
2014	$6.02
2015	$6.38
2016	$6.82
2017	$7.23
2018	$7.59
2019	$7.76
2020	$7.29
2021	$7.41
2022	$7.54
2023	$7.77
2024	$7.78
2025	$7.90
2026	$8.08
2027	$8.32
2028	$8.58
2029	$8.70
2030	$8.98
2031	$9.11
2032	$9.25
2033	$9.39
2034	$9.53
2035	$9.67

GHG Emission Allowance Price (RGGI and Federal)

The Regional Greenhouse Gas Initiative (RGGI) was the first mandatory, market-based effort in the United States to reduce greenhouse gas emissions. Currently the ten (10) Northeast and Mid-Atlantic States (including all six (6) states in ISO-NE) have

[100] Monday – Friday 7 AM – 10 PM

agreed to cap and attempt to reduce carbon dioxide (CO_2) emissions from the power sector ten percent (10%) by 2018. The RGGI CO_2 pricing will continue to be in effect until a federal cap-and-trade program can be implemented. In the EMP Base Case, Black & Veatch assumes that a federal cap-and-trade GHG program will be in place starting in 2016 at $23/short ton. Black & Veatch also assumes that in market based system generators will include carbon dioxide (CO_2) compliance costs into their energy bids into the energy markets thereby creating uplift in the electricity price.

Table 7-7 below lists the annual GHG emission allowance price forecast under the RGGI and the federally administered program.

Table 7-7: Greenhouse Gas (GHG) Emission Allowance Forecast (Source: Black & Veatch)

GHG Emission Allowance Forecast (2010 $/short ton)		
Year	Federal Cap & Trade	RGGI
2011		$2
2012		$2
2013		$2
2014		$3
2015		$3
2016	$23	
2017	$24	
2018	$26	
2019	$27	
2020	$29	
2021	$30	
2022	$32	
2023	$34	
2024	$36	
2025	$38	
2026	$40	
2027	$43	
2028	$45	
2029	$48	
2030	$51	
2031	$54	
2032	$57	
2033	$60	
2034	$63	
2035	$67	

Under the RGGI only generators from participating states larger than 50 MW are required to control GHG through the purchase of emission allowances. Under the federal cap and trade program Black & Veatch assumes that all generators will be subject to GHG regulations and would need to purchase GHG emission allowances to produce GHG. The cost of the GHG emission allowance purchase would then be included in the variable dispatch cost for each generator.

Electricity Price Forecast (Massachusetts Hub and Maine)
Black & Veatch utilizes a market-based approach to forecasting electric power prices. Generators that are price takers will bid their variable costs into the market to clear the supply curve, whereas generators that are price setters will bid variable cost plus a scarcity rent premium to recover sunk costs such as fixed and capital costs. Table 7-8 below shows the average annual forecasted electric price by time of day (TOD) for the Maine and Massachusetts (Mass) Hub market zones. The electricity prices reported in this study are representative of a zonal price, which is the load-weighted price of all the LMP nodes in a load zone.

Table 7-8: Electricity Price Forecast by Time of Day (TOD)

Annual Electricity Prices (2010 $/MWh)						
	MAINE			MASSHUB		
Year	Average	On Peak	Off Peak	Average	On Peak	Off Peak
2011	$41	$47	$34	$42	$49	$36
2012	$41	$48	$35	$43	$50	$37
2013	$42	$49	$36	$45	$52	$39
2014	$45	$53	$37	$48	$56	$40
2015	$47	$57	$39	$51	$60	$42
2016	$60	$69	$51	$63	$73	$55
2017	$60	$71	$49	$66	$75	$57
2018	$63	$75	$51	$70	$80	$61
2019	$64	$77	$52	$72	$82	$63
2020	$65	$75	$55	$69	$79	$59
2021	$67	$77	$58	$71	$82	$62
2022	$69	$79	$60	$74	$84	$64
2023	$72	$82	$63	$76	$86	$67
2024	$73	$84	$64	$78	$88	$68
2025	$76	$86	$66	$81	$91	$71
2026	$79	$90	$69	$84	$95	$74
2027	$82	$94	$72	$88	$99	$77
2028	$84	$96	$74	$90	$102	$79
2029	$87	$99	$76	$92	$104	$82
2030	$91	$103	$80	$97	$109	$85
2031	$92	$104	$81	$98	$110	$87
2032	$95	$107	$85	$101	$113	$90
2033	$96	$108	$86	$102	$114	$91
2034	$99	$110	$89	$105	$116	$95
2035	$101	$114	$90	$108	$120	$96

Capacity Price Forecast (CPF)

To supplement the energy market in ISO-NE there is also a corresponding capacity market administered by the ISO-NE, designed to meet reliability objectives. In the energy market, generators are paid for energy that is produced, whereas in the capacity market generators are paid for capacity that is made available to meet peak demand. The capacity market helps to ensure that enough capacity is available to meet the peak load plus planning reserves.

Capacity prices from 2011 – 2013 are based upon FCM auction prices that have already cleared. Black & Veatch assumes that ISO-NE capacity prices will remain at the floor price until 2023, at which time new capacity will be needed. While Maine is not expected to need any new capacity beyond the expected expansion of renewable generation, capacity prices in Maine will equal those in the balance of ISO-NE because the total claimed capability of the generation resources in Maine is expected to stay below the sum of the state's peak demand plus transmission export capability.

It is important to note that capacity prices can be volatile. For example, changing market conditions such as accelerated retirements of older, less efficient units and/or high economic load growth can cause capacity prices to rise quickly to a level in which new generation may be able to enter the market. Proposed market design changes to the current capacity market auction structure add additional uncertainty to the future capacity market prices. Likely changes in the future to the calculation of the Cost of New Entry (CONE) and the treatment of OOM resource could have a significant impact on capacity prices.

It is entirely possible that a generator over the course of year be paid only for its capacity and to receive no energy revenue. This is particular true for peaking units such as combustion turbines that may only operate under high load or during emergency situations. For these types of units, capacity revenues are normally the main source of revenue that allows these units to remain in the market. Table 7-9 shows the annual capacity revenue forecast that eligible generators are assumed able to receive when participating in the ISO-NE capacity market auction.

Table 7-9: Capacity Price Forecast (CPF)

Capacity Price (2010 $/kW-yr)		
Year	ISO-NE - Maine	ISO-NE - Rest of Pool
2011	$30	$30
2012	$30	$30
2013	$30	$30
2014	$30	$30
2015	$30	$30
2016	$30	$30
2017	$30	$30
2018	$30	$30
2019	$30	$30
2020	$30	$30
2021	$30	$30
2022	$30	$30
2023	$78	$78
2024	$73	$73
2025	$64	$64
2026	$56	$56
2027	$48	$48
2028	$52	$52
2029	$44	$44
2030	$35	$35
2031	$39	$39
2032	$32	$32
2033	$46	$46
2034	$43	$43
2035	$43	$43

7.3 MARITIME CABOTAGE LAWS

7.3.1 Introduction

Most of today's ocean wind turbines require that foundations be installed into the seabed on mono-piles or jackets or tripods, which means that the costs of installation grow dramatically as the depth of water increases. Consequently, floating turbines may make the most economical sense for deep waters, because fixed turbines must be built taller and wider at the bases as water depth increases. "Beyond 50 meters, it's not cost effective to build a massive structure that's pounded into the seabed."[101] A floating, foundationless wind turbine design would also significantly reduce the overall weight of the structure and allow for onshore assembly and installation far offshore. Floating wind farms could be well suited to the northeastern seaboard of the United States, especially in part of the coast where sea bottom depths drop off relatively quickly.

The pursuit of offshore deepwater wind development comes with great potential, but with a number of technical, market and legal challenges as well. There are natural and engineering challenges posed by the depth of the water, the struggle to pinpoint optimal siting (known as micro-siting), the force of the wind, the force of the waves, the density of the seabed, and such. There are financing challenges in locating start-up funding, determining the nature of ownership and managerial duties, securing leases, loans, and sufficient operating capital, and insuring the whole enterprise. Myriad legal challenges come from multiple statutes and regulations,[102] including the so-called "Cabotage Laws" which are the subject of this chapter. Because the installation of offshore wind turbines requires specialized vessels and portside infrastructure, both of which are currently lacking in the United States, the cabotage laws – which restrict the

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[101] See, Prachi Patel, Floating Wind Turbines to Be Tested, IEEE Spectrum (June 22, 2009), available at http://spectrum.ieee.org/green-tech/wind/floating-wind-turbines-to-be-tested (quoting Neal Bastick, CEO of Blue H Technologies).

[102] Federal statutes implicated in offshore wind development include the Coastal Zone Management Act, the Outer Continental Shelf Lands Act, the Energy Policy Act, the Marine Mammal Protection Act, the National Environmental Protection Act, the Migratory Bird Treaty Act, and at least a dozen more. For a more complete listing, see Constantine Papavizas & Gerald Morrissey, Does the Jones Act Apply to Offshore Alternative Energy Projects? 34 Tul. L. Rev. 34-35 (2010). Offshore wind development could also potentially involve myriad Federal agencies, including the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) (formerly the Minerals Management Services (MMS)), the Bureau of Safety and Environmental Enforcement (BSEE) at the Department of the Interior (DOI); the Department of Energy (DOE) and its Energy Efficiency and Renewable Energy (EERE) division; the Federal Energy Regulatory Commission (FERC); the Environmental Protection Agency (EPA); the United States Army Corps of Engineers (USACE); the Department of Commerce (USDOC) and its National Oceanic and Atmospheric Administration (NOAA); the Maritime Administration (MARAD) at the Department of Transportation (USDOT); and the Department of Homeland Security's Coast Guard division (USCG) and Customs and Border Patrol (CBP) division.

use of foreign vessels in American waters – stand to play a crucial role in offshore wind farm development.[103]

7.3.2 Cabotage and Coastwise Laws

Cabotage comes from the French, who probably took it from the Spanish word *cabo*, referring to a head of land.[104] *Cabotage*, then, referred to passage over water from one head of land to another. Today, "cabotage" also embraces air transport, but in the maritime context, the term "cabotage laws" is used interchangeably with the term "coastwise laws" to refer to the transport of goods or passengers between two "coastwise" points in the United States. Confusingly, many refer to various provisions within these laws as "the Jones Act," a term that, over the years, has been used to denote any one of several laws, or the combination of two or more, or all of them.

Because off-shore wind power will require that something, *i.e.*, several dozen or more structures, be built, maintained, operated, and eventually decommissioned at sea; because those structures are to be anchored to the seabed but also extend up to 300 feet or more above the surface; because those structures will lie within the expanded territorial waters of the United States but not within the exclusive jurisdiction of the State of Maine; and because those structures could be prefabricated to some extent but still would have to be assembled and installed on site, the question of whether and precisely how cabotage laws and regulations would apply to off-shore wind develop becomes potentially critical.

American Cabotage History

The cabotage laws, as federal laws, depend to a significant extent on their implementing regulatory agencies for clarification, adaptation, interpretation, and enforcement. The Maritime Administration (MARAD), a division of the Department of Transportation (DOT), has long had a hand in rulemaking related to cabotage, as have the Coast Guard (USCG) and United States Customs and Border Protection (CBP). MARAD tends to focus its efforts on overseeing the sale and financing of coastwise vessels and their builders to the benefit of the American merchant marine. The USCG and CBP, now both divisions of the Department of Homeland Security, have long played the lead roles in cabotage's interpretation and enforcement. Of course, the ultimate interpretation of our cabotage laws has been the province of the federal courts.

[103] Dale K. DuPont, Acting Up, Workboat.com (December 1, 2010), available at http://www.workboat.com/newsdetail.aspx?id+4295000187; see also Chris Gillis, No Logistics Breeze, 52 American Shipper No. 4 14-19 (2010) (quoting Paul Rich of Deepwater Wind: "Our vessel strategy is crucial to making us successful. . . Right now it's our weakest link.")

[104] Offshore Marine Service Association, Jones Act—Cabotage Laws, Apr. 5, 2010, http://www.offshoremarine.org/Jones-Act/Jones-Act-Cabotage-Laws.html (citing Webster's New Collegiate/New World/Ninth New Collegiate Dictionaries).

For over 200 years, the United States Customs Service, which was dissolved into the CBP in 2003, has been responsible for enforcing and administering laws and regulations that set forth procedures to control and oversee vessels arriving in, and departing from, United States ports and the coastwise transportation of merchandise between United States ports.[105] The Navigation Acts of 1817 barred foreign vessels from domestic commerce.[106] In 1886, Congress extended cabotage laws to passenger vessels, and in 1905 Congress retained United States build requirements for domestic shipping.[107]

The law governing the coastwise transportation of merchandise was definitively established by passage of the Merchant Marine Act of 1920 (often referred to as the "Jones Act" after its sponsor Senator Wesley L. Jones), which revamped the United States shipping laws governing cabotage, shipping mortgages, seamen's personal injury claims, and more.[108] The intent of the Jones Act, and of coastwise laws generally, was to protect and facilitate the development of United States shipping and the American merchant marine for purposes of both commerce and national security.[109]

To this end, within the larger Act, Section 27 (which is also often referred to as "the Jones Act") originally provided that:

> *"[N]o merchandise shall be transported by water, or by land and water, on penalty of forfeiture thereof, between points in the United States, including districts, territories, and possessions thereof embraced within the coastwise laws, either directly or via a foreign port, or for any part of the transportation, in any other*

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105 What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 1, CBP (Jan. 2009), available at http://www.cbp.gov (citing "the 11th Act of 1789"). The U.S. Customs Service was removed from the Treasury Department and became a component of the Department of Homeland Security (DHS), pursuant to the Homeland Security Act of 2002, Pub. L. 107-296 (November 25, 2002), secs. 403, 411

106 U.S. Cabotage Laws, Maritime Administration, available at www.marad.dot.gov. Offshore Marine Service Association, Jones Act—Cabotage Laws, Apr. 5, 2010, http://www.offshoremarine.org/Jones-Act/Jones-Act-Cabotage-Laws.html.

107 Policy Paper, U.S. Cabotage Laws, Maritime Administration, available at www.marad.dot.gov.

108 What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 2, CBP (Jan. 2009), available at http://www.cbp.gov.

109 What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 2, CBP (Jan. 2009), available at http://www.cbp.gov (citing CBP HQ H116630 (March 27, 2006)). As the government's Maritime Administrator points out, in addition to serving as an essential link in our national transportation infrastructure, the domestic trade fleet is a critical component of America's military readiness. Policy Paper, U.S. Cabotage Laws, Maritime Administration, available at www.marad.dot.gov. Specifically, 85 percent of the oceangoing vessels in the fleet are easily put to military militarily use, and over 40,000 merchant mariners are qualified to crew deep-sea vessels, and sealift ships. Policy Paper, U.S. Cabotage Laws, Maritime Administration, available at www.marad.dot.gov.

> *vessel than a vessel built in and documented under the laws of the United States and owned by persons who are citizens of the United States."* [110]

Similar restrictions were placed in cabotage laws on towing, dredging, salvage, and the transport of passengers. At the same time, the original Act's Section 33, which is also commonly referred to as "the Jones Act," accorded seamen the right to bring an action against their employer and receive a jury trial if they are injured in the course of their employment.[111] Sections 27 and 33, in particular, have garnered much attention and controversy over the years, and both have potentially significant application to off-shore wind power development.

The Contemporary State of Cabotage Law

The most pertinent cabotage laws for our purposes generally comprise those provisions on coastwise transportation of merchandise, dredging, towing, salvage, transportation of passengers, and the rights of seamen injured in the course of employment.

For the coastwise transport of merchandise, the cabotage laws require that all goods transported in coastwise trade between United States ports be carried in United States-flagged vessels that are constructed in the United States and owned by United States citizens.[112] Additionally, United States law generally requires that 75 percent of the crew on United States flagged vessels be United States citizens and/or permanent residents.[113] Today's version of Section 27 provides that the transportation of merchandise between United States points is reserved for United States-built, owned, and documented vessels.[114] Or, in the contemporary statute's own words, "a vessel may not provide any part of the transportation of merchandise by water, or by land and water, between points in the United States to which the coastwise laws apply, either directly or via a foreign port, unless the vessel—(1) is wholly owned by citizens of the United States for purposes of engaging in the coastwise trade; and (2) has been

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[110] What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 2, CBP (Jan. 2009), available at http://www.cbp.gov.

The Section 27 "Jones Act" was later found in 46 U.S.C. App. 883. Then, in 2006, Title 46, which covered other shipping laws, too, was substantially reorganized and recodified. As a result, that "Jones Act" is now codified at 46 U.S.C. § 55102. What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 2, CBP (Jan. 2009), available at http://www.cbp.gov (citing Pub. L. 109-304, 120 Stat. 1632 (Oct. 6, 2006).

[111] See Merchant Marine Act of 1920, Pub. L. 66-261, 41 Stat. 988. Section 33 is now codified at 46 U.S.C. § 30104.

[112] See 46 U.S.C. § 55102. "[O]wned by U.S. citizens" is elsewhere defined in statute to require that at least 75 percent of the interest in the vessel or vessel-holding entity be owned by citizens of the United States. 46 U.S.C. § 50501.

[113] *Ibid.*

[114] 46 U.S.C. § 55102.

issued a certificate of documentation with a coastwise endorsement [by the Coast Guard]. . ..”[115] Accordingly, foreign-flagged vessels are prohibited from transporting merchandise between United States coastwise points. What’s more, the same prohibitions apply to United States-flag vessels that do not have a coastwise endorsement on their documentation or are not crewed predominantly by United States personnel. This imposes obvious requirements on what kinds of vessels may be involved in the development, operation and maintenance of off-shore wind facilities, while also begging the question about whether floating wind turbine platforms might at some point be considered “vessels,” themselves subject to our cabotage laws.

These issues apply as well to passengers on vessels, including those that may be involved in transporting workers to and from off-shore wind farms. The Passenger Vessel Services Act provides that no vessel, other than one that is coastwise-qualified, shall transport passengers between ports or places in the United States either directly or by way of a foreign port.[116] “Passenger,” in the statute, is defined as “any person carried on a vessel that is not connected with the operation of such vessel, her navigation, ownership or business.”[117]

However, in the context of these legal terms, what is a “vessel”? What is “merchandise”? What does it mean to “transport” that merchandise? What is a “passenger”? Which are the “coastwise waters” of the United States? How are “coastwise points” defined? To what extent, if any, do any of these provisions apply to offshore wind farms?

1. Vessels

The coastwise laws are only applicable to vessels engaged in transporting merchandise in United States waters. “The term ‘vessel’ is not defined in the coastwise laws, but it is defined elsewhere in federal statute to include ‘every description of water craft or other contrivance used, or capable of being used, as a means of transportation in water.’”[118] The Supreme Court has stated that this definition is to be applied in any act of Congress passed subsequent to February 25, 1871, unless the context of the act indicates otherwise.[119] Despite arguments to the contrary, CBP has found even a dry dock—to the extent that is was not to be a fixed, permanently moored structure but rather used as a means of transportation of merchandise in water—to be a vessel.[120] Thus, it is entirely possible, if not

[115] *Ibid*.

[116] 24 Stat. 81, codified at 46 U.S.C. § 55103.

[117] 19 CFR 4.50(b).

[118] 1 U.S.C. § 3; 19 U.S.C. § 1401(a).

[119] *See,* Stewart v. Dutra Construction Company, 543 U.S. 481, 489 (2005).

[120] CBP HQ H032257 (Aug. 1, 2008).

likely, that many floating, offshore wind structures will be subject to the requirement of cabotage.

2. Passengers

A "passenger" is any person carried on a vessel who is not connected with the operation, navigation, ownership, or business of the vessel.[121] CBP has found, however, that certain marine personnel, crane operators, and trade personnel do not fall under this definition of "passenger" and so may be carried on the vessel without violating the coastwise laws.[122] How CBP will interpret and apply the regulatory definition to the myriad of meteorologists, marine scientists, engineers and construction workers involved in an off-shore wind facility will likely depend on the extent to which CBP sees these individuals as inextricably tied to the "business of the vessel." In the case of a purpose-built offshore wind construction vessel with a regular staff of these various experts, they might be more likely viewed as crew, rather than occasional, or one-time "passengers."

3. Transportation of Merchandise

Coastwise transportation of merchandise takes place, within the meaning of the cabotage laws, when merchandise laden at one coastwise point is unladen at another coastwise point, "regardless of the origin or ultimate destination of the merchandise."[123]

CBP uses statutory definitions to determine what is considered merchandise for purposes of enforcing the Jones Act.[124] Under these statutes the word "merchandise" means goods, wares and chattels of every description, including merchandise that is prohibited from being imported into the United States [125] Significantly, "merchandise" also includes: valueless material, such as mud, rock, or silt dredged from the seafloor.[126] This has obvious implications for the transport

[121] 19 C.F.R. 4.50(b)(1993). CBP HQ H105415 (May 27, 2010).

[122] CBP HQ H112693 (Jul. 14, 1993).

[123] 19 CFR § 4.80b(a); CBP HQ H105415 (May 27, 2010).

[124] What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 3, CBP (Jan. 2009), available at http://www.cbp.gov (citing 46 U.S.C. § 55102(a) and 19 U.S.C. § 1401(c)).

[125] 19 U.S.C. § 1401(c); see also 31 U.S.C. § 5312. The baggage and personal effects of the crew, as well as equipment of the transporting vessel, including items that are "necessary and appropriate for the navigation, operation or maintenance of a vessel and for the comfort and safety of the persons on board," are not considered merchandise. Ibid. Similarly, sea stores, like supplies for the consumption, sustenance, and medical needs of the crew and passengers during the voyage are not considered merchandise. See Treasury Decision 40934 (1925).

[126] 46 U.S.C. § 55102(a).

of scientific samples and dredge spoils resulting from wind turbine platform installation.

In some instances, however, items, which might otherwise be considered merchandise, do not fall under the cabotage laws, as long as their use and origin meet certain limitations. For example, paint or sandblasting grit may be applied to an offshore drilling platform by a foreign vessel, so long as the "merchandise" does not originate from another coastwise point, and the vessel remains stationary while it is applying the materials.[127] Likewise, where tools loaded at one coastwise point are subsequently used, but not offloaded, at another point, the coastwise laws would not be implicated. Where merchandise is laden at a foreign port and unladen at a coastwise point (without intermediate stops at any other coastwise points), entry and duty obligations would need to be met, but the coastwise laws would not be implicated.[128]

4. Coastwise Boundaries

With only a few exceptions, the cabotage laws apply to all territorial waters of the United States, its territories and possessions, including the Commonwealth of Puerto Rico. The territorial waters of the United States consist of the territorial sea, defined as the belt, three nautical miles wide, seaward of the territorial sea baseline, and to points located in internal waters, landward of the territorial sea baseline, in cases where the baseline and coastline differ.[129] The 1978 enactment of the Outer Continental Shelf Lands Act (OCSLA), extended United States jurisdiction to the full expanse of its 200 nautical mile Exclusive Economic Zone (EEZ).[130] United States cabotage laws presumably also apply out to 200 nautical miles offshore, but perhaps only specifically as concerns oil and gas exploration.[131]

5. Coastwise Points

[127] See Wayne D. Gusman, Commander, U.S. Coast Guard, Coastwise Trade Determination Letter (May 14, 1997) (referencing CBP HQ H227081 (July 10, 1996)).

[128] See CBP HQ H015078 (Nov. 7, 2007).

[129] See, 33 C.F.R. § 2.22(a)(2).

[130] The exclusive economic zone (EEZ) refers to the area outside the territorial sea which extends 200 nautical miles beyond the baseline from which the territorial sea is measured. The U.S. EEZ was established by Presidential Proclamation No. 5030 (Mar. 10, 1983). 48 Fed. Reg. 10,605 (1983).

[131] See 43 USC § 1333(a), providing, in part, that the laws of the United States are extended to "the subsoil and seabed of the outer Continental Shelf and to all artificial islands, and all installations and other devices permanently or temporarily attached to the seabed, which may be erected thereon for the purpose of exploring for, developing, or producing resources therefrom . . . to the same extent as if the outer Continental Shelf were an area of exclusive Federal jurisdiction within a State."

In order for an activity to constitute coastwise trade, there must be a transportation between "coastwise points."[132] A "point" *per se* does not have to be on shore, however. CBP has consistently ruled that a point in the United States territorial waters is a point in the United States embraced within the coastwise laws.[133] CBP regulations promulgated pursuant to 46 U.S.C. § 55102 clearly define the term coastwise points as "including points within a harbor."[134] Points also include interim stops and changeovers, even when one of these might involve the transport of merchandise over land in between port-based transfers.[135]

Additionally, because the coastwise laws have, since 1978, embraced those points on the Outer Continental Shelf (OCS) assigned for oil and gas exploration, CBP has extrapolated upon this principle to apply cabotage requirements to drilling platforms, artificial islands, and similar structures, as well as to devices attached to the seabed of the OCS, for the purpose of resource exploration operations, including warehouse vessels anchored over the OCS when used to supply drilling rigs on the OCS.[136] The legislative history of this amendment includes a statement of the reporting House committee's intent:

> *It is thus clear that Federal law is to be applicable to all activities or all devices in contact with the seabed for exploration, development, and production. The committee intends that Federal law is, therefore, to be applicable to activities on drilling rigs, and other watercraft, when they are connected to the seabed by drillstring, pipes, or other appurtenances, on the OCS for exploration, development, or production purposes.*[137]

Accordingly, the CBP has ruled that the coastwise laws are extended to mobile oil drilling units (MODUs) during the period they are secured to or submerged onto the seabed of the OCS.[138] In these cases, the installation or device must be permanently or temporarily attached, and it must be used for the purpose of exploring for, developing, or producing resources therefrom, in order to be considered a coastwise point. There is no reason to believe rigs for the installation of wind turbines would be treated differently.

[132] What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 4, CBP (Jan. 2009), available at http://www.cbp.gov.

[133] *Ibid.*

[134] See 19 C.F.R. § 4.80(a).

[135] See 46 U.S.C. § 55102(b).

[136] See Cust. Serv. Dec. 81-214; Cust. Serv. Dec. 83-52.

[137] CBP HQ H012082 (Aug. 27, 2007) (citing H. Rep. No. 95-590; 1978 U.S.C.C.A.N. 1450, 1534).

[138] Cust. Serv. Dec. 85-54; see also Cust. Serv. Dec. 81-214 and 83-52; CBP HQ H107579 (May 9, 1985); CBP HQ H012082 (Aug. 27, 2007); CBP HQ H012082 (Aug. 27, 2007); Treasury Decision (T.D.) 54281(1).

Coastwise points do not include temporarily installed marker buoys or meteorological towers. CBP has long held that that marker buoys merely attached to the OCS to mark drilling sites are not considered "installations" or "other devices" within the meaning of the OCSLA and are therefore not coastwise points.[139] This holding was based upon the legislative history to the 1978 Amendment to the OCSLA, which states that for the purposes of the coastwise laws, the term "installations and other devices" in the OCSLA may be limited to something to which merchandise or passengers can be transported and on which they can be unladen.[140] While research installations offshore may constitute "points," this would probably not be the case for basic meteorological towers temporarily installed to collect data. Moreover, buoys or offshore platforms that are beyond the 3-mile United States territorial sea but attached to the OCS for more direct purposes of oil or gas exploration, development or production are considered coastwise points pursuant to the OCSLA.[141]

On November 7, 2007, CBP issued a binding letter ruling on the question of whether the attachment of marker buoys to risers permanently installed in the seabed would implicate the coastwise laws.[142] Noting that temporarily installed marker buoys are not normally considered "points" within Section 55102, CBP found that the buoys in this instance, because they would be attached to permanently imbedded risers, would, in fact constitute "points" and thereby implicate Section 55102.[143] Any transportation of merchandise or passengers, therefore, between these points and any other coastwise points, including to and from coastal ports and other similar marker buoy positions, would need to occur in a coastwise qualified vessel.[144] The ruling further notes, however, that foreign-flagged vessels could bring such buoys or other merchandise from a foreign point to the risers' location on the OCS without triggering cabotage laws.[145]

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[139] See HQ H110959 (August 8, 1990) (installation site on OCS at which the only contact with seabed is temporary wire rope, chain, and anchor mooring system intended to hold hull and superstructure on location during exploration, development and production on OCS, is not a coastwise point during installation of marker buoys until time of attachment to drill ship) (citing Cust. Serv. Dec. 81-95, modified by Cust. Serv. Dec. 84-96); see also HQ H012082 (August 27, 2007).

[140] See House Conference Report No. 95-1474 (Aug.10, 1978).

[141] See CBP HQ H115439 (August 9, 2001).

[142] CBP HQ H015078 (Nov. 7, 2007).

[143] *Ibid.*

[144] *Ibid.*

[145] *Ibid (Nov. 7, 2007);* see also CBP HQ H115439 (Aug. 9, 2001). In this case, though, the foreign vessel would still need to deal with entry and duty issues related to its cargo. CBP HQ H015078 (Nov. 7, 2007).

Are anchoring units merchandise, too? A suction pile anchor assembly carried aboard an anchor handling tug or vessel constitutes merchandise.[146] Similarly, a lateral mooring system (LMS) consisting of wire rope, chain, buoys and anchors to be used to secure a tension leg platform in place on the OCS for drilling and production activities constitutes merchandise when carried as deck cargo aboard another vessel.[147]

Either the use of an anchor handling tug or vessel in setting and changing the location of anchors already affixed to drilling rigs or other vessels located in territorial waters or on the OCS is not a use subject to the coastwise laws, however.[148]

The increasing usage of technologically advanced dynamic positioning systems has further challenged the delineation of "points" contemplated by Section 55102 and the OCSLA. With dynamic positioning, barges, ships, or floating offshore drilling platforms can find and maintain a single position even in the midst of drilling, without ever anchoring themselves physically to the bottom. With respect to dynamically positioned vessels, the CBP has long held that the lack of any permanent or temporary attachment to the seabed operates to exclude such vessels operating over the OCS from becoming coastwise points pursuant to the OCSLA.[149] In order for a vessel to be sufficiently attached to the seafloor to represent a coastwise point, the attachment contemplated by OCSLA must be tangible and physical.[150] A vessel's use of acoustic sound wave signals beamed at the seafloor to maintain a single position does not constitute such an attachment.[151] Furthermore, even if a vessel is connected temporarily to piles by a winch, the CBP has held that a vessel used solely for pipe laying purposes and not for the purpose of "exploring for, developing, or producing resources" from the OCS is not considered "attached" to the seabed as that term is used in the OCSLA and therefore is not a coastwise point.[152]

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[146] CBP HQ H116350 (Jan. 18, 2005).

[147] CBP HQ H110959 (Aug. 8, 1990).

[148] CBP HQ H116350 (Jan. 18, 2005).

[149] CBP HQ H109576 (July 12, 1988); CBP HQ H113838 (Feb. 25, 1997); CBP HQ H115431 (Sept. 4, 2001) see also HQ 115134 (Sept. 27, 2000) (stating that floating offshore service facility vessel would not be subject to Customs and navigation laws pursuant to the OCSLA insofar as "onboard vessel propulsion system," rather than anchoring, was used to maintain the vessel's position next to drilling unit).

[150] CBP HQ H036936 (Jan. 26, 2009).

[151] CBP HQ H036936 (Jan. 26, 2009).

[152] See CBP HQ H115799 (Sep. 30, 2002); CBP HQ H115531 (Dec. 3, 2001); CBP HQ H111126 (Aug. 16, 1990).

6. How Many Coastwise "Points" in a Wind Farm?

Most of CBP's rulings addressing the cabotage requirements and the OCSLA have been issued in the context of offshore oil and gas exploration and production. Most of those, in turn, have related to single-point drilling platforms, wells, or production sites. The construction of an offshore wind farm in the deep waters of the Gulf of Maine conceivably could involve scores of wind turbines all connected in some way to one another via submersible platform, or by cable to a single power conversion station. Would each floating, anchored turbine be considered a "point"? What about a turbine that was one of five attached to the same submersible platform? Though the nature of a wind farm may raise questions not fully contemplated by existing precedent, some guidance may be found in at least one CBP ruling relating to a complex offshore drilling operation.[153] In the context of offshore drilling, a well, wellhead, and wellhead casings, whether active, capped, or temporarily abandoned, are each separate coastwise points.[154] According to CBP, one well's connection to other wells in a so-called Integrated Facility, no matter the distance apart between each well-head, would not negate the fact that the single wellhead is a coastwise point in and of itself.[155] Hence, an Integrated Facility is a location that has several coastwise points, much like a harbor with several piers and docks. [156]

7. Transboundary Issues

To look at a map of the Gulf of Maine, with Cape Cod hooking in from the south, Nova Scotia nosing in from the north, and the Gulf of Maine delimitation line slicing right through the middle, is to realize that the push to bring wind turbines to deeper and deeper waters farther and farther offshore—with "mother ships" stationed offshore for months at a time—has the potential to raise issues similar to those raised by joint management of other transboundary resources.[157] Depending on where the sites are located, there may be overlap or conflict between Maine's jurisdiction and federal jurisdiction, or between the jurisdiction of Maine and other states on the Gulf, or even between United States and Canadian jurisdiction.[158]

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[153] See CBP HQ H036936 (Jan. 26, 2009).

[154] CBP HQ H036936 (Jan. 26, 2009); see also CBP HQ H116350 (Jan. 18, 2005); HQ 113113 (June 28, 1994).

[155] CBP HQ H036936 (Jan. 26, 2009).

[156] CBP HQ H036936 (Jan. 26, 2009) (citing CBP HQ H032257 (Aug. 1, 2008) and CBP HQ W115601 (Feb. 28, 2002), both of which concluded that transportation of merchandise even over very short distances within a harbor must be executed in a coastwise qualified vessel).

[157] See generally 15 Ocean & Coastal L. J. No. 2 (2010); see also id. at 243.

[158] For insightful discussions of the interstate and Federal legal questions and responses regarding wind power development, see Rachael E. Salcido, Offshore Federalism and Ocean Industrialization, 82 Tul. L. Rev. 1355, 1394-96 (2008) (describing the conflicts between property law and preemption, the so-called Seaweed Rebellion, and various possible models for

8. Coastwise-Qualified

A system for the documentation of United States vessels was established by Congress in 1789 in order to regulate coastwise trade.[159] Today, the United States Coast Guard (USCG), in conjunction with the National Vessel Documentation Center, oversees certificates of documentation and determines the eligibility of vessels for a coastwise endorsement to appear on such certificates.[160] The standards for vessel documentation are developed and enforced solely by the USCG, which also applies standards pursuant to the Jones Act to determine the eligibility of vessels for coastwise endorsements to their documentation. To be "coastwise-qualified," a vessel must be built in the United States, owned by United States citizens, documented, and awarded a coastwise endorsement by the USCG pursuant to 46 U.S.C. § 12112.[161] In other words, a "coastwise-qualified vessel" is an American-flagged vessel having a USCG certificate of documentation with a coastwise endorsement.[162]

9. United States Ownership

Ownership by qualified United States citizens or permanent residents must be continuous and uninterrupted.[163] At least 75 percent (%) of the ownership of the vessels must lie in the hands of American citizens.[164] This requirement becomes complicated when confronted with the realities of modern-day vessel ownership,

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collaborative governance of offshore renewable energy development: regional governance, area-based management, and project-based partnerships); see also Jeremy Firestone, et al., Regulating Offshore Wind Power and Aquaculture: Messages from Land and Sea, 14 Corn. J. L. & Pub. Pol. 71, 78-87, 111 (2004) (describing the "hodgepodge" of Federal agencies and regulations likely to have jurisdiction over offshore wind development and proposing that the recent calls for a national ocean policy bring a unique opportunity to create a "one-stop shop" single Federal entity for management of Federal offshore waters). For an insightful discussion of potential transboundary conflicts with Canada and bilateral governance solutions with Canada, see Lucia Fanning & Rita Heimes, Ocean Planning and the Gulf of Maine: Exploring Bi-National Policy Options, 15 Ocean & Coastal Law Journal 293 (2010) (describing the historic and potential future interplay of governance and planning at state, regional, national, and international levels, especially with regards to fisheries and offshore renewable energy).

[159] What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 5, CBP (Jan. 2009), available at http://www.cbp.gov.

[160] *Ibid.;* see also 46 U.S.C. § 12103.

[161] *Ibid.*

[162] *Ibid*. The endorsement requirement applies only to vessels of five net tons or more. Vessels of less than five net tons engaged in coastwise trade must, nonetheless, be properly documented and "coastwise-qualified" in all other respects. See 19 CFR § 4.80(a)(2).

[163] See 46 U.S.C. § 12132.

[164] See 46 U.S.C. § 50501, supra, note 13.

which is often done by corporation or trust, with complex lease and mortgage contracts. [165]

10. United States-built

CBP rulings have specified minimum percentages of steel weight that must be derived from American shipyards in order for a boat to qualify as "built in the United States." Many ships are also rebuilt for new tasks and missions, sometimes incorporating entire sections prefabricated abroad. Rebuilding requirements are also specified by CBP.

11. Penalties

Penalties for violation of cabotage requirements include possible seizure and forfeiture of the illegally transported merchandise, or fines in the amount of the value of the merchandise, or the costs of transportation, whichever is greater.[166]

12. Waivers

Waivers of the statutory requirements relating to cabotage may be issued in the interests of national defense in one of two ways: 1) at the request of the Secretary of Defense, or 2) when the head of one of the enforcing agencies deems such a waiver necessary *and* the U.S. Maritime Administration certifies that no United States vessels are available to meet the national defense requirements in question.[167] A waiver request should include the purpose for which the waiver is requested, the port(s) and/or coastwise points involved, and the estimated period of time for which the waiver is sought.[168] Such waivers were granted where necessary in the aftermath of Hurricane Katrina and in the aftermath of the Deepwater Horizon disaster. They can be highly controversial; even in the midst of the largest environmental disaster the world has seen, many protested the use of foreign oil skimmers in the Gulf of Mexico after the *Deepwater Horizon* explosion. Cabotage waivers were not required for certain foreign-flagged vessels responding to the oil spill because 1) skimming vessels are expressly permitted under 46 U.S.C. § 55113 so long as reciprocal permission would be granted to American skimmers operating abroad, and 2) foreign-flagged vessels not engaged in skimming were operating closer to the spill, which was 40 miles offshore and thus (arguably) outside of the area in which United States cabotage requirements apply. A United States Department of Homeland Security bulletin asserted that "Jones Act jurisdiction extends to three nautical miles off United States shores.... [T]he Jones

[165] See, e.g. 46 USC 12119, MARAD Title XI.

[166] 46 U.S.C. § 55102(c).

[167] 46 U.S.C. § 501.

[168] What Every Member of the Trade Community Should Know About: Coastwise Trade: Merchandise 9, CBP (Jan. 2009), available at http://www.cbp.gov.

Act simply does not apply to vessels skimming oil outside of three nautical miles from the United States coast."[169] Regardless of this legal debate, the consensus is that waivers are costly and difficult to apply for, especially considering that the chances are slim of obtaining one. Though an argument could be made, the need to shoehorn offshore wind development into the requirement for an urgent national security rationale would likely make the task even more futile.

13. Certain Exceptions

Notwithstanding the often strict application of the cabotage laws, there are some exceptions. One of these allows for non-coastwise-qualified vessels to transport "platform jackets" and other related apparatus that are ubiquitous in offshore drilling rig construction.[170] It should be noted that structures qualifying as platform jackets in this section include tension-leg platforms and SPAR platforms,[171] both common submersible substructures in deepwater drilling, and, more importantly, both of which are proposed in designs for deepwater floating wind turbines.[172] To qualify for this exception, the carrier must first obtain a determination from MARAD as to the unavailability of a United States-flagged vessel to do the same job of transport.[173]

An additional exception for "new and different products" allows for merchandise to be laden at a coastwise point by a foreign-flagged vessel, transported to a foreign port, and returned to another coastwise point without implicating the coastwise laws, so long as the merchandise is manufactured or processed into a different product.[174] This exception has been successfully invoked to permit a foreign-flagged vessel to bring petroleum products from the United States to Canada for refining, only to bring the refined petroleum product back into the United States[175] The same exception might apply to the shipping of wind turbine

[169] Press Release, Deepwater Horizon Spill Response: Jones Act Fact Sheet, U.S. Department of Homeland Security (July 6, 2010).

[170] 46 U.S.C. § 55108.

[171] *Id.* at (a)(2).

[172] See DeepCwind Consortium, Press Kit 9, Sept. 14, 2010, www.deepcwind.org/docs/PRESSKIT_20100914.pdf.

[173] 46 U.S.C. § 55108(b).

[174] 19 CFR § 4.80b(a) ("A coastwise transportation of merchandise takes place, within the meaning of the coastwise laws, when merchandise laden at a point embraced within the coastwise laws ("coastwise point") is unladen at another coastwise point, regardless of the origin or ultimate destination of the merchandise. However, merchandise is not transported coastwise if at an intermediate port or place other than a coastwise point (that is at a foreign port or place, or at a port or place in a territory or possession of the United States not subject to the coastwise laws), it is manufactured or processed into a new and different product, and the new and different product thereafter is transported to a coastwise point.").

[175] CBP HQ H116650 (June 9, 2006).

components for manufacture into turbines and then installation by a vessel, which need not be "coastwise-qualified." It is as yet unclear, however, whether this exception could be put to any significant use in the development of an offshore wind farm with multiple wind turbine installations.

14. Towing

It is unlawful for any vessel not wholly owned by a citizen of the United States to tow any other vessel from point to point in coastwise waters, except in cases of distress.[176] This prohibition applies to the towing of vessels between any coastwise points and includes the towing of vessels carrying valueless or dredged material between one point in the United States or on the high seas within the EEZ and another point in the United States or on the high seas within the EEZ.[177]

15. Dredging

With very limited exceptions, a vessel may engage in dredging in the navigable waters of the United States only if it is coastwise qualified and properly documented and endorsed. If the vessel is chartered, the charterer must also be a citizen of the United States.[178] With that said, the sort of "dredging" that occurs for the laying of cable or pipe, or the planting of a piling is not considered to be dredging that would violate section 55109. CBP has held that fluidization of the seafloor, *i.e.*, temporarily displacing sediment and allowing a pipe to sink into the seafloor by its own weight, did not constitute an engagement in dredging for purposes of 46 U.S.C. § 55109.[179] With respect to the use of cable burial devices employing a jetting action resulting in the emulsification of the seabed surrounding the cable, CBP has also long held that such an operation does not constitute an engagement in "dredging" for purposes of the 46 U.S.C. § 55109.[180] This is a key exception as it would relate to the installation of electric transmission and other cables from shore out to a wind power facility.

16. Salvage

Foreign vessels are generally prohibited from engaging in salvaging operations on the Atlantic or Pacific coast of the United States, in any portion of the Great Lakes or their connecting or tributary waters, including any portion of the Saint Lawrence River through which the international boundary line extends, or in territorial waters of the United States on the Gulf of Mexico.[181] Cabotage

[176] 46 U.S.C. § 55111(a).

[177] 46 U.S.C. § 55109.

[178] 46 U.S.C. § 55109.

[179] See CBP HQ H115972 (Apr. 22, 2003); CBP HQ H115823 (Oct. 28, 2002).

[180] CBP HQ H012082 (Aug. 27, 2007).

[181] 46 U.S.C. § 80801.

requirements would thus apply to any recovery of damaged or lost off-shore wind farm components or of the vessels servicing wind farms. Will the salvage provisions be extended from territorial waters to the outer limits of the EEZ? If the nearest available American salvage tug is in New York, can a salvage tug from St. John, New Brunswick respond to help at a United States wind farm in the Gulf of Maine? The question of who will or will not have legal rights to engage in salvage of foundering installation vessels, or turbines that have sunk to the sea floor, should be contemplated and addressed ahead of time, especially since such questions otherwise usually tend to arise under emergency circumstances.

17. Workers' Claims/Personal Injury

Section 30104, the other provision commonly known as the "Jones Act," provides that a seaman injured in the course of employment (or, if the seaman dies from the injury, the personal representative of the seaman) may elect to bring a civil action at law, with the right of trial by jury, against the employer. This provision, however, is not as simple in its application as it may seem on its face. Particular controversy surrounds the definitions of "seaman," "vessel" (again), and "navigating." These controversies have played out in countless court decisions over the years, but as liability claims in the event of injury would be a secondary issue in preparing for offshore wind development, the complexities of this "Jones Act" lie beyond the scope of this chapter.

CBP Interpretations of United States Cabotage Laws of Potential Significance to the Development of Off-shore Wind Power

Following are summaries of several CBP decisions interpreting United States cabotage laws in ways that may instruct offshore wind development.

- CBP has long held that neither drilling nor pile driving, in and of itself, conducted by a stationary vessel, constitutes coastwise trade or coastwise transportation.[182]
- CBP recently found that the driving of a monopile foundation into the seabed to fix a meteorological platform at the surface was substantially similar in nature and so would not violate cabotage requirements.[183] Where a foreign-constructed vessel would be stationary while undertaking the emplacement of a monopile foundation and other components of a meteorological tower and would not transport anyone from one port or place to another within the United States; where that vessel furthermore will come from abroad with only

[182] CBP HQ H105415 (May 27, 2010); see also HQ 109817 (Nov. 14, 1988); HQ 111412 (Nov. 28, 1990).

[183] CBP HQ H105415 (May 27, 2010).

its crew, none of whom would disembark or be considered a passenger, as defined in 19 CFR § 4.50b(a), there is no violation of 46 U.S.C. § 55103.[184]

- CBP has long held that the use of vessel-mounted crane to load and unload cargo or construct or dismantle a marine structure is permissible so long as "any movement of merchandise is effected exclusively by the operation of the crane and not by movement of the vessel, except for necessary movement which is incidental to a lifting operation while it is taking place."[185] In so holding, however, CBP has drawn a fine line to prohibit any non-incidental, lateral movement of *the vesse*l in such a situation.[186] In HQ 115630 dated March 25, 2002, CBP held that where lateral movement of the entire floating crane/barge was required to lift and place its load, such activity constituted the coastwise transportation of merchandise because it exceeded movement necessary and incidental to a lifting operation.[187] Thus, a crane barge could lift merchandise with its crane at one coastwise point, be pivoted while remaining at one location, and put down the merchandise at a place other than that from which it was lifted.
- A crane barge would be prohibited from lifting merchandise with its crane at one coastwise point, being towed or pushed or otherwise moving to another coastwise point while the merchandise is suspended from the crane, and placing the merchandise at a second coastwise point.[188] CBP has drawn an even finer line in permitting lateral rotation of a vessel around a central axis, but barring lateral movement around a fulcrum point at one end of the vessel.[189]

7.3.3 Keeping a Weather Eye: Recent, Ongoing, and Potential Near-Future Developments in the Law

A number of technical revisions were made during the recodification of the cabotage laws in 2006, but there has thus far been no discernible movement to change them to accommodate offshore wind energy development. On the other hand, there has been a heated debate in the aftermath of the *Deepwater Horizon* disaster over whether the oil spill clean-up was hampered by the Jones Act provisions. This added attention to the Act brought calls for its modification or repeal from the likes of Senators Kay Bailey Hutchison, John Cornyn, and John McCain. Senators Hutchison and Cornyn co-

[184] CBP HQ H105415 (May 27, 2010).

[185] CBP HQ H116225 (May 6, 2004).

[186] See, e.g., CBP HQ H106351 (Nov. 1, 1983); HQ H113858 (Apr. 4, 1997).

[187] CBP HQ H115630 (Mar. 25, 2002).

[188] CBP HQ H106351 (Nov. 1, 1983) and CBP HQ 108213 (Mar. 6, 1986).

[189] CBP HQ H115181 (Apr. 21, 2003).

sponsored legislation known as the Water Assistance from International Vessels for Emergency Response (WAIVER) Act (S.3512), which would have waived the Act for purposes of spill clean-up, as, they said, had been done in the aftermath of Hurricane Katrina.[190] Meanwhile, Senator McCain sponsored legislation that would have outright repealed the Jones Act.[191] Neither bill made it out of committee.[192] Defenders of the cabotage laws insist that they did not hamper the clean-up at all, given that foreign oil skimmers are expressly allowed to engage in clean-up activities offshore, and the Department of Homeland Security was able to issue a number of waivers where needed.

The following bills, or elements thereof, to the extent they have not already been addressed by agency action, can be expected to resurface in the 112th Congress in one form or another:

- The Consolidated Land, Energy, and Aquatic Resources Act (CLEAR) of 2009, is a wide-ranging bill that proposes, *inter alia*, to reorganize and consolidate the various federal administrative bodies governing minerals and energy into a single office at the Department of the Interior.[193] However, in two relatively unobtrusive provisions, it would also prescribe a definitive policy regarding the eligibility of vessels working on offshore wind farms. Insofar as OCSLA was originally written primarily with an eye towards offshore oil and gas production, its terms reflect the uses of those industries.[194] Consequently, there is no question in CBP rulings that the cabotage laws were extended along with all other American laws to oil and gas activities on the OCS in 1978.[195] However, the increasing interest in offshore development of alternative energy sources such as wind power begs the question whether the OCSLA amendment also applies to these activities. At this time, there seem to be no clear answers to this question.

  With two key provisions, however, the CLEAR Act proposes to resolve much

[190] The Water Assistance from International Vessels for Emergency Response Act, S.3512, 111th Cong. (2010).

[191] Open America's Waters Act, S. 3525, 111th Cong. (2010).

[192] See S. 3512: Water Assistance from International Vessels for Emergency Response Act, http://www.govtrack.us/congress/bill.xpd?bill=s111-3512; S. 3525: Open America's Waters Act, http://www.govtrack.us/congress/bill.xpd?bill=s111-3525.

[193] Consolidated Land, Energy, and Aquatic Resources (CLEAR) Act of 2009, H.R. 3534, 111th Cong. (2009).

[194] Major Maritime Reform Efforts Advancing in the U.S. Congress Go Well Beyond the DEEPWATER HORIZON Incident, Winston & Strawn, LLP (Aug. 2010), available at www.winston.com/siteFiles/Publications/MaritimeReReformBills.pdf.

[195] See, e.g. CBP HQ H107579.

of this uncertainty. Section 204 of the CLEAR Act of 2009 would amend the jurisdictional section in OCSLA to explicitly encompass exploration, development and production of not only oil and gas, but also "energy from sources other than oil and gas."[196] Presumably, just as coastwise laws were extended to offshore oil and gas production in 1978, this would effectively apply already existing coastwise requirements to all offshore wind development as well.

However, to remove all doubt, in the so-called "EEZ Americanization amendment" the CLEAR Act goes one step farther.[197] Certain activities, such as drilling, construction activities, and pipe- and cable-laying, have historically not required the use of a coastwise-qualified vessel. Section 709 of the CLEAR Act, however, would extend Jones Act-like restrictions to any such activity engaged "in support of exploration, development, or production of resources on, in, above, or below the exclusive economic zone."[198] If enacted, this provision would apply "only with respect to exploration, development, production, and support activities that commence on or after July 1, 2011."[199] The next question, of course, is whether such an express statutory clarification implies that such Jones Act-like requirements would *not* apply *before* July 1, 2011. However, the answer to this question is likely to bear upon only a very small number of offshore wind projects already at an advanced stage. The CLEAR Act passed the House on July 10, 2010, but has not yet made it to the Senate floor.

- In the meantime, the Department of Interior reorganized the Minerals Management Service. Under its new name, the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), its mission will be modified to avoid the conflicts of interest that arose in the MMS. In addition, the Board of Safety and Environmental Enforcement has been created to enforce safety and environmental regulations.

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[196] Consolidated Land, Energy, and Aquatic Resources (CLEAR) Act of 2009, H.R. 3534, 111th Cong. (2009).

[197] See Major Maritime Reform Efforts Advancing in the U.S. Congress Go Well Beyond the DEEPWATER HORIZON Incident, Winston & Strawn, LLP (Aug. 2010), available at www.winston.com/siteFiles/Publications/MaritimeReReformBills.pdf.

[198] Consolidated Land, Energy, and Aquatic Resources (CLEAR) Act of 2009, H.R. 3534, 111th Cong. (2009).

[199] Consolidated Land, Energy, and Aquatic Resources (CLEAR) Act of 2009, H.R. 3534, 111th Cong. (2009).

- The POWERED (Program for Offshore Wind Energy Research and Development) Act of 2010 sponsored by Sen. Sherrod Brown proposes to implement a number of programs and incentives for wind power development. The bill has been referred to the Committee on Energy and Natural Resources.
- Senator Hutchison proposed legislation known as the Water Assistance from International Vessels for Emergency Response Act (S.3512), which sought to provide waivers for foreign vessels helping with *Deepwater Horizon* response. It was referred to the Commerce Committee but did not come up for a vote, as the Department of Homeland Security granted those waivers that were required.
- The Clean Energy Jobs and Oil Company Accountability Act of 2010 (S.3663), a broad bill including, for example, the Outer Continental Shelf Lands Reform Act of 2010 (S.3516), which proposes to reform management of the leases on the OCS, was reported out by its committee but did not come up for a full vote in the Senate.

Meanwhile, the Department of the Interior, in addition to its reorganization of the Minerals Management Service, has also announced its intent to speed the development of offshore wind power. To this end, it has begun to institute a "Smart from the Start" permitting process, and BOEMRE has formed task forces with a whole host of states, including Maine.

7.3.4 Conclusion

Private energy developers have ramped up the level of their own investment and planning activity, with at least eight developers expressing interest in building wind farms on the Atlantic seaboard and three industry conferences scheduled for 2011 in the Northeast alone. In Massachusetts, *Cape Wind* has received its final pre-construction approvals, and in Rhode Island *Deepwater Wind* is planning to construct the first "second-generation" offshore wind farm in the country. As a consequence of cabotage requirements, a number of these companies have teamed with American shipyards to begin developing a fleet for construction of offshore wind construction and maintenance vessels. Pursuant to the final report of the Governor's Ocean Energy Task Force, the Maine legislature announced findings and a statewide policy that steer strongly toward offshore wind development. In late January 2011, the Department of Conservation and Maine Land Use Regulation Commission (LURC) began seeking public comment on a proposed rule change that would house much of the permitting for offshore wind development with LURC.

Despite this activity, the only signs of CBP action to modify the maritime cabotage laws have come in the form of one aborted attempt to modify and review some controversial ruling letters regarding the transportation of merchandise and one aborted attempt to engage in proposed rulemaking. Trade interests rallied to kill the first effort, while the public never knew the content of the second, much less why it was abandoned.[200] MARAD, meanwhile, continues to offer a variety of grants and incentives to promote the construction and repair of American vessels in the United States.

Cabotage is a crucial issue in offshore wind farm development because installation of offshore wind turbines requires specialized vessels and portside infrastructure, both currently lacking in the United States.[201] Barring CBP action, wind power developers will need to focus on helping to establish an American fleet capable of supporting and servicing off-shore wind development, cognizant of the complex legal, financial, and logistical maneuvers that would be involved in utilizing foreign vessels and crews to work on wind farms, affecting change to the cabotage laws and regulations, or some combination of all three.

A new bill moving through Congress would require the use of United States-owned and operated vessels for "exploration, development or production of resources" in the United States exclusive economic zone (EEZ), which extends 200 miles offshore. The proposal could extend beyond oil and gas to new ventures such as offshore wind farms. [202] Until CBP or Congress acts, though, precise answers to the question of whether and how the cabotage laws apply to offshore wind development will remain uncertain.

[200] Charlie Papavizas, Customs Goes Back to the Drawing Board (Again) on Jones Act Equipment Exception, Posted Nov. 16, 2010, http://www.winston.com/index.cfm?contentID=19&itemID=222&itemType=25&postid=382.

[201] Dale K. DuPont, Acting Up, Workboat.com (Dec. 1, 2010), http://www.workboat.com/newsdetail.aspx?id=4295000187. See DOE Report.

[202] Dale K. DuPont, Acting Up, Workboat.com (Dec. 1, 2010), http://www.workboat.com/newsdetail.aspx?id=4295000187.

8.0 Findings

This report consists of the compilation and preliminary analysis of relevant data on the Gulf of Maine, to provide important information for parties seeking to respond to the RFP (***Request for Proposals for Long-Term Contracts for Deep-Water Offshore Wind Energy Pilot Projects and Tidal Energy Demonstration Projects***) released September 1, 2010 by the Maine Public Utilities Commission (PUC). The RFP calls for bidders to propose the sale of renewable energy produced by a deep-water offshore wind energy pilot project that is connected to the electrical transmission system located in the State and employs one or more floating turbines in the Gulf of Maine (GoM) at a location 300 feet (91 m) or greater in depth no less than ten (10) nautical miles from any land area of the State other than coastal wetlands or an uninhabited island. As specified in the Act (see Appendix E.1 in Section 10.5.1), the PUC may authorize one or more long-term contracts for an aggregate total of no more than 30 megawatts (MW) of installed capacity and associated renewable energy and renewable energy credits (RECs) from deep-water offshore wind energy pilot projects or tidal energy demonstration projects. No more than five (5) MW of the total can be supplied by a tidal energy project. Among other requirements (see Appendix E.2 in Section 10.5.2), bidders must demonstrate in their proposals the potential to construct a deep-water offshore wind energy project of 100 MW or greater capacity in the future.

8.1 REGIONAL ANALYSIS CRITERIA

In evaluating the potential for the initial development of up to a 30 MW floating offshore wind project and larger commercial-scale (100 MW and larger) project in federal waters off the coast of Maine, the following criteria are considered:

- Met-ocean conditions/wind resource
- Bathymetry
- Distance to coastline
- Environmental resource impacts
- Distance to grid interconnection
- Constructability and supply chain availability

The key aspects of each criterion are described more fully in the following subsections.

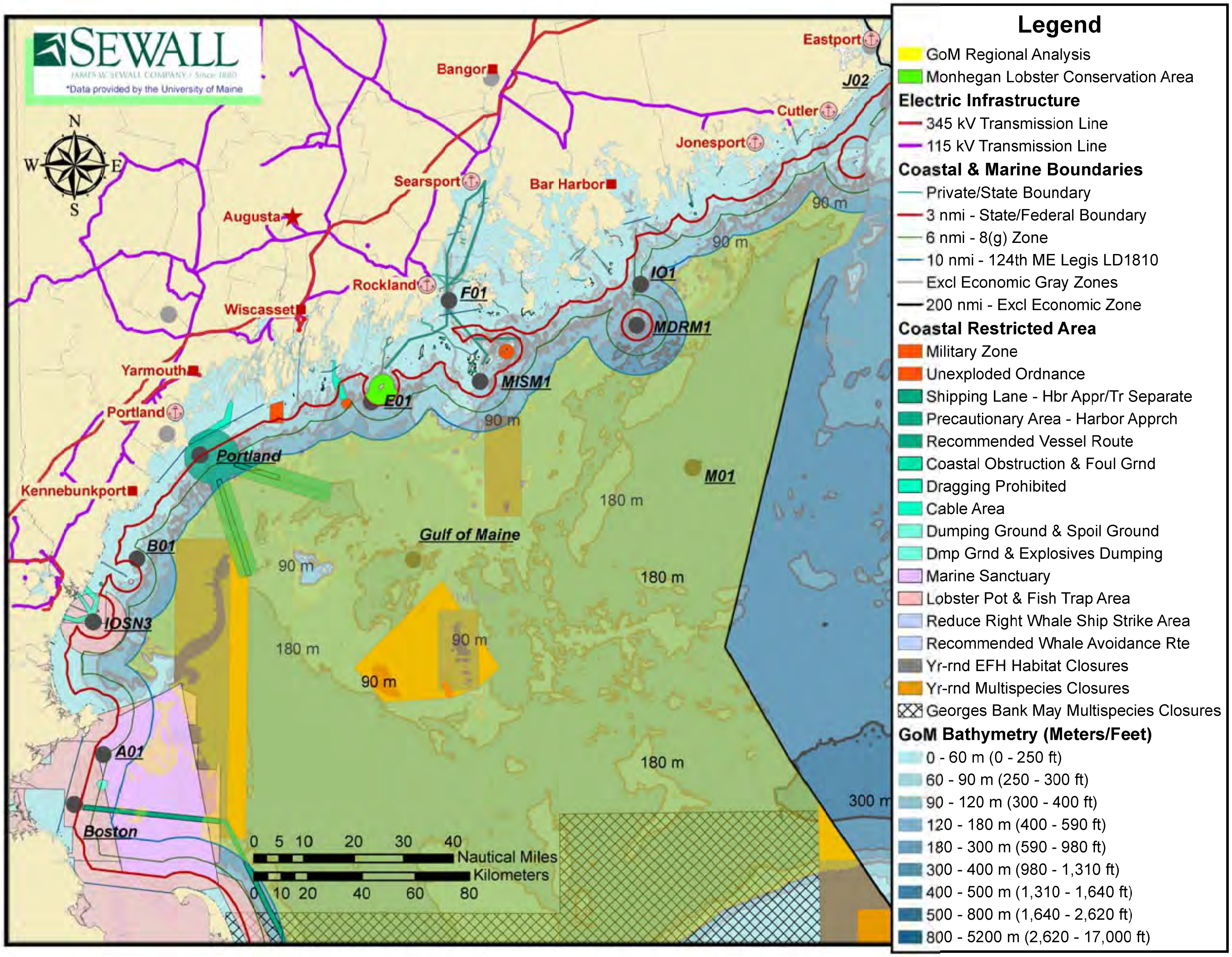

Figure 8-1: Gulf of Maine Offshore Wind Energy Regional Analysis

8.1.1 Met-ocean Conditions/Wind Resource

The GoM consistently exhibits mean annual wind speeds of at least eight meters per second (8 m/s) (Class 6+) at 50 m elevation, based on wind resource estimates from the Department of Energy (DOE) National Renewable Energy Laboratory (NREL), at distances ten (10) nmi or greater from the coastline (See Figure 5-3). In addition, buoys and land-based weather stations within the GoM have nine (9) to 31 years of recorded wind measurements. Estimates using data from these buoys are generally consistent with the NREL estimates, and suggest even better wind resource at a hub height of 65 m than predicted by NREL at a height of 50 m. This increase in wind speed with elevation is consistent with the power law approximation of the wind speed profile.

8.1.2 Bathymetry

Based on depth soundings data for the GoM compiled by Roworth and Signell (1998) of the USGS, the GoM consistently exhibits depths greater than 300 ft (90 m), the minimum depth required by the PUC RFP, at distances ten (10) nmi or greater from the coastline (See Figure 3-8).

8.1.3 Distance to Coastline

The PUC RFP specifies (and as put forth in LD1810) that offshore renewable energy pilot projects must be a minimum of ten (10) nmi from any land area of the State of Maine other than coastal wetlands and uninhabited islands.

8.1.4 Environmental Resource Impacts

The primary environmental resources of concern for offshore wind projects include migratory birds, bats, and threatened and endangered marine species (e.g., North Atlantic right whales). For the subsea cable route and nearshore construction, assembly and wet storage areas, impacts to coastal wildlife (including coastal seabird nesting areas), essential fish habitat areas, and coastal threatened and endangered species (e.g., Atlantic Salmon and Atlantic Sturgeon) are also important considerations (See Figure 5-7 and Figure 5-8 showing coastal wildlife and migratory marine species activities).

Care should be taken to (1) avoid marine sanctuaries and minimize potential impacts to critical habitat areas for coastal wildlife and marine species, and (2) minimize intersections with Seasonal Management Areas (SMAs) and Dynamic Management Areas (DMAs), which represent areas of mandatory and voluntary, respectively, vessel speed restrictions due to increased North Atlantic right whale activity (See Figure 5-8 and Figure 8-1).

8.1.5 Distance to Grid Interconnection

Minimizing the distance to grid interconnection is particularly important to managing the overall development and construction costs of the offshore wind project. An interconnection pre-feasibility study was conducted as part of the development of this report (See Section 4.0). The key findings of this study regarding distance to grid interconnection points and related subsea cable route include the following:

- Existing substations have been located along the southern coast and Midcoast areas with the capacity to handle energy from a "stepping stone" offshore wind farm of up to 30 MW, including 15 substations located in the southern and Midcoast areas;
- Potential subsea cable routes have been identified for the western portion of the regional analysis domain and that the cable length in that region will be limited to less than 45 km; however, additional studies are needed to plan and design subsea cable routes, with an emphasis on geophysical and coastal engineering characteristics of the route; and
- Biological assessments, including evaluation of critical habitat areas, for Endangered Species Act (ESA)-listed species and Essential Fish Habitat (EFH)-managed species will be needed for final cable route selection

Based on data currently available, it appears the best and most flexible interconnection points are located within the Bath, Wiscasset, Boothbay and Rockland areas (See Figure 5-6).

8.1.6 Constructability and Supply Chain

Midcoast Maine and the Penobscot Bay area have adequate facilities and capabilities to support early stage development of a floating offshore wind farm (See Section 6.0). The following are key points regarding available resources in this region:

- Available assembly and wet storage areas in Penobscot Bay, east of Islesboro, with existing port infrastructure and potential industrial waterfront availability in nearby Searsport. This provides construction/assembly and storage/office areas within a reasonable distance from each other via water or land transport.
- Large, medium and small crane, barge, support vessels and other resources available within the region, or within the nearby neighboring northeastern states. Local companies have established relationships with supply and equipment resources throughout New England and the East Coast.
- Local contractors and construction firms experienced with offshore construction and onshore wind power projects.

- Maritime skills and shipbuilding heritage including experience building complex naval vessels and repairing steel ferries and barges.
- Presence of support industries, such as marine steel fabrication and composite materials manufacturing.
- Ready access to railways, road and interstate systems, and airports for supply chain accessibility and transportation.

8.2 EVALUATION AND DEVELOPMENT OF FLOATING PLATFORM DESIGNS BY THE UNIVERSITY OF MAINE

Under funding from DOE, the University of Maine (UMaine) has undertaken a multi-year program focused on the development and testing of floating offshore wind energy platforms. As part of this program, UMaine has led a thorough evaluation of more than fourteen different platform technologies submitted by designers from around the world. Starting in 2011, the first of these platform concepts will be designed at an intermediate (approximately 1/3) scale to carry a 100 kW turbine. This first intermediate-scale platform will be fabricated and deployed into UMaine's Deepwater Wind Demonstration Site off Monhegan Island in July 2012, for a period of approximately three to four months. Performance data will be gathered during this deployment, and will be used to refine the design for potential full-scale development. UMaine is currently developing plans to build and deploy additional intermediate-scale platforms in 2013 and 2014, to evaluate multiple platform technologies, validate numerical models, and study the interaction of the platforms with the environment.

8.3 CRITICAL ISSUES

Activities regarding wildlife and habitats are regulated at the federal level under the Endangered Species Act (ESA), the Migratory Bird Treaty Act (MBTA), the Bald and Golden Eagle Protection Act (BGEPA), and the Marine Mammal Protection Act (MMPA) by the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). Though Bald Eagles have now been de-listed as endangered by USFWS, the provisions set forth in the BGEPA remain in place with modifications. For more information on modifications to 'taking' under BGEPA see the following USFWS web site: http://www.fws.gov/midwest/eagle/protect/fnlpermitregs_qas.html.

At the state level, the most recent revision to the listed species under Maine Endangered Species Act (MESA) occurred in May 2007, and is available at the following web site: http://mainegov-images.informe.org/ifw/wildlife/species/pdfs/etlist_recommendations.pdf. There is a separate list of threatened and endangered marine species maintained by DMR, which is available from the following web site: http://janus.state.me.us/legis/statutes/12/title12sec6975.html.

The listed threatened and endangered marine species in the GoM include Atlantic salmon and the North Atlantic right whale. The Atlantic sturgeon has been proposed to be listed as a threatened species. The critical habitat for the GoM Distinct Population Segment (DPS) of Atlantic salmon is designated to include all perennial rivers, streams, and estuaries connected to the marine environment. The Atlantic salmon critical habitat is depicted in Figure 8-2. The GoM DPS is divided into three salmon habitat recovery units (SHRUs), which are the Downeast Coastal SHRU, the Penobscot Bay SHRU and the Merrymeeting Bay SHRU (Federal Register, 19 June 2009). While the critical habitat does not include areas along the OCS, these habitat areas will need to be considered carefully, and potential impacts minimized, in the routing of the proposed subsea cable to the onshore interconnection point.

NMFS recently (6 October 2010) proposed a rule change that would list Atlantic sturgeon as "threatened" because of the threatened destruction, modification or curtailment of its habitat or range. The GoM DPS includes all Atlantic sturgeon in watersheds ranging from the Maine/Canadian border and extending southward to include all associated watersheds draining into the GoM and wherever these fish occur in coastal bays, estuaries and the marine environment. Atlantic sturgeon have been documented in the Penobscot, Kennebec, Androscoggin, Sheepscot, Saco, Piscataqua and Merrimack Rivers. The Kennebec River is currently the only known spawning river in the GoM area, however the Penobscot, Sheepscot, Androscoggin and Merrimack River have supported spawnings in the past (Federal Register (FR), 6 October 2010). Two of the threats identified for the Atlantic sturgeon habitat include dredging and water quality. Environmental impacts of dredging include removal or burial of organisms, increased turbidity and contaminant resuspension, noise and alterations to physical habitat. Similar environmental impacts might be anticipated for subsea cable trenching and burial operations. Atlantic sturgeon habitat will need to be considered carefully in selecting the subsea cable route to the onshore grid interconnection.

The North Atlantic right whale has been listed as endangered under the ESA since 1973, and is also designated as depleted under the Marine Mammal Protection Act (MMPA). On September 16, 2009, a petition was filed with the National Marine Fisheries Service (NMFS) requesting that the critical feeding and calving habitat area for the North Atlantic right whale be expanded to include state and federal waters off the coast of every state along the eastern seaboard from Maine to Florida. The petition focused on the New England coast in particular, requesting that all waters north of Cape Cod out to 200 nmi be designated as critical habitat. Furthermore, the petition identified that potential threats related to offshore wind energy development could include noise pollution during installation of offshore platforms and as part of ongoing operations (Butler and Taylor, 2009). The petition summarized several supporting studies, including a 2008 evaluation of foraging habitat and potential overwintering habitat in the GoM. On 6 October 2010, NMFS announced their findings and determination on how to proceed with respect to the petition. NMFS found that the petition presented substantial scientific information indicating that the requested revision may be warranted. Accordingly, NMFS now intends to continue the rulemaking process with the expectation that a revised critical habitat rule will be published in the Federal Register in the second half of 2011 (Federal Register, 6 October 2010). The NMFS finding is available on the Internet at http://www.nero.noaa.gov/nero/regs/. The expansion of the critical habitat area could significantly impact the permitting of the offshore wind energy pilot project and larger commercial-scale project. As such, concentrated feeding and calving habitat areas should be avoided in the final offshore project site selection.

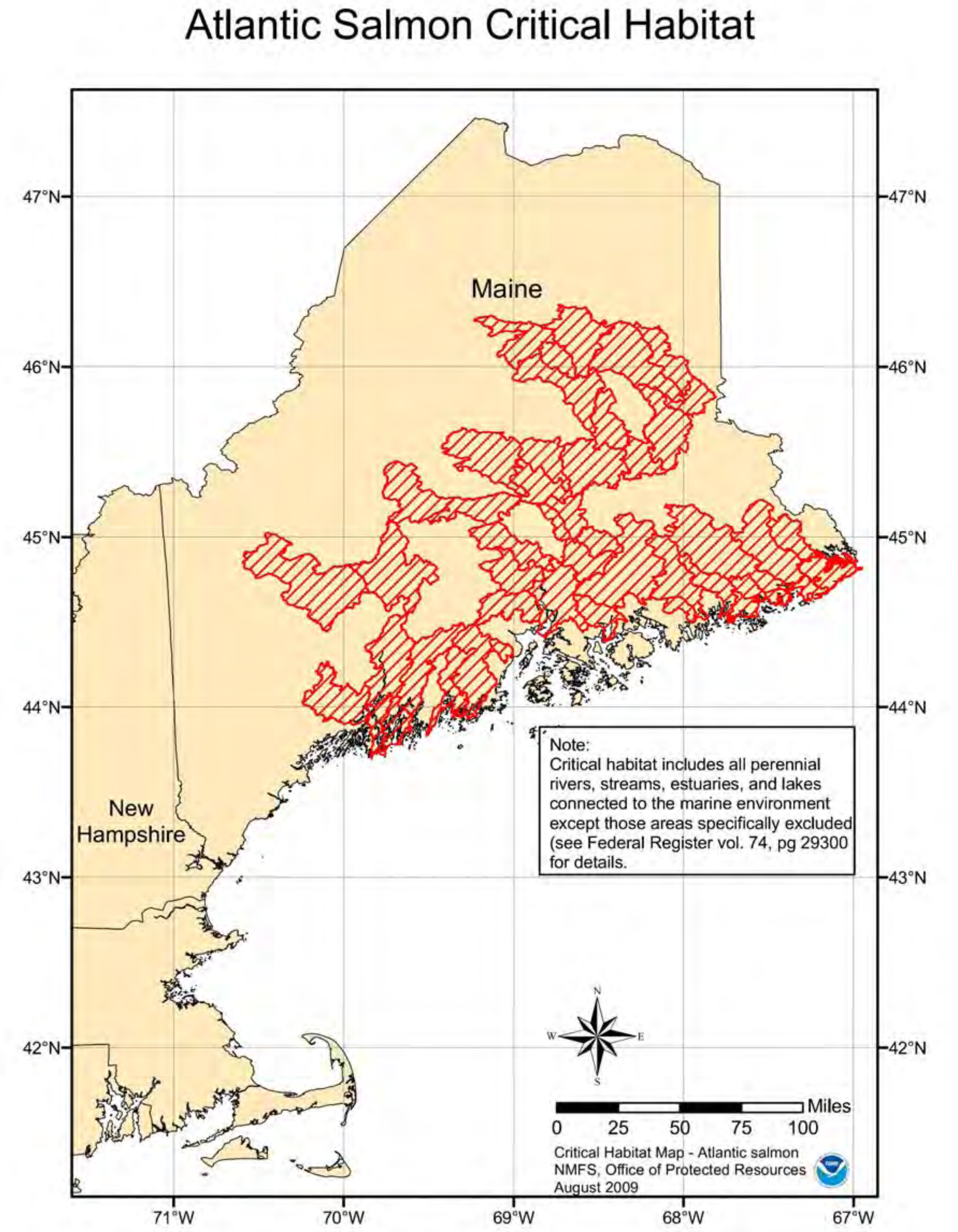

Figure 8-2: Atlantic Salmon Critical Habitat (NMFS, Office of Protected Resources, August 2009)

Most issues above regarding wildlife and habitat can be and will likely be addressed by adaptive management, after an Environmental Assessment (EA) or Environmental Impact Statement (EIS) is presented. The adaptive management plan is likely to include, in addition to known information and known field studies, letters of support and documentation from national and regional experts. Currently, the Cape Wind EIS is used as the blueprint for EA and EIS preparations for offshore wind energy projects. This EIS included the discussion of impacts on the following resources (both at the staging site and the construction site): oceanographic properties (primarily physical ocean properties including water temperature, salinity, visibility, water quality, etc.), geology (bathymetry, surficial soils, substrate, etc.), atmospheric properties (wind resource, air quality, etc.), coastal and marine wildlife, avian species and bats, shellfish, lobsters, finfish, benthic habitat, cultural resources (historical and native lands), viewsheds (landscapes and seascapes), and social, economic, and recreational impacts.

In order to expedite the permitting process, the authors recommend preparation of an extended biological assessment for the proposed project area to (1) evaluate the effects of the project on the co-located species and (2) identify reasonable and prudent alternatives regarding impacts on wildlife and habitats such that the project can proceed. Likewise, it is recommended to prepare an Incidental Take Statement consistent with ESA provisions or to apply for an "Incidental Take Permit" through USFWS or NMFS depending on the species of concern. In preparation for an Incidental Take Permit, a habitat conservation plan is developed which describes the actions taken to monitor, minimize, and mitigate any impacts to the threatened species. The habitat conservation plan also includes alternative actions and justification for why the "no action" option is unreasonable.

In a related manner, the MMPA prohibits, with some exceptions, the taking of marine mammals from US waters. One exception is that NMFS or USFWS may authorize, for a period of not more than five consecutive years, the "incidental" taking of a small number of marine mammals. These small numbers of incidental takes may be authorized if they are found to have a negligible impact on the species or stocks (Vann, *Wind Energy: Offshore Permitting*, CRS R40175, 2009). See 50 C.F.R. § 18.27 (USFWS regulations); 50 C.F.R. Part 216, Subpart I (NMFS regulations) for more information.

Though the United States Fish & Wildlife Service (USFWS) has not set specific actions regarding the Migratory Bird Treaty Act (MBTA) and permitting for wind turbines, they have adopted voluntary interim guidelines to minimize wildlife impacts from wind energy turbines (http://www.fws.gov/habitatconservation/wind.pdf). Compliance with the USFWS interim guidelines does not protect against prosecution for MBTA violations. However, Vann's report (2009) suggests that those groups "who have made good faith efforts to avoid the taking of migratory birds" are viewed favorably by the USFWS and the Department of Justice.

8.4 PERMITTING CONSIDERATIONS

The permitting process with state and federal regulatory agencies will play a key role in the ultimate success of offshore wind development and will likely represent the critical path in the project development timeline. Early coordination and regular meetings with the permitting authorities will be critical to managing the overall permitting process. Assembling a team of qualified consultants (e.g., engineers, ecologists, environmental scientists and permitting specialists) and environmental attorneys with permitting experience and relationships with the regulatory agencies will also be critical to project success.

While the permitting process is complex and multi-layered, with many overlapping jurisdictions among regulatory agencies at the state and federal levels, the following represent some of the most important factors to consider in permitting an offshore wind energy project off the coast of Maine:

- The Energy Policy Act of 2005 (EPAct 2005) designated Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service (MMS), the lead federal agency for offshore wind projects located in the Outer Continental Shelf (OCS) region (federal waters between three (3) nmi and 200 nmi from the coastline). The existing BOEMRE process for issuing an OCS lease includes both a National Environmental Policy Act (NEPA) review and a Coastal Zone Management Act (CZMA) consistency determination. The process is quite lengthy and may require seven to ten years to obtain successfully the necessary state and federal approvals. The State of Maine has formed a joint task force with BOEMRE and is in consultation to develop the *Maine Deepwater Wind Energy Pilot Project*, a streamlined process that would provide a three-year environmental review and approval process once BOEMRE determines no competitive interest for an OCS lease or selects a potential lessee through its competitive process. The process stipulates that the lessee will have 60 days to submit a Site Assessment Plan (SAP) to BOEMRE once they are selected through a competitive process or no competitive interest is determined.
  The SAP, among other state and federal permit applications, will likely require 18 to 24 months of environmental monitoring (e.g., birds, bats and marine mammals) and at least six months of preparation time. Even under the streamlined process, this represents up to a five-year permitting process with BOEMRE (two (2) years for environmental studies and surveys plus an additional three (3) years for the application process), which is a critical path timeline for the project. A key feature of the Maine pilot project is that the project's wind turbines and transmission interconnection could be built and operated commercially as technology testing during the five-year site assessment period following BOEMRE approval of the SAP. It will be extremely important for developers to work with the Governor's office and

the members of the Maine-BOEMRE task force to get clarification and assurance from BOEMRE that they will be following the streamlined process for a proposed up to 30 MW pilot project. Any larger future projects, particularly in the 100 – 300 MW range, are likely to require a longer permitting schedule through the full BOEMRE leasing and environmental review process.

- The other major component of the offshore wind project, the subsea cable route to shore and the land-based transmission line to the electric grid interconnection point, will require federal permitting with the United States Army Corps of Engineers (USACE) (Section 404 of the Clean Water Act (CWA)/Section 10 of the Rivers and Harbors Act (RHA). This permit will be particularly focused on impacts to coastal marshland, mudflats, and coastal and freshwater wetlands. As offshore wind energy is a new technology in the United States, the USACE Section 404/Section 10 permits will be treated and reviewed as a joint application for an Individual Permit. These permits typically require 6-12 months for review; however the permit application review process can take as long as 18 months depending on the number of comments and additional monitoring or investigation requests from the resource agencies (e.g., USFWS, NMFS, etc.) and other regulatory agencies commenting on the permit application. Developers can apply for the USACE permits concurrent with the BOEMRE OCS lease; therefore the Army Corps permitting timeframe is not anticipated to be critical path for the overall permitting timeline.
- The subsea cable route to shore and the land-based transmission line to the electric grid interconnection point will also require a site development permit from the Maine DEP (Site Law). Impacts to coastal or freshwater wetlands may also require a National Resources Protection Act (NRPA) permit, unless jurisdiction for all of these resources is assumed by the USACE, which is likely given the "new technology" associated with offshore wind projects. By statute, DEP has 180 days to review Site Law applications once the application is deemed complete. DEP permit decisions can be appealed to the BEP and/or the Superior Court. Any decision of the Superior Court may be further appealed to Maine Supreme Judicial Court. Therefore, the permitting timeline for Site Law permits can range from six months to 24 months, depending on number of appeals of the permit decision. Preparation of the Site Law permit application will require 18 to 24 months, which will be performed concurrent with and contain much of the same information as the BOEMRE OCS lease application.
- The primary environmental stakeholders for offshore wind projects in the GoM include commercial fishermen (mobile-gear and fixed-gear), environmental non-governmental organizations, and coastal residents. In addition, tourism operators, coastal land trusts, and island electric cooperative

representatives can also play important roles in supporting or opposing a proposed offshore wind project. Care should be taken to avoid areas of highly concentrated fishing activity. Almost the entire GoM is fished for one species or another, with the most abundant and important species being lobster and Atlantic herring. The American Lobster fishery accounted for 70% (percent) of the commercial fishing economy in Maine waters for 2009 (See Figure 5-23). As the offshore lobster season is most intense during the winter months, it is unlikely that this fishing industry will conflict with the offshore construction of the wind pilot project. Furthermore, as lobstering is a trap fishery, the impact of floating offshore wind turbines on the fishery is thought to be minimal. The biggest impact to fisheries will be to the groundfish fishery, which typically uses trawls and gillnets that would be incompatible with the anchoring and mooring systems of the floating offshore wind farm. With that said, coordinating with the fishing industry in micrositing the turbine locations in the offshore wind project to avoid active and productive fishing areas will be important. Nearshore, the lobster season is June through December, therefore potential conflicts with lobstering will need to be examined as part of the siting of the subsea cable route, as well as any proposed tow out route or construction, storage and assembly area. Coordinating with tourism operators, coastal land trusts and coastal residents to construct the project to minimize viewshed impacts will also be important. Early outreach to fishermen and other ocean users during the project planning process to identify potential conflicts and concerns, and promote information exchange, will be very important to the project permitting and development process.

There are a number of other state and federal regulations that will be addressed during the permitting process. Activities affecting wildlife and habitats are regulated under the Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), Bald and Golden Eagle Protection Act (BGEPA) and the Marine Mammal Protection Act (MMPA) by the USFWS and NMFS. To address the requirements of these regulations, it is recommended to prepare an extended biological assessment of the project area during the permit application process. Additionally, it is recommended to apply for Incidental Take Permits through USFWS and/or NMFS, depending on the species of concern. The species of particular concern in the areas of interest for project development include Atlantic salmon, Atlantic sturgeon, and the North Atlantic right whale.

A summary of applicable laws to wind energy development is presented in Table 8-1. This table is a regulatory matrix that was prepared by the Maine State Planning Office (SPO) as part of the Maine Ocean Energy Task Force (OETF) process for identifying offshore wind energy demonstration site locations in the Gulf of Maine (GoM). Table 8-2 is a summary of the required permits and assessments necessary for Outer Continental Shelf (OCS) wind energy development in the State of Maine.

Table 8-3 provides the action status and quality of existing baseline data for supporting environmental permit applications. The table lists some of the key species and topic areas for the GoM and identifies the quality of existing data sources. Table 8-4 is projected timeline for obtaining the necessary state and federal approvals to support development of a floating offshore wind project in Maine waters.

Table 8-1: Wind Energy Development Regulatory Matrix (Maine Ocean Energy Task Force, 2009)

Wind Energy Development Regulatory Matrix				
	Review Authority/Agency/Approval	Maine's Coastal Waters: Organized Areas	Maine's Coastal Waters: Unorganized Areas	Federal Waters[1]
State	Site Location of Development Act - DEP - Permit[2]	X		
	Natural Resources Protection Act - DEP - Permit	X		
	Stormwater/Erosion and Sedimentation Control Laws - DEP - Permit/ Requirement[3]	X	X	
	Maine Endangered Species Act - DIFW and/or DMR - Review; Requirement[4]	X	X	
	Submerged Lands Lease - Bureau of Public Lands - Lease	X	X	
	Maine Historic Preservation - Maine Historic Preservation Commission - Review[5]	X	X	
	Coastal Zone Management Act - SPO - Federal Consistency Review[6]	X	X	X
	Wind Energy Act - DEP - Certification[7]	X		
	Rezoning - LURC - Rezoning Approval[8]		X	
	Land Use Standards - LURC - Permit		X	
	Clean Water Act, Sec. 401 - DEP or LURC - Water Quality Certification[9]	X	X	
Municipal	Mandatory Shoreland Zoning Act - Municipality - Permit[10]	X		
Federal	Rivers and Harbors Act; Sec. 10, CWA, Sec. 404 - Army Corps of Engineers - Permit	X	X	X
	Outer Continental Shelf Lands Act - Minerals Management Service (MMS) - Lease or ROW			X
	Executive Order 10485; Federal Power Act - Department of Energy/Federal Energy Regulatory Commission - Permit/Interconnection Approval[11]	X	X	X
	FAA Circular I-864 - Federal Aviation Administration - Guidance Conformity	X	X	X
	Federal Navigation Laws - U.S. Coast Guard - Permit	X	X	X
	National Environmental Policy Act - ACOE or MMS - Review[12]	X	X	X
	Additional Federal Reviews: Endangered Species Act - U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS)[13], Marine Mammal Protection Act - NMFS and USFWS[14], Migratory Bird Treaty Act - USFWS, Magnuson-Stevens Fisheries Conservation and Management Act - NMFS[15], Naval operations laws - U.S. Navy	X[16]	X[16]	X[16]

[1]Federal requirements apply in both Maine's coastal waters and federal waters. State permitting and leasing requirements apply to project elements, e.g, transmission line, located on state-owned submerged lands.
[2]DEP evaluating approach to measuring project area.
[3]DEP evaluating applicability. In practice, administered by LURC in unorganized areas.
[4]Provision for "incidental take" under certain conditions for DIFW - managed species. No "take" provision applies to DMR - managed marine listed species.
[5]Applicable under Site Law and NEPA
[6]Activities in state waters are reviewed through pertinent permit processe(s). Activities in federal waters may be subject to review for consistency with applicable state enforceable policies, including, e.g., Site Law and NRPA, as applicable
[7]Applies only to small scale wind energy development (<100KW).
[8]Except as provided by PL 2007 c. 661, wind energy development is not an allowed use in LURC subdistricts.
[9]As Applicable
[10]Local land use permit and building permit may also be required for land-based elements
[11]DOE approval is required under Executive Order for international export of power. Must meet FERC's minimum interconnection standards.
[12]Preparation of Environmental Impact Statement or Environmental Assesment; "hard look" at wide range of issues. Lead agency is ACOE when within state waters and MMS when within federal waters
[13]Incidental take provision review if applicable
[14]Incidental take provision review if applicable
[15]"Essential fish habitat" review
[16]Review agencies comments considered in NEPA process and various permit reviews

Table 8-2: Summary of Required Permits and Assessments for the Outer Continental Shelf (OCS) Wind Energy Development in Maine

PERMIT/ASSESSMENT	AUTHORITY	DESCRIPTION	COMMENTS
Federal			
Outer Continental Shelf Lands Act / Site Assessment Plan (SAP) Construction & Operations Plan (COP)	Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE)	BOEMRE lease for offshore wind project area in federal waters on the OCS	Requires desktop and field studies: physical characterization (e.g., geological, geophysical and hazards) and baseline environmental (e.g., biological, archaeological)
Rivers and Harbors Act (RHA), Sec. 10; Clean Water Act (CWA), Sec. 404 / Individual Permit application	US Army Corps of Engineers (USACE)	USACE permit for discharging dredged or fill materials into, building a structure within, or modifying US navigable waters.	Requires desktop and field studies: similar surveys as for BOEMRE OCS lease
National Environmental Policy Act (NEPA) / Environmental Impact Statement (EIS)	USACE in state waters; BOEMRE in Federal waters	NEPA review required under BOEMRE and USACE permitting processes	EIS likely given scale of development and technology that is new to the US; Similar desktop & field studies as required for BOEMRE OCS lease
FAA Circular I-864 / FAA permit application	Federal aviation Administration (FAA)	Permit required for structures ≥ 200 feet in height	Require desktop studies to identify location of wind turbines and provide lighting plan
Federal Navigation Laws / Navigation Safety Plan	United States Coast Guard (USCG)	Permit for private aid to navigation on fixed structures in US waters (marking and lighting)	Requires desktop studies; Navigational risk assessment by USCG may be necessary

Table 8-2 continued

Federal (continued)			
Endangered Species Act (ESA) / Biological Assessment Incidental Take Permit / habitat conservation plan	US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS)	Section 7 endangered species consultation	Consultation as part of permit review through lead federal agencies (BOEMRE and USACE); Requires development of Biological Assessment and habitat conservation plan; Summarize desktop studies and field studies required for BOEMRE OCS lease
Marine Mammal Protection Act (MMPA) / Incidental Take Permit / habitat conservation plan	NMFS and USFWS	Assessment of potential impacts to marine mammals	Consultation as part of permit review through lead federal agencies (BOEMRE and USACE); Requires development of habitat conservation plan; Summarize desktop studies and field studies required for BOEMRE OCS lease
Magnuson-Stevens Fisheries Conservation and Management Act (MSA) / Essential Fish Habitat (EFH)Assessment	NMFS	Assessment of EFH impacts	Consultation as part of permit review through lead federal agencies (BOEMRE and USACE); Requires development of EFH assessment; Summarize desktop studies and field studies required for BOEMRE OCS lease
Migratory Bird Treaty Act (MBTA)	USFWS	Assessment of impacts to migratory bird species	Consultation as part of permit review through lead federal agencies (BOEMRE and USACE);
Bald & Golden Eagle Act (BGEA)	USFWS	Assessment of impacts to Bald and Golden Eagles	Consultation as part of permit review through lead federal agencies (BOEMRE and USACE);

Table 8-2 continued

Federal (continued)			
Clean Air Act (CAA)	Environmental Protection Agency (EPA)	CAA permit for emissions from vessels on OCS during construction	Consultation as part of permit review through lead federal agencies (BOEMRE and USACE); Requires emission estimates/modeling for all vessels used in project construction, operations and maintenance
Executive Order 10485, Federal Power Act	Department of Energy (DOE) / Federal Energy Regulatory Commission (FERC)	DOE approval for international power export; interconnection must meet FERC minimum standards	
State			
Site Location of Development Act (SLODA) / Site Law Permit application	Department of Environmental Protection (DEP)	DEP permit for development of wind project site, including state-owned submerged lands and onshore development	Requires project description, site plans, assessment of impact on human and natural resources, and proposed mitigation measures; Similar desktop and field studies as required for BOEMRE OCS lease; Bureau of Environmental Protection (BEP) may assume jurisdiction
Natural Resource Protection Act (NRPA) / NRPA permit application	DEP	DEP permit for offshore wind project activities onshore or in state waters that may impact natural resources	Requires project description, site plans, assessment of impact on resources, and proposed mitigation measures; Similar desktop and field studies as required for BOEMRE OCS lease

Table 8-2 continued

State (continued)			
Stormwater / Erosion and Sedimentation Control Laws	DEP	DEP requirement for erosion & sedimentation control and stormwater management	Likely apply to onshore portions of an offshore wind project (e.g., transmission line coming ashore, substation or lay down area)
Land Use Standards	Land Use Regulation Commission (LURC)	LURC land development permit	Only applicable if onshore portion of project impacts "unorganized territory"; Requires similar content as Site Law permit application
Rezoning	Land Use Regulation Commission (LURC)	LURC rezoning approval for wind energy development not in defined expedited area	Only applicable if onshore portion of project impacts "unorganized territory" not include in expedited wind permitting area
Maine Endangered Species Act (MESA)	Department of Inland Fisheries and Wildlife (DIFW) and/or Department of Marine Resources (DMR)	DIFW and/or DMR review / requirement	"Incidental take" provision for DIFW managed species, no "take" provision for marine species managed by DMR; Similar desktop and field studies as required for BOEMRE OCS lease;
Maine Historic Preservation (MHP)	Maine Historic Preservation Commission (MHPC)	State Historic Preservation Officer (SHPO) review of offshore wind project impact on historical or cultural resources	Consultation with SHPO as part of permit review through lead state (DEP) and federal agencies (BOEMRE and USACE)
Clean Water Act (CWA), Sec. 401	DEP or LURC	Water quality certification	Consultation as part of permit review through lead state (DEP) and federal agencies (BOEMRE and USACE)

Table 8-2 continued

State (continued)			
Coastal Zone Management Act (CZMA)	State Planning Office (SPO)	SPO review of offshore wind project activities in federal waters for consistency with state policies	Consistency determination required as part of BOEMRE permitting process
Submerged Lands Lease	Bureau of Parks and Lands (BPL)	BPL lease for offshore wind project	Part of application "package" (ref. chapter 4.4.9) for various agencies approval
Certificate of Public Convenience and Necessity (CPCN)	Maine Public Utilities Commission (PUC)	Applies where PUC or merchant transmission company owns and constructs transmission line from project to grid	
Municipal/Local			
Mandatory Shoreland Zoning Act	Municipality	Municipal permit for approval of offshore wind project activities in shoreland areas	Land use and building permits may also be required from the municipality for onshore portions of project

Table 8-3: Status of Existing Baseline Data for Environmental Permit Applications

TOPIC	DATA QUALITY		
	POOR	MEDIUM	GOOD
Birds	X		
Marine mammals	X		
Sea turtles	X		
Threatened and endangered fish species	X		
Sensitive benthic habitats			X
Fisheries species		X	X
Fisheries habitats		X	
Archaeology	X		
Geology and morphology		X	
Sediments	X		
Met-ocean	X		

Notes: "Poor" = field studies necessary, desktop studies also informative
"Medium" = desktop studies necessary
"Good" = sufficient data to submit to the authorities

This table is intended to provide information with respect to baseline information only. Fish and Wildlife Monitoring Plans will need to incorporate field studies across a suite of environmental concerns.

Table 8-4: Floating Offshore Wind Project Estimated Timeline - DRAFT

Permit	Assessment	2011	2012	2013	2014	2015
		Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4
FEDERAL						
BOEMRE OCS Lease (SAP)						
USACE Sect. 404/Sect. 10 Individual Permit						
NEPA Environmental Impact Statement (EIS)						
	Physical characterization studies					
	Baseline environmental surveys					
	USCG Navigation Safety Plan					
	EFH Assessment					
Endangered Species Act - Section 7 Consultation						
	Biological Assessment					
	Incidental Take Permit					
CZMA Consistency Determination	(part of BOEMRE lease app.)					
CWA Sect. 401 Water Quality Certification	(part of USACE permit app.)					
Clean Air Act Permit						
FAA Circular I-864 Permit Application						
STATE						
SLODA (Site Law) Permit Application						
NRPA Permit Application						
LURC Land Development Permit						
	Physical characterization studies					
	Baseline environmental surveys					
Maine Endangered Species Act Consultation						
SHPO Review and Consultation						
BPL Submerged Lands Lease						
MUNICIPAL/LOCAL						
Shoreland Zoning Development Permit						
Local Land Development Permit						

Key:
- **Assessment/Study**
- **Permit Application Preparation**
- **Regulatory Review**

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THE UNIVERSITY OF MAINE

10.0 Appendices

10.1 APPENDIX A – GULF OF MAINE RESOURCE SUPPLEMENTAL INFORMATION

10.1.1 Appendix A.1 – Journal Articles

Vol. 57: 147-161, 1989 | MARINE ECOLOGY PROGRESS SERIES Mar. Ecol. Prog. Ser. | Published October 5

Community structure of macroinvertebrates inhabiting the rocky subtidal zone in the Gulf of Maine: seasonal and bathymetric distribution*

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ABSTRACT: Community structure of the macroinvertebrate fauna inhabiting a rocky subtidal habitat at Pemaquid Point, Maine, USA, was studied, using qualitative and quantitative descriptions of the distribution, diversity and abundance of benthic species, as well as their spatial (bathymetric) and temporal (seasonal) changes. A total of 60 species of macroinvertebrates representing 9 phyla were found in the 133 (0.25 m^2) disruptive benthic samplings obtained by SCUBA between August 1984 and October 1986. Crustaceans, mollusks and polychaetes were best represented accounting for ca 77 % of the total number of species identified. Green sea urchin *Strongylocentrotus droebachiensis* and horse mussel *Modiolus modiolus* were consistently the most important (in biomass and density) assemblage components. Bathymetrically, there were clear patterns in the composition and abundance of macroinvertebrates. Sea urchins decreased in abundance with depth (from 5 to 18 m), while the opposite was observed in horse mussels. Distribution and abundance patterns of remaining benthic macroinvertebrates were strongly influenced by the spatial distributions of sea urchins (at 5 and 10 m depth) and horse mussels (at 18 m). Species richness was higher in the deepest zone (18 m; 41 species) than in the shallower zones (5 and 10 m; 34 and 31 species respectively), due to the presence of clumps of *M. modiolus*. Comparative analysis at 18 m depth showed that the invertebrate fauna within *Modiolus* beds is significantly more abundant, dense, and diverse than that outside pointing out the functional importance of *Modiolus* beds in providing spatial refuges from predators, and suitable and stable microhabitats for numerous invertebrates. No significant temporal changes were observed in the biomass and density of the invertebrate community. Number of species, however, showed marked seasonal variations. Maximum values occurred during summer, intermediate values in fall and spring, and minimum values in winter, probably related to migration or changes in activity of some species. Results of this and other studies indicate that coralline communities, despite their low primary productivity, are ecological systems with relatively high species diversity and secondary productivity, sometimes comparable to systems dominated by kelps.

INTRODUCTION

Kelp forests and systems dominated by encrusting organisms and sea urchins are probably the most conspicuous and prevalent communities of rocky subtidal habitats of most temperate coasts (Mann 1972, Miller & Mann 1973, Steneck 1978, 1986, Duggins 1980, Ayling 1981, Choat & Schield 1982, Moreno & Sutherland 1982, Hagen 1983, Logan et al. 1984, Santelices & Ojeda 1984, Dayton 1985a, b, Sebens 1985, 1986a, b, Johnson & Mann 1986a). Characteristically, kelp forest communities are highly productive and structurally complex. Because of the ecological and economic importance of kelp species, communities dominated by these large brown algae have been studied extensively throughout the world (e.g. reviews by North 1971, Dayton 1985).

In contrast, communities dominated by encrusting organisms such as crustose coralline algae and large herbivores such as sea urchins have low productivity and species diversity, and in general have received relatively little attention.

Crustose coralline communities (or 'barren grounds'

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0171-8630/89/0057/0147/$ 03.00

sensu Lawrence 1975) have recently stimulated considerable research particularly on ecological mechanisms responsible for their origin and maintenance. Basically, kelp forest and crustose coralline communities have been shown to represent alternative states (Mann 1977, Harrold & Reed 1985, Scheibling 1986). The transition from one state to the other is usually attributed to changes in the abundance of sea urchins. At high densities, urchins are known to deplete the marine flora (mostly kelp), producing large 'barren' patches dominated by crustose red algae. The nearshore ecosystem along coastal Atlantic Canada (Nova Scotia) has recently experienced this kind of dramatic change of state. Destructive overgrazing by sea urchins transformed kelp forests into crustose coralline communities in the mid 1960's, and the more recent (in the 1980's) mass mortalities of sea urchins have caused the recovery of kelp (Mann 1977, Pringle et al. 1980, Wharton & Mann 1981, Miller 1985, Scheibling 1986; see Pringle 1986 for review).

Rocky subtidal habitats of the New England (USA) coast are dominated largely by crustose coralline communities (Steneck 1986), dense populations of green sea urchins *Strongylocentrotus droebachiensis* and a diverse fauna both of sessile and mobile forms (Steneck 1978, 1986, Larson et al. 1980, Logan et al. 1983, 1984, Sebens 1985, 1986a, Witman 1985). In these environments, kelp species (mainly *Laminaria* and *Alaria*) and other macroalgal associations are in general less common, usually occupying a narrow zone in shallow waters, or a more extensive band in some protected habitats where urchins are absent or rare (Sebens 1985, 1986a; pers. obs.). Vertical rocky surfaces of these subtidal habitats support diverse assemblages of organisms, usually dominated by a suite of encrusting invertebrate species (Sebens 1986a, b).

The distributional patterns and other relevant aspects of the ecology of crustose coralline algal species inhabiting subtidal rocks of the Gulf of Maine have recently been documented by Steneck (1978, 1982) and Garwood et al. (1985). Similarly, the structure and organization of several encrusting invertebrate communities occurring in the sublittoral zone of the New England coast have been examined by Osman (1977) and Sebens (1982, 1986a, b). Other important aspects related to the community organization of these subtidal systems have recently been reported by Witman (1985) and Harris (1986).

Studies describing invertebrate macrofauna inhabiting crustose coralline communities in the Gulf of Maine are also limited. Although Logan et al. (1983) have recently described spatial patterns of distribution of the species comprising coralline-dominated communities of the Bay of Fundy (New Brunswick, Canada), other important autecological aspects of some of the most conspicuous macroinvertebrates as well as temporal changes in the structure of such communities remain unknown.

This study describes the community structure of macroinvertebrates inhabiting a crustose coralline community in a rocky subtidal habitat off the coast of Maine. This characterization involves qualitative and quantitative descriptions of the distribution, diversity and abundance of benthic macrofauna as well as their spatial (bathymetric) and temporal (seasonal) changes. Large mobile predators (such as decapod crustaceans and fish of large size) are excluded in this study as well as the epibenthic invertebrate fauna typical of vertical walls. The large mobile fauna associated with this community is discussed separately elsewhere (Ojeda & Dearborn unpubl.). As noted previously, the invertebrate assemblages inhabiting vertical and undercut rocky surfaces have been analyzed extensively by Sebens (1982, 1986a, b; and papers cited therein).

The ecological patterns described in this study have important implications since they provide a base line for future research and the required ecological background toward our understanding of the organization and the dynamic processes operating in this kind of community.

DESCRIPTION OF STUDY SITE

This study was conducted in the shallow subtidal zone off the southwest end of Pemaquid Point, Maine, USA (43°50′ N; 69°31′ W) (Fig. 1). The site is exposed to the prevailing southeast ocean swells and consists of a sloping bedrock surface extending down to ca 18 to 20 m depth (Fig. 2). The shallower portion of this bedrock (between 12 and 15 m depth) consists of a broad ledge. The substrate here is relatively flat, almost free of silt and cobble, and occasionally cut by crevices and small cracks. Large rocks and boulders are commonly found on shelves of bedrock at depths of 15 to 20 m. The substrate at depths greater than 20 m consists primarily of sand with occasional round boulders (Fig. 2).

The zonation pattern of species found in the study area is quite uniform and representative of wave-exposed habitats of the New England coasts. The shallowest subtidal zone (0 to 5 m below Mean Low Water Level; MLWL) at this site is clearly dominated by macroalgal species. Extending from the low intertidal zone to the uppermost sublittoral zone there is a conspicuous belt of *Chondrus crispus*. A narrow band of kelp species (primarily *Laminaria saccharina*, *L. digitata*, and *Alaria esculenta*) occurs immediately below the *Chondrus* zone. Most of these kelps, however, are juveniles (less than 1 m long) with few adult individuals

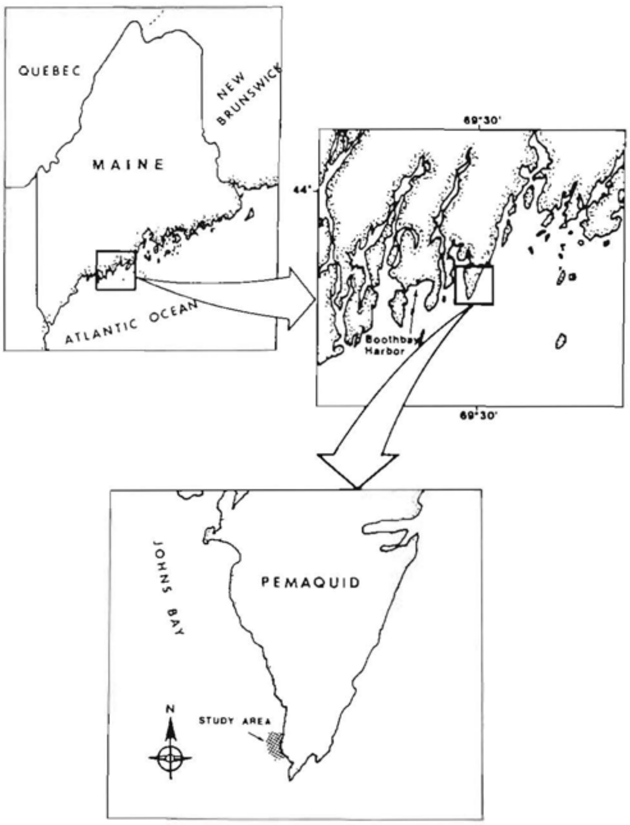

Fig 1. Maine, USA, showing location of study site

reaching sizes larger than 2 m. The understory of the kelp zone is mostly composed of dense tufts of *Corallina officinalis*, and small patches of *Phycodrys rubens, Phyllophora* sp., and *Ceramium rubrum*. The deeper border of the macroalgal zone is occupied by a diverse algal turf primarily consisting of elongated individuals of *Enteromorpha* spp. *Ulva* spp. *Chordaria flagelliformis, Polysiphonia* spp., *Chaetomorpha melagonium* and *C. linium* (Fig. 2).

Most of the primary substratum (ca 70 to 80 %) across the rock ledge (between 4 and 15 m depth) is covered by crustose coralline algae which form a nearly continuous pink carpet. A similar situation is observed on the top surfaces of the rocks and boulders found in the deeper zone (between 15 and 20 m depth). The shallow portion of the coralline zone (between 4 and 15 m) is dominated by the corallines *Lithothamnium glaciale, L. lemoineae, Clathromorphum circumscriptum*, and *Phymatoliton rugulosum*. The top surfaces of the large boulders and rocks of this zone (between 16 to 20 m) are mostly dominated by *Lepthophytum laeve* and *Phymatolithon laevigatum*. A detailed description of the crustose coralline assemblages inhabiting this locality was given by Steneck (1978).

The most conspicuous organism inhabiting horizontal and sloping rock surfaces of the coralline zone is the green sea urchin *Strongylocentrotus droebachiensis*, which forms dense aggregations extending from 3 to 12 m deep. At this location green urchins occur to depths of 20 to 25 m, however, their abundance declines sharply below 15 m (Fig. 2). Patchily distributed clumps of the horse mussel *Modiolus modiolus* occur at depths of 10 to 20 m. Their large shells are usually covered with encrusting coralline algae, barnacles, and small tunicates. The interstices between the mussels and the weft of byssus threads create a suitable habitat and shelter for numerous invertebrate organisms. At the deeper edge of the rocky boulder field (ca 17 to 20 m) isolated individuals of *Agarum cribosum* are usually found attached to top surfaces of large rocks and boulders (Fig. 2).

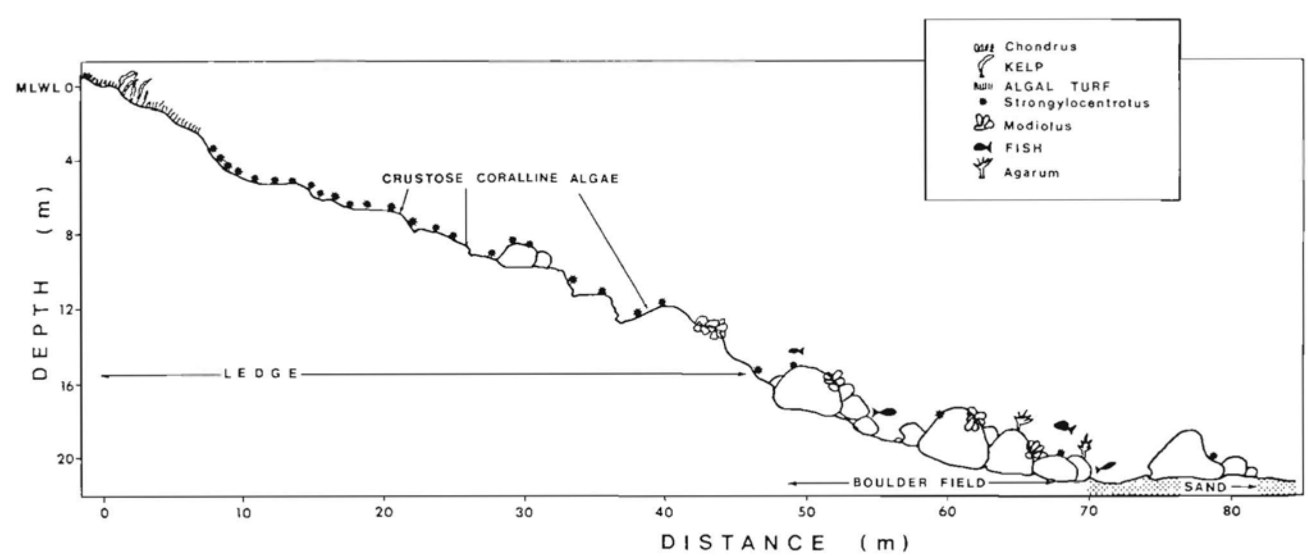

Fig 2. Transectional view of a typical subtidal coralline community at Pemaquid Point, Maine

MATERIALS AND METHODS

Nine disruptive samplings were conducted seasonally using SCUBA from August 1984 to October 1986. In each of the seasonal samplings several transects were carried out perpendicular to the shore. Four to 8 quadrat samples (0.25 m^2) (Pringle 1984) were randomly taken from 3 different depth ranges (4 to 6 m, 9 to 11 m, and 16 to 20 m; hereafter designated 5, 10 and 18 m respectively) according to a stratified random sampling design (Elliott 1977). All macroinvertebrates found within the quadrat were removed from the substrate with the aid of scraping knives and forceps. The organisms then were either manually collected and deposited in diver sampling bags of 1 to 2 mm mesh size or vacuumed with an airlift device (Chess 1978, Witman 1985). All sampled organisms of each quadrat were placed in labelled plastic bags, fixed in a 5 to 10 % solution of buffered (borax) formalin-seawater mixture, and transported to the laboratory for analysis.

In the laboratory, the organisms were sorted, identified to the lowest taxon possible, usually to species, counted, measured with a caliper to the nearest 0.1 mm and weighed on a Mettler P1200 balance to the nearest 0.1 mg.

In order to establish spatial patterns of species associations, a cluster analysis based on Ward's method which uses Euclidean distance as a metric (CLUSTER Procedure; SAS 1986) was performed using mean density values at 3 depths (5, 10 and 18 m) of the 24 most abundant macroinvertebrate taxa found in the samples. The data on macroinvertebrate densities and biomasses were tested for homogeneity of variances using the F_{max} test (Sokal & Rohlf 1981). The results of this test on densities and biomasses showed that the variances were nonhomogeneous over the bathymetric and temporal gradients studied. Therefore a logarithmic transformation (log [n+1]; Sokal & Rohlf 1981, p. 419) was used on all these data before further analysis. One-way ANOVA followed by a Student-Newman-Keuls (SNK) multiple comparison test (Sokal & Rohlf 1981) were employed for the detection of changes in density and biomass of macroinvertebrates over bathymetric and temporal gradients.

RESULTS

Community structure

A total of 60 species of macroinvertebrates representing 9 phyla were found in the 133 (0.25 m^2) benthic samples collected from August 1984 to October 1986 (Table 1). Crustaceans, mollusks and polychaetes are the best-represented taxonomic groups with 18, 14, and 14 species respectively. They account for about 77 % of the total number of species recognized in these samples (Table 1).

The green sea urchin *Strongylocentrotus droebachiensis* is numerically the most important macroinvertebrate in this community with average density of 100 ind. m^{-2}, and accounting for about 56 % of the total number of individuals collected in the benthic samples (Table 2). *Modiolus modiolus*, *Tonicella ruber*, and *Ophiopholis aculeata* are the next species in the ranking of abundances, with density values of ca 9 to 13 ind. m^{-2} (Table 2). The remaining 56 species (93 % of the total number of species) contribute together only 23.8 % of the total number of individuals collected. Few of these 56 species however, are represented with more than 1 ind. m^{-2} (Table 2).

Strongylocentrotus droebachiensis is the dominant species in biomass in the samples with an average biomass of 2699 g m^{-2}, representing 65.5 % of the total biomass (Table 2). It is followed by *Modiolus modiolus*, with average biomass of 1303 g m^{-2} (30.9 % of the total biomass). These 2 species together account for about 95 % of the total biomass of macroinvertebrates (Table 2). Most of the remaining 58 species are represented with less than 10 g m^{-2}, contributing relatively little to the overall biomass in this community (usually less than 1 %; Table 2).

Spatial patterns

The bathymetric range of distribution of all macroinvertebrate species found in the samples is also presented in Table 1. Fifteen species (25.4 % of the total) restrict their bathymetric distribution exclusively to the shallowest subtidal zone sampled (5 m). Most of these species were gastropod mollusks (e.g. *Lacuna vincta* and *Littorina littorea*), and small crustaceans such as amphipods and isopods (Table 1). Most of the species of this group were found associated with the macroalgal turf typical of this sublittoral zone (Fig. 2). Two other species (3.4 % of the total) were exclusively found at depths of 5 and 10 m, while a group of 17 species (28.8 % of the total) was widely distributed along the bathymetric gradients analyzed (Table 1). The most abundant species of this community (e.g. sea urchins, mussels, chitons, brittle stars; see Table 2) belong to this group (Table 1). Two other groups of species were found to be restricted to the deepest zone: one composed of 9 species (15.2 % of the total) which occur at depths of 10 and 18 m; and, another group of 13 species (22.4 %) found only in the 18 m samples (Table 1). Most of the species of this latter group were closely associated with the *Modiolus* clumps.

The total number of species (species richness) was markedly higher in the samples taken at 18 m depth

(41 species, 69.5 % of the total) and lower at the intermediate depth of 10 m (31 species, 52.5 % of the total). The samples taken at 5 m depth contained a few more species than those found at 10 m depth (34 species, 57.6 %).

An analysis of the bathymetric variation of total macroinvertebrate biomass values (Fig. 3) shows no significant changes with depth (1-way ANOVA; $p > 0.08$). In contrast, the density of invertebrates significantly declines with depth (1-way ANOVA; $p < 0.01$), from about 60 ind. 0.25 m^{-2} at 5 m depth to about 36 ind. 0.25 m^{-2} at 10 and 18 m (Fig. 3). Analysis of the variations in density and biomass of the 7 most important species of this community (Fig. 3) shows 2 clear bathymetric patterns among these species: (1) a general decrease of both biomass and density with depth, exhibited by *Strongylocentrotus droebachiensis* and *Asterias vulgaris* (1-way ANOVA; $p < 0.01$ in both species), and (2) a general increase of both density and biomass with depth, exhibited by *Modiolus modiolus*,

Table 1. Taxonomic list and bathymetric distribution (depth range) of the macroinvertebrate species found in subtidal benthic samples taken at Pemaquid Point, Maine

Species	Depth range (m)	Species	Depth range (m)
PORIFERA		*Pherusa plumosa* (Muller)	18
Scypha ciliata Fabricius	10–18	*Capitella capitata* (Fabricius)	18
Halicondria panicea (Pallas)	5	*Pectinaria granulata* (Linnaeus)	18
Cliona celata Grant	18	ARTHROPODA (Crustacea)	
PLATYHELMINTHES		Cirripedia	
Notoplana atomata (Muller)	5–10	*Balanus balanoides* (Linnaeus)	10
NEMERTEA		Isopoda	
Amphiphorus sp.	18	*Idothea balthica* (Pallas)	5
CNIDARIA		*Idothea phosphorea* Harger	5
Anthozoa		Amphipoda	
Metridium senile (Linnaeus)	5–18	*Gammarus oceanicus* Segerstrale	18
MOLLUSCA		*Gammarellus angulosus* (Rathke)	5–18
Gastropoda		*Calliopius laeviusculus* (Kroyer)	5–10
Crepidula fornicata Linnaeus	10–18	*Jassa falcata* (Montagu)	5
Crepidula plana Say	10–18	*Unciola inermis* (Say)	5
Tectura (=Acmaea) testudinalis (Muller)	5–18	*Caprella linearis* (Linnaeus)	5
Lacuna vincta (Montagu)	5	*Caprella septentrionalis* Kroyer	5
Littorina littorea (Linnaeus)	5	*Aeginella longicornis* (Kroyer)	5
Buccinum undatum (Linnaeus)	10–18	Decapoda	
Nucella (=Thais) lapillus (Linnaeus)	5–18	*Cancer irroratus* Say	5–18
Polyplacophora		*Cancer borealis* Stimpson	5–18
Tonicella ruber (Linnaeus)	5–18	*Hyas araneus* (Linnaeus)	5
Bivalvia		*Lebbeus polaris* (Sabine)	18
Mytilus edulis Linnaeus	5	*Eualus pusiolus* (Kroyer)	5–18
Modiolus modiolus (Linnaeus)	5–18	*Crangon septemspinosa* Say	18
Hiatella arctica (Linnaeus)	10–18	*Pagurus pubescens* Kroyer	5–18
Mya arenaria Linnaeus	5	ECHINODERMATA	
Astarte subequilatera Sowerby	18	Asteroidea	
Spisula solidissima (Dillwyn)	18	*Asterias vulgaris* (Verrill)	5–18
ANNELIDA		*Henricia sanguinolenta* (Muller)	5–18
Polychaeta		Ophiuroidea	
Lepidonotus squamatus (Linnaeus)	5–18	*Ophiopholis aculeata* (Linnaeus)	5–18
Harmothoe imbricata (Linnaeus)	5–18	Echinoidea	
Harmothoe oerstedi (Linnaeus)	18	*Strongylocentrotus droebachiensis* (Muller)	5–18
Amphitrite johnstoni Malmgren	10–18	Holothuroidea	
Pista maculata (Dalyell)	10–18	*Psolus fabricii* (Duben and Koren)	10
Thelepus cincinnatus (Fabricius)	10–18	*Cucumaria frondosa* (Gunnerus)	5–18
Eulalia viridis (Linnaeus)	5	CHORDATA	
Eteone longa (Fabricius)	18	Ascidiacea	
Nereis pelagica Linnaeus	5–18	*Dendrodoa carnea* (Agassiz)	10–18
Potamilla reniformes (Leuckart)	5	*Molgula* sp.	10–18
Nainereis quadricuspida (Fabricius)	18		

Table 2. Average density (ind. m^{-2}) and average biomass (g m^{-2}) of the 22 most abundant macroinvertebrate taxa found in the 133 subtidal benthic samples collected at Pemaquid Point, Maine. In parentheses: standard error

Taxon	Density	Biomass
Strongylocentrotus droebachiensis	100.4 (74.0)	2699.0 (1416.4)
Modiolus modiolus	14.4 (11.2)	1303.2 (960.0)
Tonicella ruber	13.3 (6.8)	1.5 (0.8)
Ophiopholis aculeata	8.8 (7.2)	7.2 (5.6)
Polychaetes	8.8 (2.0)	1.6 (0.4)
Asterias vulgaris	6.0 (2.0)	4.4 (2.8)
Tectura testudinalis	4.0 (0.8)	2.4 (0.8)
Lacuna vincta	0.2 (0.1)	0.2 (0.1)
Amphipods	3.7 (2.1)	*
Idothea spp.	2.4 (1.1)	*
Caprella spp.	1.7 (0.9)	*
Cancer spp.	1.0 (0.3)	0.3 (0.1)
Crepidula spp.	0.9 (0.4)	0.9 (0.3)
Dendrodoa carnea	0.7 (0.3)	*
Balanus balanoides	0.6 (0.1)	4.0 (2.7)
Mya arenaria	0.5 (0.1)	0.7 (0.2)
Nucella lapillus	0.6 (0.3)	0.2 (0.1)
Hiatella arctica	0.5 (0.1)	0.9 (0.2)
Buccinum undatum	0.5 (0.2)	0.2 (0.1)
Crangon septemspinosa	0.5 (0.2)	*
Pagurus pubescens	0.3 (0.1)	0.1 (0.1)
Eualus pusiolus	0.3 (0.1)	*

* Less than 0.1 g

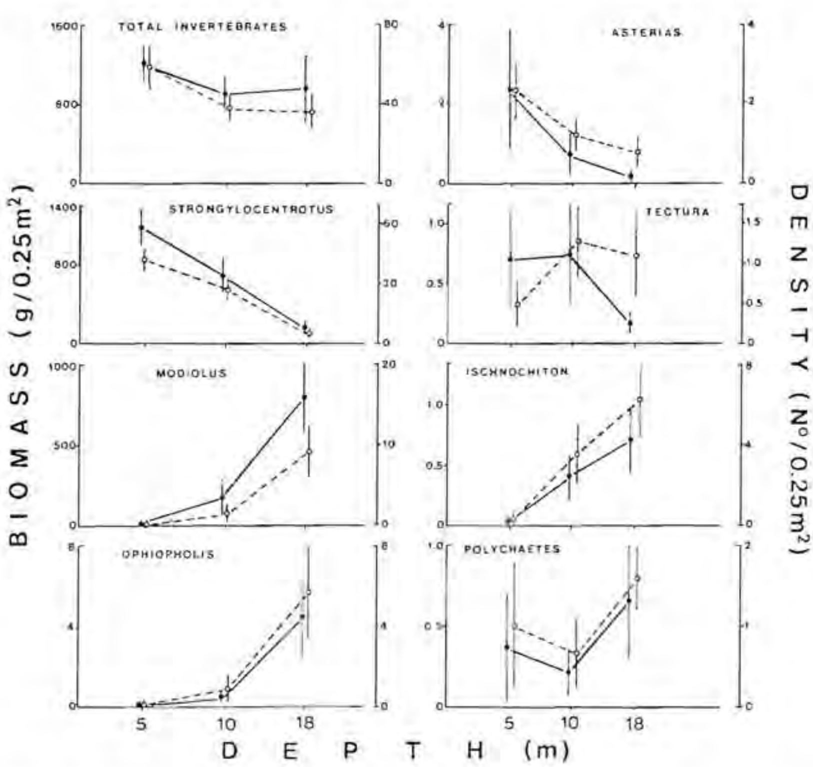

Fig. 3. Bathymetric variation in biomass ($\bar{X} \pm 2$ SE; ●) and density ($\bar{X} \pm 2$ SE; ○) of total invertebrates, and of the 7 most common invertebrate taxa occurring in the subtidal benthic community studied

Ophiopholis aculeata and *Tonicella ruber* (1-way ANOVA; $p < 0.01$ in all these species). Limpet *Tectura testudinalis* shows a significant decline in biomass from 10 to 18 m depth (1-way ANOVA; $p < 0.01$; and a posteriori SNK test) with no significant differences between 5 and 10 m. The bathymetric variation of the densities of *T. testudinalis* (Fig. 3) shows, however, a significant increase from 5 to 10 m (1-way ANOVA; $p < 0.01$, and a posteriori SNK test). The opposite trends in biomass and density exhibited by *Tectura* suggest that the mean size of their individuals decrease with depth.

Polychaetes (all species grouped) show no significant bathymetric change in their abundances (both in biomass and density; 1-way ANOVA; $p > 0.20$ and $p > 0.17$, respectively) (Fig. 3). The bathymetric patterns of variation observed in this group of polychaetes is probably due to their association with other benthic species such as macroalgae which were occasionally found within the quadrats sampled at 5 m. The holdfasts of these macroalgae and the sediment accumulated among them probably provide suitable microhabitats for some polychaete species such as *Nereis pelagica* and *Lepidonotus squamatus*. A similar situation occurs at 18 m depth, but in this case it is the presence of *Modiolus modiolus* which significantly increases the opportunities of microhabitat utilization for the polychaete fauna. At this depth (18 m) there is also a greater number of polychaete species (12; see Table 1) with 6 of them living exclusively within the *Modiolus* beds.

The cluster analysis separated the 24 commonest species of benthic invertebrates into 2 major groups (Fig. 4). The first cluster (A) is formed by 14 taxa that were most abundant at 5 and/or 10 m depth. The most abundant species of Group A is the sea star *Asterias vulgaris* which appears closely associated with some species that are typical of the intertidal-subtidal border such as *Lacuna vincta*, *Idothea* spp., and juvenile *Cancer* spp. Another important component of Group A in the cluster is the limpet *Tectura testudinalis*, which shows its maximum abundance on shallow rocks usually covered by the crustose coralline alga *Clathromorphum circumscriptum* (Steneck 1982; pers. obs.). This alga has recently been shown to be the dominant crustose species in shallow rocks at Pemaquid Point (Garwood et al. 1985).

The second group recognized in the cluster (Group B; Fig. 4) consists of 11 species. Their association in this group reflects that they all attain maximum abundances around the 18 m depth. The most conspicuous organism of this group is the horse mussel *Modiolus modiolus*, which commonly forms patchy clumps at around 18 m and is the dominant species in terms of biomass in the deepest zone (Fig. 3). Other important species of Group B are the ophiuroid *Ophiopholis aculeata* and the red chiton *Tonicella ruber*. The spatial distributions of these 2 species as well as of the remaining species forming Group B, however, are not random at the 18 m depth. Indeed, the distribution and abundance patterns of most of these species, as well as of a significant number of other species not included in the cluster analysis, are strongly correlated with the presence of the *Modiolus* clumps typical of this zone (Figs. 2 and 3). A comparative analysis of the differential distribution of macroinvertebrates found at 18 m depth within *Modiolus* beds (16 quadrats), and outside *Modiolus* beds (18 quadrats) shows that the invertebrate fauna inhabiting *Modiolus* clumps is significantly more abundant, dense, and diverse than the fauna occurring outside the beds (Table 3). Sea urchins are significantly most numerous (but not largest) within the *Modiolus* beds as are *O. aculeata*, *T. ruber*, and the polychaete fauna (Table 3). In the latter categories, however, both biomass and densities are significantly higher within the mussel beds than outside them (Table 3). Note, however, that at 18 m depth (*Modiolus* zone), *Strongylocentrotus droebachiensis*, in contrast to *O. aculeata* and *T. ruber*, occurs at much lower densities than in the shallow zones (Fig. 3). Similar results have been reported by Witman (1985) for the benthic community occurring inside and outside beds of *M. modiolus* at the Isles of Shoals, Maine.

Strongylocentrotus droebachiensis does not show any significant association with any of the species analyzed in the cluster in Fig. 4. This means that the

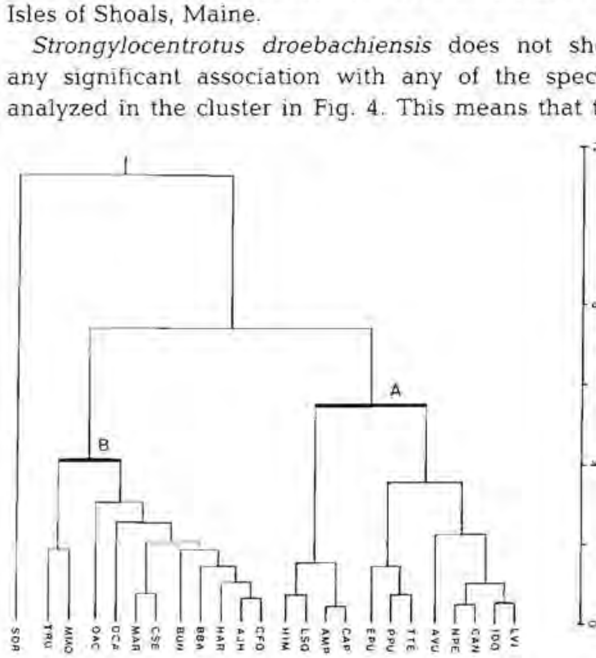

Fig 4. Dendogram of similarity (expressed as the Euclidean distance) based upon the mean density values of the 24 most common taxa found at 3 depths (5, 10 and 18 m) in a subtidal coralline community at Pemaquid Point, Maine. LVI = *Lacuna vincta*; IDO = *Idothea* spp.; CAN = *Cancer* spp.; NPE = *Nereis pelagica*; AVU = *Asterias vulgaris*; TTE = *Tectura testudinalis*; PPU = *Pagurus pubescens*; EPU = *Eualus pusiolus*; CAP = *Caprella* spp.; AMP = amphipods; LSQ = *Lepidonotus squamatus*; HIM = *Harmothoe imbricata*; CFO = Crepidula fornicata; AJH = *Amphitrite johnstoni*; HAR = *Hiatella arctica*; BBA = *Balanus balanoides*; BUN = *Buccinum undatum*; CSE = *Crangon septemspinosa*; MAR = *Mya arenaria*; DCA = *Dendrodoa carnea*; OAC = *Ophiopholis aculeata*; MMO = *Modiolus modiolus*; TRU = *Tonicella ruber*; SDR = *Strongylocentrotus droebachiensis*

Table 3. Comparisons of the biomass and density of invertebrates, number of species, and abundance patterns of 4 invertebrate species found in 16 and 18 quadrats of 0.25 m^2 taken at 18 m depth inside and outside *Modiolus* beds, respectively. Biomass is expressed in g, density in no. of individuals

Taxon	Inside Mean ± SE	Outside Mean ± SE	t-statistic
Invertebrates			
Biomass	1590.8 ± 250.5	295.2 ± 56.6	5.325**
Density	53.5 ± 6.0	14.4 ± 2.4	5.685**
No. of species	9.9 ± 0.9	3.5 ± 0.6	5.466**
Strongylocentrotus droebachiensis			
Biomass	164.6 ± 46.8	145.2 ± 32.8	0.354
Density	8.0 ± 1.6	3.4 ± 0.7	2.744**
Ophiopholis aculeata			
Biomass	7.5 ± 2.3	1.3 ± 2.9	3.689**
Density	9.7 ± 2.5	1.2 ± 0.4	3.689**
Tonicella ruber			
Biomass	0.9 ± 0.2	0.3 ± 0.1	2.524*
Density	8.6 ± 1.6	2.6 ± 0.5	3.734**
Polychaetes			
Biomass	0.9 ± 0.4	0.1 ± 0.05	1.989*
Density	4.1 ± 1.1	1.2 ± 0.4	2.651**

* $p<0.05$; ** $p<0.01$

abundance patterns of sea urchins do not seem to be correlated with any other invertebrate species pattern.

Seasonal patterns

Temporal variations in the occurrence of all macroinvertebrate species found in the 9 subtidal seasonal samples taken at Pemaquid Point are summarized in Table 4. Of the total of 59 species collected in all these samples, 13 (22 %) of them were consistently found in all seasonal samples and seemingly constitute permament populations in this community (*Crepidula fornicata, Tectura testudinalis, Tonicella ruber, Modiolus modiolus, Hiatella arctica, Lepidonotus squamatus, Harmothoe imbricata, Nereis pelagica, Balanus balanoides, Calliopius laeviusculus, Asterias vulgaris, Ophiopholis aculeata* and *Strongylocentrotus droebachiensis*). As noted above, these are also the most abundant species in this community (Table 2). The presence of the 46 remaining species was restricted to some months or seasons of the year (Table 4). Most were of a rare occurrence in the samples and generally were represented by few individuals. Some show, however, a consistent temporal pattern of occurrence in the samples (e.g. *Nucella lapillus, Idothea* spp., *Pagurus pubescens* and *Jassa falcata* which occur in the summer samples; Table 4), while others do not exhibit any clear seasonal pattern.

An analysis of the temporal variation of the total number of species found in each of the 9 seasonal samples (Table 4) shows a clear pattern, with maximum values of species richness occurring in summer samples intermediate values during the spring samples, and minimum values in the fall and winter samplings. Since sample size (effort) was quite similar among seasons (see Table 4) the diversity pattern found does not represent a sampling artifact.

Temporal variations in biomass and density of the macroinvertebrate fauna is shown in Fig. 5. In general, no significant change was observed for the invertebrate biomass values at any of the 3 depths (1-way ANOVA; $p = 0.52$, $p = 0.23$, and $p = 0.62$ at 5, 10, and 18 m, respectively).

Analysis of the temporal density values, however, showed (Fig. 5) a significant pattern of variation at 5 m depth, with one statiscally significant peak in October 1984 (1-way ANOVA; $p < 0.03$, a posteriori SNK test). No peak, however, was observed in October 1986. The density values observed for 10 and 18 m depth did not disclose any clear significant temporal pattern of variation (1-way ANOVA; $p = 0.57$ and $p = 0.90$, respectively; Fig. 5).

Analysis of the temporal changes in the abundance of *Strongylocentrotus droebachiensis* shows that at 5 m depth there was a significant increase in density in October 1984 (1-way ANOVA; $p < 0.03$ and a posteriori SNK test; Fig. 6). With respect to biomass changes at 5 m (Fig. 6), no significant differences were detected among these values (1-way ANOVA; $p = 0.08$). No

Table 4. Presence of macroinvertebrate species found in 9 seasonal subtidal transects carried out at Pemaquid Point, Maine. Presence (X) indicates ocurrence of a given species in at least one of the 16 to 30 quadrats of 0.25 m^2 sampled in each transect

Taxon	1984		1985			1986			
	Aug	Oct	May	Sep	Nov	Feb	Jun	Aug	Oct
PORIFERA									
Scypha ciliata				X				X	
Halicondria panicea		X	X	X	X		X		X
Cliona celata	X								X
PLATYHELMINTHES									
Notoplana atomata	X			X					
NEMERTEA									
Amphiphorus sp.				X				X	
CNIDARIA									
Anthozoa									
Metridium senile	X		X				X	X	
MOLLUSCA									
Gastropoda									
Crepidula fornicata	X	X	X	X	X	X	X	X	X
Crepidula plana	X	X		X		X		X	X
Tectura testudinalis	X	X	X	X	X	X	X	X	X
Lacuna vincta				X					
Littorina littorea	X			X	X			X	
Buccinum undatum	X	X		X					X
Nucella lapillus	X	X		X	X		X	X	
Polyplacophora									
Tonicella ruber	X	X	X	X	X	X	X	X	X
Bivalvia									
Mytilus edulis				X		X			
Modiolus modiolus	X	X	X	X	X	X	X	X	X
Hiatella arctica	X	X	X	X	X	X	X	X	X
Mya arenaria				X					
Astarte subequilatera				X					
Spisula solidissima								X	
ANNELIDA									
Polychaeta									
Lepidonotus squamatus	X	X	X	X	X	X	X	X	X
Harmothoe imbricata	X	X	X	X	X	X	X	X	X
Harmothoe oerstedi								X	
Amphitrite johnstoni	X	X	X	X	X		X	X	X
Pista maculata						X			
Thelepus cincinnatus						X			
Eulalia viridis					X				
Eteone longa					X			X	
Nereis pelagica	X	X	X	X	X	X	X	X	X
Potamilla reniformes					X		X		
Nainereis quadricuspida					X				
Pherusa plumosa			X			X			
Capitella capitata						X			
Pectinaria granulata			X					X	
ARTHROPODA (Crustacea)									
Cirripedia									
Balanus balanoides	X	X	X	X	X	X	X	X	X
Isopoda									
Idothea balthica		X		X				X	X
Idothea phosphorea	X			X			X	X	

Table 4 (continued)

Taxon	1984		1985			1986			
	Aug	Oct	May	Sep	Nov	Feb	Jun	Aug	Oct
Amphipoda									
Gammarus oceanicus	X		X	X	X			X	
Gammarellus angulosus		X		X			X		
Calliopius laeviusculus	X	X	X	X	X	X	X	X	X
Jassa falcata	X			X			X	X	
Unciola inermis				X					X
Caprella linearis	X	X	X		X	X	X	X	
Caprella septentrionalis	X	X		X			X		
Aeginella longicornis	X							X	
Decapoda									
Cancer spp.	X	X		X	X		X	X	X
Hyas araneus	X	X						X	
Lebbeus polaris		X							
Eualus pusiolus						X	X		X
Crangon septemspinosa							X	X	
Pagurus pubescens	X			X			X		
ECHINODERMATA									
Asteroidea									
Asterias vulgaris	X	X	X	X	X	X	X	X	X
Henricia sanguinolenta		X			X			X	
Ophiuroidea									
Ophiopholis aculeata	X	X	X	X	X	X	X	X	X
Echinoidea									
Strongylocentrotus droebachiensis	X	X	X	X	X	X	X	X	X
Holothuroidea									
Psolus fabricii	X		X					X	
Cucumaria frondosa	X		X		X			X	X
CHORDATA									
Ascidiacea									
Dendrodoa carnea	X	X			X	X		X	
Molgula sp.	X		X						
No. of species	34	27	23	35	27	22	27	37	23
No. of quadrats (0.25 m^2) sampled	14	27	20	12	12	12	12	12	12

significant density change was observed at 10 m depth (1-way ANOVA; $p = 0.11$; Fig. 6). A similar pattern was found with respect to the biomass values. In this case, however, a significant decrease was observed in October 1984 and in August 1986 (1-way ANOVA; $p < 0.06$ and a posteriori SNK test). The temporal variation in the abundance of sea urchins at 18 m (Fig. 6), both in density and biomass, did not disclose any clear pattern, and no statistically significant differences were detected among these values (1-way ANOVA; $p = 0.67$ and $p = 0.81$ for density and biomass, respectively).

No clear temporal patterns in density and biomass were observed for *Modiolus modiolus* at 10 and 18 m depths. Moreover, no significant differences were observed among the density and biomass values at both depths during the seasonal samplings (1-way ANOVA; $p = 0.23$ and $p = 0.22$ for density and biomass values respectively at 10 m; and $p = 0.60$ and $p = 0.85$ for density and biomass values respectively at 18 m depth). These results, however, should be taken cautiously, because they could represent an artifact of the random sampling associated with the extremely patchy spatial distribution of *Modiolus*.

DISCUSSION

A total of 60 invertebrate species were recorded in the benthic samples obtained from the subtidal crustose coralline community studied at Pemaquid Point, Maine. Numerous diving observations by one of the authors (F.P.O.) along the coast of Maine indicate that these species seem to constitute the typical invertebrate fauna of horizontal and sloping rock substrates of subtidal environments of this coast. Other conspicuous habitats of these environments such as vertical and

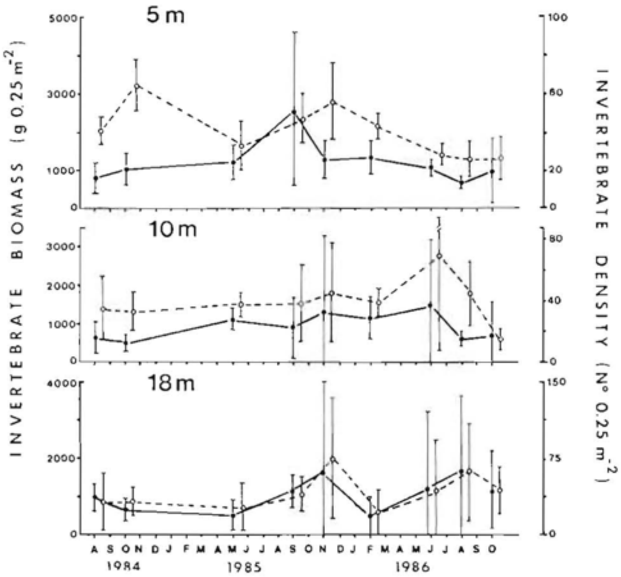

Fig 5. Temporal changes in biomass ($\bar{X} \pm 2$ SE; •) and density ($\bar{X} \pm 2$ SE; o) of macroinvertebrates at 3 depths (5, 10 and 18 m)

undercut rocky surfaces were not investigated in this study. They generally harbor different kind of benthic communities, usually dominated by sponges and tunicates. Recently, such communities have been studied by Noble et al. (1976), Sebens (1982, 1986a, b), Logan et al. (1984) and Witman (1985).

Relatively little is known about rocky sublittoral benthic communities of the Gulf of Maine, particularly regarding their composition and community structure. Comparable sublittoral studies conducted by Noble et al. (1976) and Logan et al. (1983, 1984) in the Bay of Fundy, Canada, have recognized the existence of 2 distinctive types of benthic communities occupying different microhabitats: the crustose coralline algae community, which is dominant on upper surfaces from 0 to 20 m depth, and the community dominated by the brachiopod *Terebratulina septentrionalis*. Communities dominated by this brachiopod occur cryptically on the undersides of rocks and crevices of the upper sublittoral zone dominated by crustose algae (0 to 20 m depth), and on upper surfaces of rocks and ledges at greater depths (> 20 m) (Noble et al. 1976, Logan et al. 1983, 1984). Logan et al. (1983) reported a total of 84 species of invertebrates inhabiting crustose coralline communities in the Bay of Fundy; most of these species were the same as those reported in this study. The differences in the specific composition and total number of species between this study and of Logan et al. (1983) is probably due to the fact that those authors included invertebrate species found both on horizontal rocky surfaces and vertical walls. A similar situation occurs when our results are compared with those reported by Witman (1985) for the rocky sublittoral zone off the Isles of Shoals, Maine. He reported a total of 171 invertebrate species of which 80 were frequently found in the benthic samples. Witman's (1985) study showed strong similarities in community composition with this study. Most of the invertebrate species found at Pemaquid Point were also recorded in similar subtidal habitats off the Isles of Shoals (see Table 1 in this study and Table A1 in Witman 1985). Furthermore, horizontal habitats studied by Witman (1985) and in this study were both dominated by sea urchins, horse mussels, chitons and limpets. The observed differences in number of species with Witman's (1985) study are probably attributable to the greater depth of the Isles of Shoals communities (30 m), and to the inclusion of the invertebrate fauna typical of vertical walls in that study.

Although crustose coralline communities have often been considered systems of very low diversity and productivity (for which they have been named 'barren grounds' or 'barren communities', see Lawrence 1975 for review), the results of this study and those cited above demonstrate that, despite their low primary productivity, coralline communities are ecological systems with relatively high species diversity and secondary

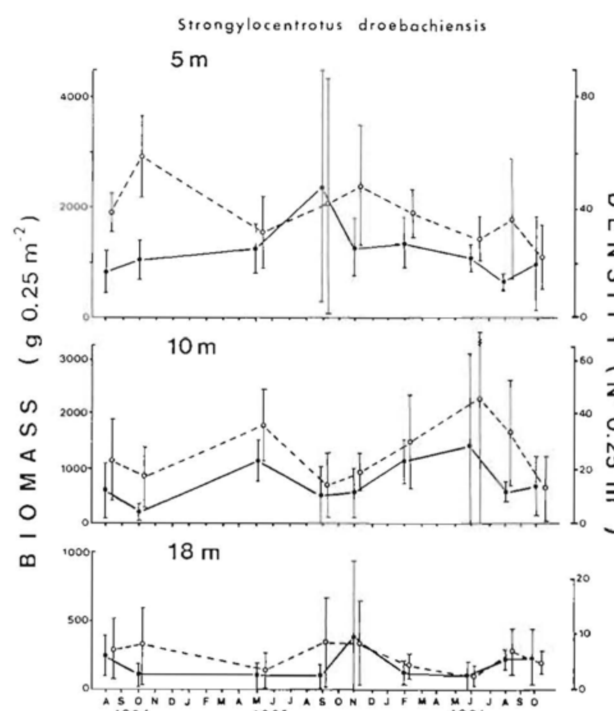

Fig 6. *Strongylocentrotus droebachiensis*. Temporal changes in biomass ($\bar{X} \pm 2$ SE; •) and density ($\bar{X} \pm 2$ SE; o) at 3 depths (5, 10 and 18 m)

productivity, sometimes comparable to systems dominated by kelps (e.g. Shannon's H diversity index for macroinvertebrates = 1.83 in this study and H = 2.23 in Ojeda & Santelices 1984). Accordingly, the term 'barren ground' should be used more cautiously, only in reference to the general absence of macroalgae due to heavy overgrazing by sea urchins. In this study we use the term 'crustose coralline communities' because we believe it clearly denotes the most evident algal feature of these systems.

This study shows clear bathymetric trends in the composition and abundance of macroinvertebrates. The observed patterns of species distribution, however, are strongly influenced by the particular spatial distribution of the 2 most abundant invertebrate species in this community: *Strongylocentrotus droebachiensis* and *Modiolus modiolus* (Table 2). The shallow zone (3 to 12 m depth) is mostly dominated by sea urchins which from dense aggregations of up to 240 ind. m^{-2}, and comprise more than 90 % of the total biomass at these depths (Table 2). This zone is strongly affected by the grazing activities of sea urchins, which at these high densities are able to limit the distribution and abundance of almost any fleshy macroalgae. Experimental removals of green urchins conducted by Breen & Mann (1976) in Nova Scotia, and by Himmelman et al. (1983) in the St. Lawrence estuary, have demonstrated their ecological importance in determining diversity, abundance and distributional patterns of macroalgal species. The recent mass mortalities of urchins and the dramatic growth of fleshy algae along the Nova Scotia eastern coasts (Miller & Colodey 1983, Scheibling & Stephenson 1984, Scheibling 1986) have confirmed, on a large scale, the importance of sea urchins in rocky sublittoral environments. Crustose coralline algae, however, remain relatively unaffected by sea urchins because of their effective structural defense mechanisms against grazing (Paine & Vadas 1969, Steneck 1982, 1986, Johnson & Mann 1986a), thus monopolizing most of the primary substrate of rocky surfaces of sublittoral habitats, as observed in this study.

Most of the invertebrate species found exclusively at 5 m depth were typical intertidal forms that extended their distribution to the shallowest sublittoral zone (e.g. gastropod mollusks and amphipods), or were species closely related to the macroalgal turf of this shallow zone (e.g. polychaetes and small clams). The existence of this macroalgal turf as well as of a narrow band of kelp in the uppermost portion of the sublittoral zone (0 to 2 m below MLWL) is due to the general absence of sea urchins in this zone. Strong water movements, and wave turbulence, in addition to sea bird predation (Himmelman & Steele 1971) are probably major factors limiting the distribution of sea urchins into this shallowest subtidal zone, and the low intertidal zone as well (Himmelman 1986). The large aggregations of urchins in the shallow zone (5 m depth) were commonly observed feeding on drift algae as reported elsewhere (Lawrence 1975, Johnson & Mann 1982, Himmelman 1986, Sebens 1986a).

The reduction in number of species, and in abundance of invertebrates observed in the mid-sublittoral zone (9 to 11 m depth), is probably a result of intense grazing by *Strongylocentrotus droebachiensis*. The general absence of particular microhabitats that usually provide spatial refuges from predators may also contribute to this phenomenon. Indeed, the bedrock in the mid-sublittoral zone is markedly flat with few topographic irregularities such as large crevices and small cracks. Such spatial refuges are particularly relevant because sea urchins also feed upon a number of invertebrate species (Himmelman et al. 1983, Witman 1985, Sebens 1986a). Sea urchins, therefore, in addition to the mobile predator fauna of these environments, may be also exerting important influences in the abundance and distributional patterns of invertebrates in this community (Himmelman & Steele 1971, Keats et al. 1984, Witman 1985, Johnson & Mann 1986b, Ojeda & Dearborn unpubl.).

In the Gulf of Maine, settlement of *Strongylocentrotus droebachiensis* larvae has been shown to be random (Harris et al. 1984). The relative scarcity of sea urchins found in the deeper zone (16 to 20 m depth; Fig. 3) is probably related to differential survival. Low survivorship of urchins in this zone could be a result of low availability of food, or of heavy mortality exerted by the abundant mobile predators found at these depths (Ojeda & Dearborn unpubl.).

The change in species composition of macroinvertebrates observed at the deeper zone (18 m depth) as well as the marked increase in species richness (Table 1) were associated with increases in the abundance of *Modiolus modiolus* occurring in this zone (i.e. to the large numbers of individual *Modiolus* clumps; Fig. 3). Indeed, most of these macroinvertebrate species occur exclusively inside *Modiolus* beds (Table 3). A similar phenomenon has been documented in other populations of *M. modiolus*. Brown & Seed (1977), for example, found 90 invertebrate taxa associated with subtidal clumps of *M. modiolus* in Northern Ireland. Similarly, subtidal *Modiolus* beds off the Isles of Shoals studied by Witman (1985) contained significantly higher densities of invertebrates (infauna) than other subtidal habitats.

Experimental studies conducted by Witman (1985) on the ecological causes of such differential distribution and abundance of invertebrates have shown a functionally important role of *Modiolus* beds as spatial refuges from predators. This role, which is a by-product of the structural complexity of mussel beds (Witman 1985, Suchaneck 1986), is particularly significant because it has been suggested that predation and grazing by urchins are major determinants of community structure in New England rocky subtidal habitats (Witman 1985).

Modiolus clumps, however, also provide suitable and stable microhabitats for numerous invertebrates that are probably more important for specific life history processes of these species than for protection from predators (Brown & Seed 1977). This is probably the case with some infaunal organisms such as polychaetes and clams inhabiting the sediment and detritus that usually accumulate at the base of the mussels (Witman 1985, Suchaneck 1986, pers. obs.). These kinds of microhabitats are relatively rare on rocky substrates, which explains why some of these species were exclusively found inside the mussel beds. Alternatively, the shells and the intertices between the mussels, as well as the weft of byssus threads, may represent optimal feeding grounds for some epifaunal species. This is likely the situation occurring with some suspension and filter feeders such as barnacles, tunicates and ophiuroids which exploit the turbulences and slow water flows created by mainstream currents colliding with individual mussels (Connell 1972, Wainwright & Koehl 1976). Furthermore, because of the 3 dimensional asymmetric configuration of individual mussel clumps (i.e. mussels oriented in different directions) those turbulences (eddies) may also enhance retention of food particles inside the clumps, favoring prey capture in suspension-feeding organisms such as some octocorals and ophiuroids (Patterson 1984, Mary W. Wright pers. comm.).

Although the experimental results presented by Witman (1985) support the predation-refuge hypothesis, additional experiments to test the hypothesis of microhabitat selection are necessary before any conclusion is made on the causes explaining this phenomenon.

The invertebrate community, in general, did not show drastic temporal changes in abundance of organisms (biomass and density; Fig. 5) during the time span of this study (27 mo). However, it could be possible that on a longer temporal scale, these communities might be drastically affected by exceptional climatic events such as violent storms or hurricanes. Along the bathymetric gradient, the general temporal patterns in biomass and density observed in this subtidal community were mostly determined by the abundance pattern exhibited by *Strongylocentrotus droebachiensis* (at 5 and 10 m depth), and by *Modiolus modiolus* in the deeper zone (18 m depth) (Fig. 3). The only significant increase in the abundance (density) of macroinvertebrates was observed in October 1984 at 5 m depth (Fig. 5). It was due to a significant increase in density of *S. droebachiensis* (Fig. 6).

Population dynamic of sea urchins along this coast most likely represents population changes resulting from the combined and compensatory interactions of several processes involving recruitment, migration, and differential predation. Bathymetric migrations, for example, probably occur in response to the more severe climatic conditions observed in the shallowest subtidal zone during winter. Himmelman (1986) found that populations of green sea urchins of exposed locations in Newfoundland migrate in winter to greater depths where they encounter more favourable conditions than shallow habitats. On the other hand, seasonal changes in the abundance of sea urchins in the shallowest zone may well be the result of differential mortalities primarily affecting the juveniles. Drastic temperature changes and severe storms occurring in late fall and winter along New England coasts could account for seasonal mortalities of small sea urchins. Similarly, predation exerted by benthic mobile predators (lobsters, crabs and fishes) has also been shown to drastically affect the abundance and distribution patterns of sea urchins populations in these environments (Himmelman & Steele 1971, Johnson & Mann 1982, Keats et al. 1984, 1986, Witman 1985, Himmelman 1986, Ojeda 1987). Despite all these antecedents, at present, the relative importance of these processes is unclear.

The number of macroinvertebrate species (species richness) showed marked seasonal variations during this study. Maximum values were observed during summer, intermediate values in fall and spring, and a minimum value in winter of 1986 (Table 4). Most of these seasonal changes, however, were due to temporal variations in the occurrence of rare species (Table 4). In contrast, the most conspicuous and abundant species, such as sea urchins, mussels, limpets, chitons and sea stars, were permanent members of this community (Table 4).

The observed seasonal pattern of species richness, therefore, could be ascribed to seasonal inshore movements of some migratory invertebrate species (e.g. shrimps, amphipods), and to seasonal increase in the activity of other species such as gastropods mollusks associated with increasing temperature.

In summary, the results of this study agree with other studies in documenting well-defined patterns of zonation of benthic macroinvertebrates species inhabiting crustose coralline communities of shores of the Gulf of Maine (Noble et al. 1976, Logan et al. 1983, 1984, Sebens 1985, 1986a, Witman 1985). These patterns are the result of the combined effect of several ecological factors such as predation, competition, and physical disturbances (Sebens 1985, 1986b, Witman 1985, Ojeda 1987).

Acknowledgements. This paper represents a portion of the Ph. D. dissertation submitted by F. P. O. to the Department of Zoology, University of Maine, Orono. Drs Hugh DeWitt, Bill Glanz, Irv Kornfield, Robert Scheibling, Robert Steneck, Les Watling and Dave Tapley provided critical comments and valuable suggestions that greatly improved the manuscript. We appreciate the diving assistance and logistic support given by Mike Dunn, Phil Garwood, Chuck Gregory, Jef Guy, Sally Hacker, David Knowles, Mike Lesser, Curt Moody, Greg Podniesisnski, Baron Richardson, Kevin Scully, Dave Tapley, Robert Vadas, Rick Wahle, and Mary Wright. This work was supported by an ODEPLAN Chilean Scholarship, a University Graduate Research Fellowship of the University of Maine, and by grants from the Migratory Fish Research Institute (MFRI), the Graduate Student Board (GSB), the Department of Zoology awarded to F. P. O., and by the Center for Marine Studies, and the Ira C. Darling Center, all of them of the University of Maine.

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This article was presented by Dr J. Winter, Valdivia, Chile

Manuscript first received: November 5, 1988
Revised version accepted: June 9, 1989

SEASON OF ATTACHMENT AND GROWTH OF SEDENTARY MARINE ORGANISMS AT LAMOINE, MAINE[1]

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Introduction

In recent years a number of studies have been made of the ecology of sedentary marine organisms in various regions. Interest in this subject has been stimulated by the problem of fouling of ships, buoys and other immersed objects. Aside from practical applications these animal and plant communities are of general ecological interest. Examples of papers dealing with this subject are those of Visscher ('27), Coe ('32), Pomerat and Reiner ('42), and Engle & Loosanoff ('44). None have dealt with the faunal region represented by Frenchman's Bay on the Coast of Maine, although a general biological survey of the Mt. Desert region has been made (Procter, '33), and its results have been useful in the present study. The objectives of the study at Lamoine were: (1) To identify the species of "foulers"; (2) To determine the seasonal range of attachment and the time of maximal attachment; (3) To study the growth of individual species after attachment; and (4) To correlate the amount and type of fouling with ecological conditions. Preliminary observations were made during the summer of 1942, and more extensive surveys carried out in 1943 and 1944. Dr. Benjamin Speicher has assisted in identification, and has given valuable suggestions based on several summers' observations at Lamoine.

General Methods

Panels for use as collectors were made by cutting in two a 1 ft. by 2 ft. asbestos shingle commonly used for house siding. These are light grey in color, furnish a good surface for attachment and show no sign of deterioration in sea water. These panels were nailed to the side arms of a wooden cross with the flat surfaces in a horizontal position. The panel holders were sometimes anchored and marked by a buoy. In other instances they were suspended from a pier. The 1943 series of panels was mostly anchored. The 1944 series included both types, but accidents and storms caused the loss of most of the anchored group. The panels were exposed according to a schedule which left some immersed for relatively short periods (to determine season of attachment), and others for longer periods (to observe growth.)

During 1943 a number of small celluloid panels, 9 × 8 cm., were exposed. These proved useful for studying time of attachment, but growth was poor on them and they were not used for growth studies. Film-formers can be observed easily on these transparent sheets.

At each visit during 1943 the surface water temperature was recorded and salinity determinations were made for a period of two months. Results are tabulated in table I.

Table I. *Surface water temperatures and salinities at Lamoine, Maine in 1943*

Date	Temperature ° C.	Salinity
May 2	4.4	32.66
May 16	7.7	31.96
May 27	8.3	—
June 12	12.2	32.26
June 26	13.3	32.56
July 10	16.1	32.40
July 28	15.6	32.44
Aug. 11	15.6	—
Aug. 22	15.0	—
Sept. 9	13.9	—
Oct. 23	11.0	—

At the end of the exposure period the panels were wrapped individually in cheesecloth and preserved in formalin

[1] Supported by a grant from the Woods Hole Oceanographic Institution.

solution. Later the organisms were identified, counted and measured. Organisms attached to buoys, panel holders and ropes were scraped into jars, preserved and studied in a similar manner. Counts of the larger and rarer species were made on the entire panel. Smaller and more abundant organisms were counted in random sq. inch areas and the density of each species calculated in numbers per sq. ft. The rate of attachment has been expressed as numbers per sq. ft. per week (No./sq. ft./wk.).

General Description of the Area

Observations were limited to the vicinity of the University of Maine Marine Biological Laboratory which is located on the northern shore of Eastern Bay, an arm of Frenchman's Bay. In 1943 the first collectors were set out on May 2 and the last ones taken up on October 23. In 1944 the corresponding dates were June 2 and September 25. All but one of the collectors were suspended from the old coaling pier at the station, or were anchored near it. The one exception was exposed at Googin's ledge about one-half mile out from shore. The tidal range in the bay is 10 to 11 feet. A beach of coarse gravel slopes gently to a depth of about 12 feet at mean low water, then drops off rapidly to a depth of 40 feet. The slope is so steep that two collectors slid down and were lost in the deep water. Along the shore are dense beds of *Mytilus edulis*. *Mya arenaria* is fairly common. In the shallow area occur large numbers of the echinoderms, *Asterias vulgaris, Echinarachnius parma* and *Strongylocentrotus drobachiensis*. Rocks on the beach and the pilings on the pier are densely encrusted with the common barnacle, *Balanus balanoides,* between the tide levels. Below the low water mark the pilings are inhabited by *Metridium dianthus, Cucumaria frondosum, Tubularia crocea* and other species of similar habitat. Rockweeds such as *Fucus* are common but do not reach maximum abundance. During the summer this area is subjected to only moderate wave action. Tidal currents are of moderate strength near shore where observations were made.

General Nature of Collections

The collections made are poor in number of species as compared with more southerly regions. As a general thing it may be stated that growth is also slow. At certain seasons of the year, however, the density of attaching forms is very high and approaches the maximum possible concentration. It is possible to classify the species into four groups:

(1) Film formers. These include the diatoms, the minute filamentous or encrusting green and brown algae, together with certain protozoa of the class Suctoria. They can be studied best on glass or celluloid panels. No detailed study of these organisms has been made for this report, although material has been preserved for such a project.

(2) Primary attached forms. These are the barnacles, mussels and hydroids, bryozoans and tubeworms whose planktonic larvae attach to the collectors and develop into the adult form. The larger green and brown algae are also classified in this group.

(3) Casually attached or adherent forms. This is a rather heterogeneous group. On some of the panels large mussels were found which could not possibly have developed directly from their larval form during the period of exposure of the panel. Presumably they had been torn loose from a mussel bed and transported by water currents to the panels. During August both starfish and sea urchins climbed up the anchor ropes to the panels and practically denuded some of them. The sea slug, *Dendronotus arborescens,* and the polychaete *Lepidonotus squamatus* were other casual visitors. Possibly the polychaete, *Polydora ciliata,* should be included here. It occurred in great numbers on panels in sheltered locations during the month of August.

(4) Detritus. This may be either organic or inorganic. Pieces of kelp and

rockweed were frequently entangled with the collectors. These were discarded and not weighed. Silt sometimes accumulated on the upper surfaces of the collectors to a weight of over 1,000 grams/sq. ft. A very striking phenomenon during August, 1943, was the retention of silt by the tubes formed by the spionid worm, *Polydora ciliata*. The mass of tubes and silt covered some panels solidly to a depth of 25 mm. and eliminated other species with the exception of the common mussel. This phenomenon was repeated to a less degree in 1944. To a lesser extent *Obelia articulata* entrapped inorganic silt.

Seasonal Characteristics

The seasonal picture is pieced together from a study of the collected panels and field observation. It would undoubtedly be possible to date events more accurately by carrying out similar observations while in actual residence at the station. Panels were collected or observed at two-week intervals during both summers. The seasonal characteristics of both years are similar, but show some differences.

May (1943): A slight growth of film-forming organisms was the only finding. A filamentous diatom, *Fragillaria* sp., and *Acineta tuberosa* (Suctoria) were abundant. Water temperatures were below 10° C. during this month.

June (1943): A dense growth of algae was evident with *Cladophora rupestris* most abundant. On June 12 actinulae of *Tubularia* were collected. Attachment of *Balanus balanoides* began before June 12, but reached its peak during the latter part of June. It is possible that a few mussel larvae set in the last week of June, but the great peak of the mussel attachment came in July. Among the film-formers were Suctoria, Chlorophyceae and many diatoms.

June (1944): Algae were scant. The Bryozoans, *Electra pilosa, Tegella unicornis* and *Hippothoa hyalina,* attached throughout the month. Only a few *Balanus balanoides* and no mussels were found on the panels taken up June 25.

July (1943): The first two weeks in July were characterized by a very heavy set of *Mytilus*. This continued throughout the month, but less intensely. *Tubularia* continued to grow and establish new colonies. A few *B. balanoides* were found to have attached after July 10. Towards the end of the month this species was replaced by *B. crenatus*. New growth of *Cladophora* was very scant. In its stead the panels and ropes showed a development of the hydroid, *Obelia articulata*. During the last two weeks of the month swarms of the spionid worm, *Polydora ciliata,* became evident for the first time. Their activity is described above.

July (1944): *Balanus balanoides* set in large numbers during the first two weeks of this month. The maximum was about 2 weeks later than 1943. *Mytilus* set very heavily between July 9 and July 25. A very few were collected on July 9. *Polydora ciliata* was scarce. Five species of Bryozoa were collected during this month.

August (1943): In August the water temperature began to fall slowly and there was a diminution in the number of new attached forms. *Mytilus* larvae still set, but in tremendously reduced numbers. There was even a regression in total fouling brought about by several factors. Practically all the panels were visited by one or more of the common echinoderm species. In some cases these removed all mussels, algae, barnacles and similar forms. In other instances the cleanup action was less complete. Another cause of reduction was the loosening of the *Polydora* tubes so that wave action or other disturbance caused the entire mass of adherent material to slip off. An interesting sessile protozoan was a blue species tentatively identified as a species of *Platycola*. During August, *B. crenatus* occurs in considerable numbers. Its occurrence, however, was somewhat sporadic and was restricted to the deeper panels.

August (1944): The set of *Mytilus* continued heavy into early August and in reduced numbers throughout the month. Loss of two panels prevented counting of the late set. *Balanus crenatus* again appeared throughout the month. Large numbers of *Spirorbis spirorbis* were collected. Bryozoan species were similar to those of July.

September and October (1943): It was not possible to visit the station regularly during these months. However, the overall picture was that of a declining population with very little new growth. An exception was *Obelia articulata* which made good growth on panels exposed between September 9 and October 23. Some *Mytilus* were found on the same panels but they were limited to the line of contact between frame and panel. It is probable that they simply shifted their point of attachment a few millimeters. New colonies of *Lichenopora* developed during these months. However on the greater part of the surface of many panels, the only new growth was limited to diatoms. In particular no barnacles attached to test panels set out September 9 or later. *B. balanoides* and *Tubularia* underwent degeneration and were dead or in very poor condition by October 23.

September (1944): Newly attached species during the first half of the month included *Tegella unicornis, Lichenopora verrucaria, Spirorbis spirorbis,* and *Mytilus edulis.* Three panels exposed from September 17 to September 25 showed only *Spirorbis* and a single individual each of *Mytilus edulis* and *Balanus crenatus.* Throughout the month large numbers of young *Anomia simplex* became attached to the panels. The effect of predation was noted in both August and September of this year.

Growth Rate of Sedentary Organisms

By a study of the size range of members of a species in the collection from panels exposed for known periods of time, it is possible to construct a curve of growth. Providing the dates of larval attachment are known, one can calculate the extremes in age represented by the individuals on any panel. For example take a species with an attachment period during the month of July. If a panel is set out the first of July and taken up on August 30, the ages of this species will range between approximately four and eight weeks. We may assume that the smallest size group is four weeks old, the largest group is eight weeks old, and others will be intermediate. Results on those species for which adequate data were obtained during the survey are recorded below. When three numbers are given they signify minimum, average and maximum size within the age group. Growth figures for 1943 and 1944 were averaged and no significant difference was found unless specifically indicated. All depths are given relative to mean low water level.

Tubularia crocea:

Attachment period: Macroscopic colonies develop from early July to mid-August. Actinulae of this species were collected June 12, 1943. Maximum attachment during late July and early August.

Density and rate of growth: At 15 ft. from July 23 to Aug. 20, 0.5 per cent of surface/week; from Aug. 4 to Sept. 3, 0.75 per cent of surface/week.

4 weeks: 20 mm. high. Colonies 10–20 mm. in diameter containing 10 to 20 polyps.

8 weeks: 40–60 mm. high. Colonies may contain hundreds of polyps. Great variation between individual colonies.

During September and October there is a great reduction in polyps and only broken stalks were found on October 23, 1943.

Obelia articulata and *O. dichotoma:*

In the early season collections of 1943 and 1944 a species of *Obelia* was found which could not be positively identified because of immaturity. In September and October of 1943 an abundant growth of *O. articulata* was found on many panels. If these were mature individuals of the earlier type the attachment period may begin as early as late June. It certainly extends into mid-September. Growth is scanty during July, but is rapid during August and September. On Sep. 9, 1943, colonies averaged 40–70 mm. high. On Oct. 23 they ranged from 50–150 mm. (average 100 mm.). Although bulky the weight of this species is low. In 1944 *O. articulata* was not found. A hydroid was found to attach commonly during June and July in 1944, but it grew poorly. Although not well preserved for taxonomic purposes it is believed to be *Obelia dichotoma.*

Bougainvillea carolinensis:

In 1944 this species was found closely associated with *Obelia dichotoma* on two panels exposed at 3 feet. Attachment period in July. Growth scanty. Maximum height, 15 mm.

Balanus balanoides:

Attachment period (1943): Middle of May to middle of July. Maximum during June. (1944) About two weeks later than in 1943. Maximum during first two weeks of July.

Attachment density on lower surface (1944)

Depth	Dates	No./sq. ft./week
3 ft.	June 25–Aug. 4	340
15 ft.	June 25–July 23	500
30 ft.	July 9–Aug. 4	1340

The growth of the 1943 specimens is tabulated below. The 1944 individuals grew much more slowly and their average growth is approximately the minimum given here. The reason appears to be the unfavorable location of the 1944 group on the lower surface of deep panels. The 1943 series was collected near the surface.

Diameter of base: mm.

Age	Min.	Ave.	Max.
4 weeks	1.0	4.0	8.0
8 weeks	1.5	6.0	9.0
12 weeks	2.0	8.0 (?)	14.0

This species has a very high mortality rate in September and October.

Balanus crenatus:

Late July to mid-September. Maximum probably during the middle of August. Not found at surface or at 3 feet Average growth is similar to that of *B. balanoides,* but the maximum size reached during the season was less. Attachment density, July 23–Sept. 17, 1944, 15 ft., 18/sq.ft./week.

Mytilus edulis:

Attachment period (1943): Last week in June to the third week of August. Maximum during the first ten days of July.

(1944) Very few during early July. Sudden rise shortly after July 9, and continuous high rate through the first week of August. Continues at a slower rate as late as Sept. 3, but none after Sept. 17.

Attachment density on lower surface (1944)

Depth	Dates	No./sq. ft./week
3 ft.	June 18–July 9	80
3 ft.	July 9–Aug. 4	20,000
3 ft.	Aug. 20–Sept. 3	2,000
3 ft.	Sept. 3–Sept. 17	130

The general picture is similar to that described by Engle and Loosanoff ('44) at Milford, Conn. with the beginning of the attachment period from 3 to 4 weeks later. The decline following the maximum is less abrupt at Lamoine than at Milford.

Approximately equal density was found on the 15 ft. panels, but much lower numbers on the 30 ft. group. This is due in part to the attacks of bottom-dwelling animals on the deep panels, so that the difference is not a measure of rate of attachment. Engle and Loosanoff (*op. cit.*) found attachment all the way to the bottom, but the greatest depth studied was 6 ft.

The measurements given below were made on mussels of the 1943 collections and represent the length of the valve in millimeters.

Growth: Length of valve in mm.

Age	Min.	Ave.	Max.
1 week	—	0.25	—
4 weeks	1.0	2.0	4.0
8 weeks	1.0	3.0	5.0
12 weeks	2.0	6.0	8.0
16 weeks	3.0	8.0	18.0

The variation in size increases with advancing age. This is probably due to competition for space. Unfavorably situated animals obtain less food, and are eventually crowded out. Data on growth at different depths was obtained in 1944 and is summarized below:

Average length in mm. of Mytilus *at different depth levels*

Depth	Age	
	4 weeks	11 weeks
Surface float	2.5	8.0
Panel 3 ft.	0.98	6.7
Panel 15 ft.	0.74	2.3
Panel 30 ft.	0.85 (?)	2.0 (?)

All of these mussels were continuously submerged, a favorable factor for rapid growth as has been shown by Coulthard ('29).

Molluscs (other than *Mytilus*):

From July onward a few *Mya arenaria* approximately 2 mm. in length were collected on the panels. A single *Cardium pinnulatum* was found in October, 1943. Large numbers of *Anomia simplex* were collected during late August and September, 1944. Their maximum density of attachment was 3000/sq.ft./week, at 3 ft. between Sept. 3 and Sept. 25.

Spirorbis spirorbis:

This small worm attached from June to September, and seemed to become progressively more abundant during the season. It is less abundant at 3 ft. than at the two deeper levels.

Attachment density on lower surface (1944)

Depth	Dates	No./sq. ft./week
15 ft.	June 2–June 18	0.5
15 ft.	June 18–July 9	12.0
15 ft.	July 9–Aug. 4	0—Crowded out by *Mytilus*
15 ft.	Aug. 4–Sept. 3	575.0

Bryozoa:

Five species of Bryozoa were identified on the panels in 1944. All are recorded as common in Procter's ('33) survey of the Mt. Desert Region. They were found at all depths and on certain panels were the dominant foulers. In order of abundance they are: *Tegella unicornis, Lichenopora verrucaria, Hippothoa hyalina, Callopora craticula,* and *Electra pilosa.* A few *Tegella* attached in June, but the maximum density (60 to 100/sq.ft./week) was during July and August. The 15 ft. level was preferred. On one panel exposed from June 2 to Sept. 25 *Tegella* covered 40 per cent of the surface with colonies ranging up to 26 mm. in diameter. Average colonies grew from 10 to 15 mm. in diameter. The season and density of attachment of *Lichenopora* were similar, but the growth was much slower. The maximum size of colonies was 7 mm. with an average for 8-week colonies of 5 mm. It was less abundant at 3 ft. than at the two deeper levels. *Electra pilosa* var. *dentata* was found throughout the season in moderate numbers. Although it is commonly stated to be a rapidly growing species, it was overgrown by both *Callopora* and *Tegella.* *Hippothoa* attaches from June to September, but grows more rapidly during August. Four-week colonies are from 3.6–4.0 mm. diameter; six-week colonies have a maximum diameter of 8.5 mm. *Callopora* is predominantly a late summer form. It makes rapid growth and colonies attain a size of 10 mm. in about six weeks.

Cladophora rupestris:

It is uncertain that all the specimens of *Cladophora* were of this species, since some were observed in a very immature condition. It is predominantly an early season form becoming established in May, but making little growth until June and July. At the end of June filaments extended up to 4 cm. At the end of July the maximum length was about 15 cm. This was the only alga to grow well on the submerged panels or wooden frames. An idea of its growth may be obtained from the following figures for wet weight of material scraped from panels on which this was the dominant form.

Weight of Cladophora from panels (1943)

Depth	Dates	Grams/sq. ft.
Surface	May 2–June 26	7.2
Surface	May 2–July 10	22.0
Surface	May 2–Aug. 28	84.0

Algae:

Ulva lactua, Punctaria latifolia and *Capsosiphon fulvescens* grew well on the wooden floats and occupied most of the available space. Many young mussels were attached to them. The average length of the thallus of each species during the last of August, 1943, was: *Ulva,* 10 cm.; *Punctaria,* 20 cm.; and *Capsosiphon,* 18 cm. The wet weight of these algae ranged from 114 to 176 grams per sq. ft.

Weight of Organisms and Sediments

The wet weights of most samples were taken after preservation in formalin solution. The material was allowed to drain and pressed gently to remove adherent drops, but still contained much capillary water. Most of the 1943 samples were dried at room temperature and reweighed. The average dry weight of 21 samples was 27 per cent of the wet weight.

Conditions at Lamoine favor sedimentation, and heavy accumulations of silt were found on many of the panels. This is a serious hazard for sedentary organisms on the upper surface of the panels. The highest sample weights (ranging from 300 to 1000 grams/sq.ft.) occurred on the upper surface of panels densely covered by *Mytilus* and *Polydora.* The worm tubes helped to hold the sediments in place. It is estimated that 90 to 95 per cent of these samples was inorganic material.

Well developed *Cladophora* in midsummer of 1943 weighed up to 85 grams/sq.ft. Algae on surface floats attained a weight of 94 to 176 grams/sq.ft. during the summer period of 3 to 4 months. *Mytilus* in practically pure population attained weights of from 60 to over 200 grams/sq.ft. from July to October. *Obelia articulata* was the only other species quantitatively to dominate a panel. Wet weights ranged up to 40 grams per sq. ft. On the lower surfaces of the 1944 panels weights of less than 5 grams/sq.ft. were found after a month's exposure, and seasonal growth reached a maximum wet weight of approximately 50 grams/sq.ft. The weights of organisms on the upper surfaces were less than this, because of smaller numbers and the effects of heavy silt deposits mentioned above.

Except in cases where one form preempts all available space and then increases in mass through growth, there is little correlation between the duration of exposure, and weight of accumulated organisms. Instead the weights seem to depend upon the dominant species, and this in turn is dependent upon the season of exposure and the amount of predation. In Maine waters panels exposed in May are covered with algae, so that later season species do not find a suitable foothold. *Mytilus* is an exception as it attaches readily to algae and to the stalks of hydroids. Panels set out in July and August showed the most rapid fouling due to the great numbers of *Mytilus edulis, Balanus balanoides,* and Bryozoa. Only scattered new growth appeared after August.

Effect of Depth, Mode of Suspension, and Selection of Upper and Lower Surfaces

As explained above panels were exposed in two different ways. One group was anchored so that it remained at a fixed distance above the bottom. Another series was suspended from the Marine Station pier. Previous discussions with Dr. L. W. Hutchins of the Woods Hole

Oceanographic Institution, had suggested the possibility that there was a difference between buoy fouling, and the fouling of suspended panels. Unfortunately a heavy storm carried off most of the anchored panels in 1944, so that direct comparison is not possible. The chief difference noted over the two-year period is the more abundant algal growth on the anchored series. This may be due to better illumination in open water, and to smaller accumulation of silt on these panels. Bryozoa grew more luxuriantly on the suspended series. Mussels and barnacles were found equally on each.

The best data on depth distribution come from the panels suspended from the pier in 1944. Relative to mean low water these were placed at depths of 3 ft., 15 ft., and 30 ft. Within this depth range there are no absolute qualitative differences and quantitative differences must be accepted with caution, since the number of panels studied to date is not large enough for statistical analysis. This is particularly true at 30 ft. since these panels were heavily grazed by starfish and sea urchins. Characteristics of depth distribution are summarized for the more important species and groups.

Cladophora grew fairly well on the early season panels at 3 ft. and 15 ft. but was scanty at 30 ft. Hydroids were found at all depths with *Tubularia* most abundant at 3 ft. and *Obelia* at 15 ft. Bryozoa were most abundant and grew best at 15 ft. *Balanus balanoides* set about uniformly at all three depths, but *Balanus crenatus* was restricted to 15 and 30 ft. *Mytilus* set most densely at the two upper levels and grew better near the surface as described above.

There is a striking difference between the fouling of the upper and lower surfaces. The upper surface is more suitable for *Cladophora* and *Polydora* though neither species is restricted to this habitat. The lower surface was much more favorable for barnacles, *Tubularia* and Bryozoa. The count of mussels was higher on the upper surface in 7 instances and on the lower surface in 18 instances. Because sediments on the upper surface interfere with counting and measurement as well as with the growth of sedentary organisms, the quantitative data of this report have come from the lower surfaces. This result agrees with that of Pomerat and Reiner (*loc. cit.*). These authors discuss the mechanism of attachment in terms of geotropic and phototropic factors. In long periods of exposure such as were used in the Lamoine experiments, silting and predation appear to be the most important factors affecting the success of individuals once they have succeeded in becoming attached. Both of these hazards are greater on the upper surface.

Summary

(1) An investigation of the growth of sedentary organisms at Lamoine, Maine, was carried out during the summers of 1943 and 1944. The more common species are: *Tubularia crocea, Obelia articulata, Obelia dichotoma, Balanus balanoides, Balanus crenatus, Mytilus edulis, Spirorbis spirorbis, Polydora ciliata, Callopora craticula, Electra pilosa, Hippothoa hyalina, Lichenopora verrucaria, Tegella unicornis, Cladophora rupestris, Capsosiphon fulvescens, Punctaria latifolia* and *Ulva lactua.*

(2) Data are presented concerning the seasonal occurrence of these species, their relative abundance and rate of growth. Fouling occurs throughout the period from June to September, but is most rapid during July and August.

(3) Preliminary observations on the influence of depth, method of panel suspension, location and other ecological factors are reported.

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10.1.2 Appendix A.2 – Surficial Geology of the Maine Inner Continental Shelf Maps

Surficial Geology of the Maine Inner Continental Shelf

Boothbay Harbor to North Haven, Maine

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GEOLOGIC MAP NO. 96-10
1996

Funding for the preparation and publication of this map was provided by the Regional Marine Research Program (RMRP #NA46RM0451)

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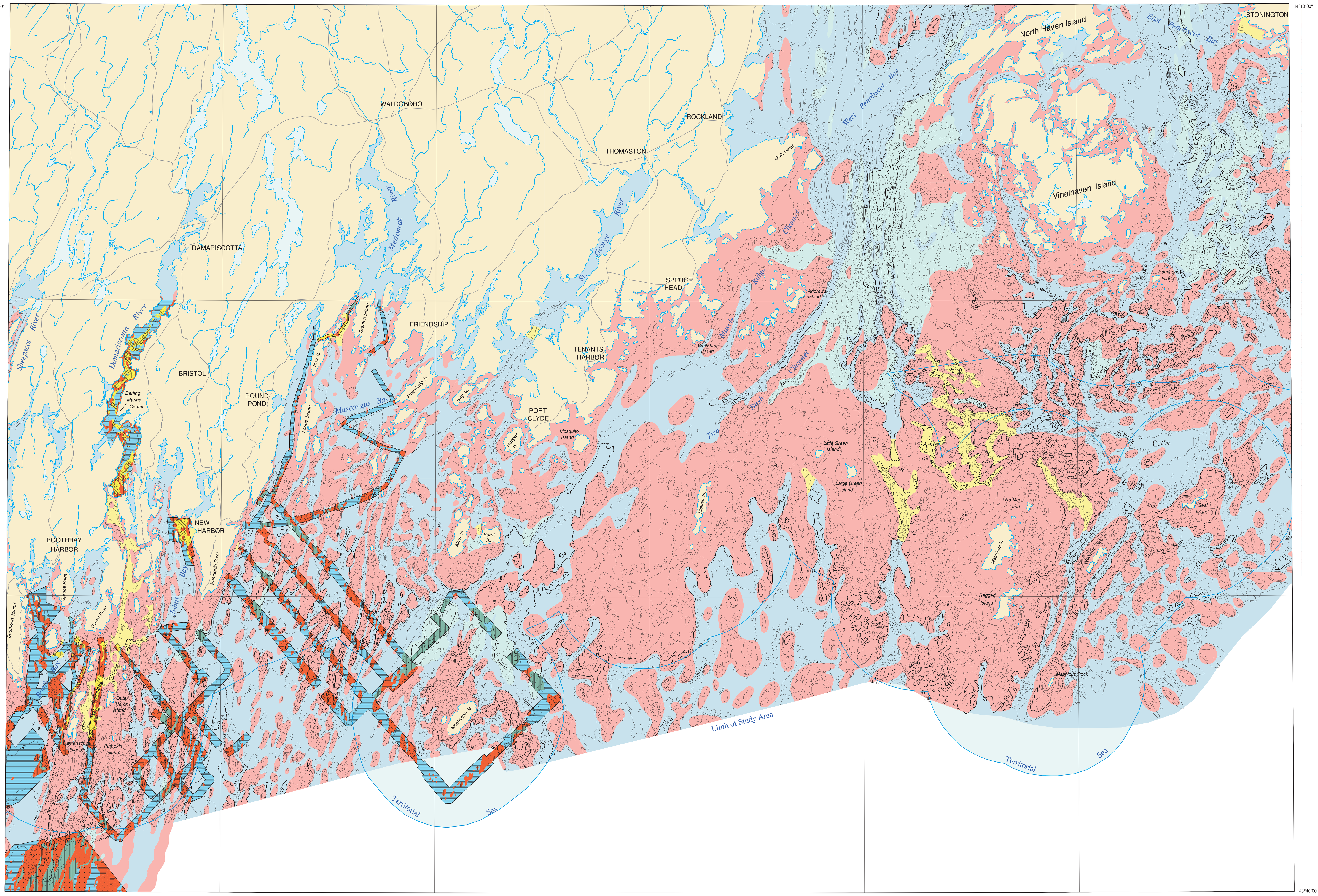


Map Projection: Universal Transverse Mercator, Zone 19
1927 North American Datum

Nautical Miles (nmi)

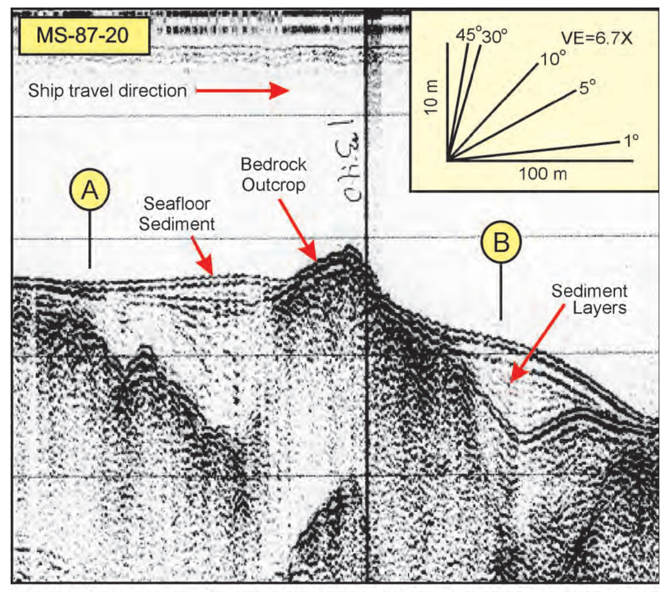
Map Scale 1:100,000

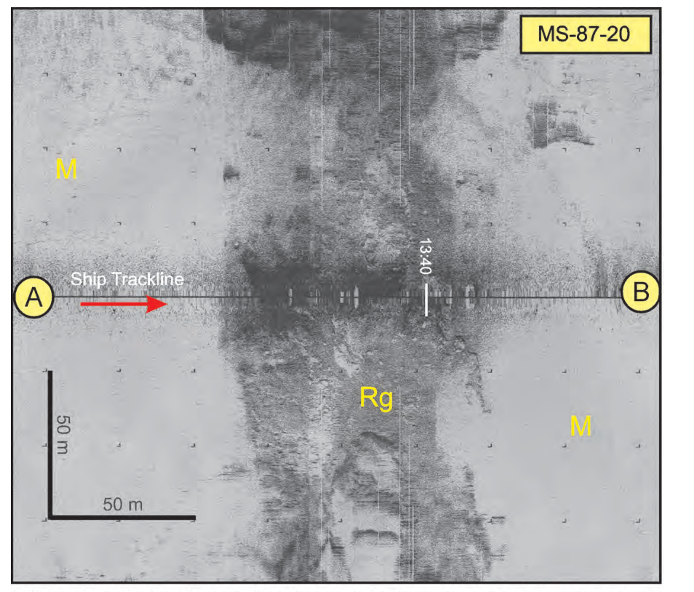
Kilometers (km)

National Geodetic Vertical Datum of 1929
Contour Interval 10 Meters

INTRODUCTION

SURFICIAL GEOLOGY





METHODS

Surficial Geology Legend

The map above shows the geology of the surface of the ocean floor. This map of Maine's inner continental shelf is based on geophysical data, bottom samples, National Ocean Service provisional bathymetric maps and published nautical charts. These data were supplemented with bottom photographs and direct observations from submersibles. Experience with these data, together with side-scan sonar images (the underwater equivalent of aerial photographs), permitted generalized mapping of the inner continental shelf.

The map areas shown by the four colors below were not directly imaged with side-scan sonar. Contacts between these geologic units were inferred, based on bathymetry and other information (see **Features and Data Source Map**).

The bright colors on the map and in the **Interpretation of Side-Scan Sonar Images** legend to the right show areas of seafloor imaged by sonar. The linear colored swaths on the map above follow ship tracklines and have a width that represents the sonar swath to each side of the vessel.

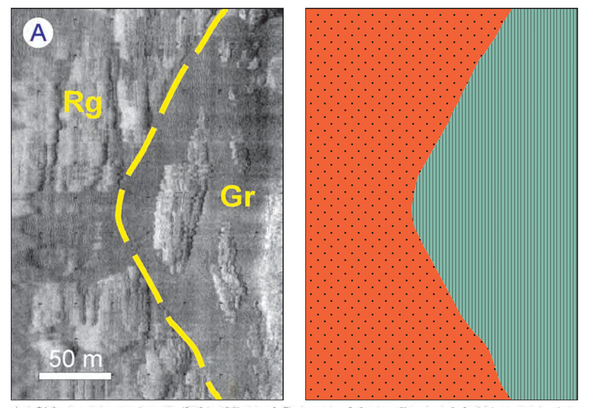
ROCKY - Rugged, high-relief seafloor is dominated by bedrock outcrops (ledge) and is the most common type on the Maine inner continental shelf, especially in depths of less than 60 m (~200 ft). Accumulations of coarse-grained sediment occur in low-lying areas and at the base of rock outcrops.

GRAVELLY - Generally flat-lying areas are covered by coarse-grained sediment, with clasts up to several meters (yards) in diameter. In some areas gravel and boulders directly overlie bedrock. These deposits are not presently accumulating on the shelf but represent Pleistocene (Ice Age) material. Ripples are common in well-sorted gravel, indicating that some of the older glacial sediments are presently being reworked by waves, currents, and tides.

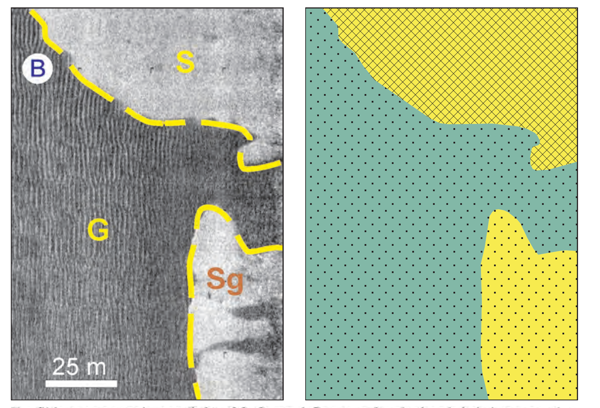
SANDY - Generally smooth seafloor consists primarily of sand-sized particles derived from rivers, reworked glacial deposits and/or biogenic shell production. This bottom type, although well represented in southwestern areas, is the least common on the Maine inner continental shelf.

MUDDY - Deposits of fine-grained material form a generally flat and smooth seabed commonly found in sheltered bays and estuaries and at depths of greater than 60 m (~200 ft). In some submarine valleys the mud may be meters (yards) thick. Deep depressions (gas-escape pockmarks) occur in some muddy bays.

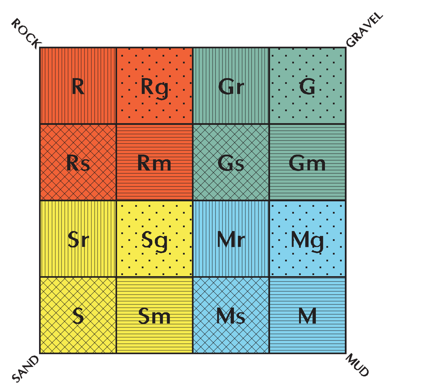
Interpretation of Side-Scan Sonar Images



A. Side-scan sonar image (left) of **Rg** and **Gr** areas of the seafloor and their interpretation (right). In the image, gravelly areas appear dark gray and bedrock outcrops show irregular perimeters, dark (sound reflective) streaks and light gray acoustic shadows. Fractures are prominent in the bedrock; gravelly areas have low relief.



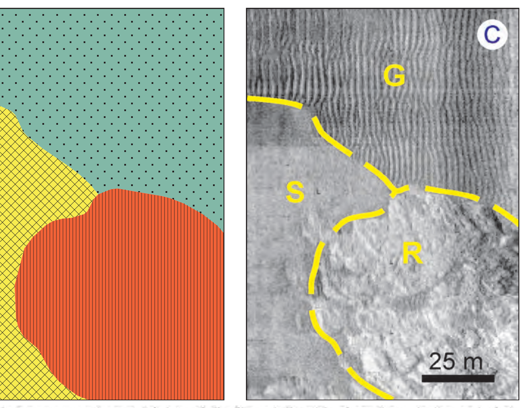
B. Side-scan sonar image (left) of **S, Sg,** and **G** areas of seabed and their interpretation (right). Sandy seafloor is lighter gray and appears smooth while the gravelly seafloor has wave ripples with straight crestlines about 1 m (3 ft) apart. **Sg** areas occur as a patchwork of **S** and **G** types, but are too small to discriminate at this map scale.



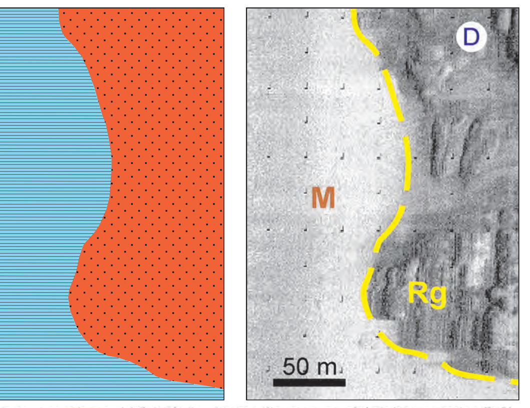
On side-scan sonar images, rock, gravel, sand, and mud reflect acoustic energy differently and appear as various shades of gray printed by the instrument's recorder. The classification scheme above is unique and based on the acoustic reflectivity of the Maine inner continental shelf. The dominant "end member" (**R**ock, **G**ravel, **S**and, or **M**ud) is abbreviated with a capitalized first letter. A less abundant, subordinate seafloor type is represented with a lower case letter (**r, g, s,** or **m**). For example, a predominantly rocky seabed with gravel infilling fractures is designated **Rg**. The sixteen combinations of seafloor types shown above are used for areas where side-scan sonar coverage exists and appear as bright colors on the map. In areas beyond the scan range only four generalized units were used (see the **Surficial Geology Legend**).

When individual units of rock, gravel, sand, and mud were greater than 10,000 m^2 in area (about the size of 3 football fields), they were mapped as separate features. In many places, however, a heterogeneous seabed composed of numerous small features required composite map units. In areas where no single seafloor type exceeded 10,000 m^2, a composite map unit was used. The selection of map units to describe this complexity involves a compromise between providing detailed information where it exists, and generalizing where data are scarce or absent. In many places the seabed is composed of numerous small features, none exceeding the minimum area of 10,000 m^2. Consequently, not all details in the sonar records could be presented on this map. It should be realized that spatial heterogeneity exists at all scales, even down to areas less than a square meter (ten square feet).

Rock yields a strong, dark, acoustic return. In areas with steep bathymetric relief and fractures, light acoustic shadows are visible within the dark areas of rock (see adjacent panels **A**, **C**, and **D**). Gravel deposits also produce a relatively strong acoustic return (black to dark gray), and are often closely associated with rock, but lack relief (**A**, **B**, **C**, **D**). Sand produces a much weaker acoustic return (light to dark gray) than either gravel or rock, and usually lacks local relief (**B**). Mud yields a very weak surface return (light gray to white) and, except where it accumulates on steep slopes or near gas-escape pockmarks, it is associated with a smooth seabed (**D**). The **Surficial Geology** section in the far right column describes the distribution and abundance of these areas on Maine's inner continental shelf.

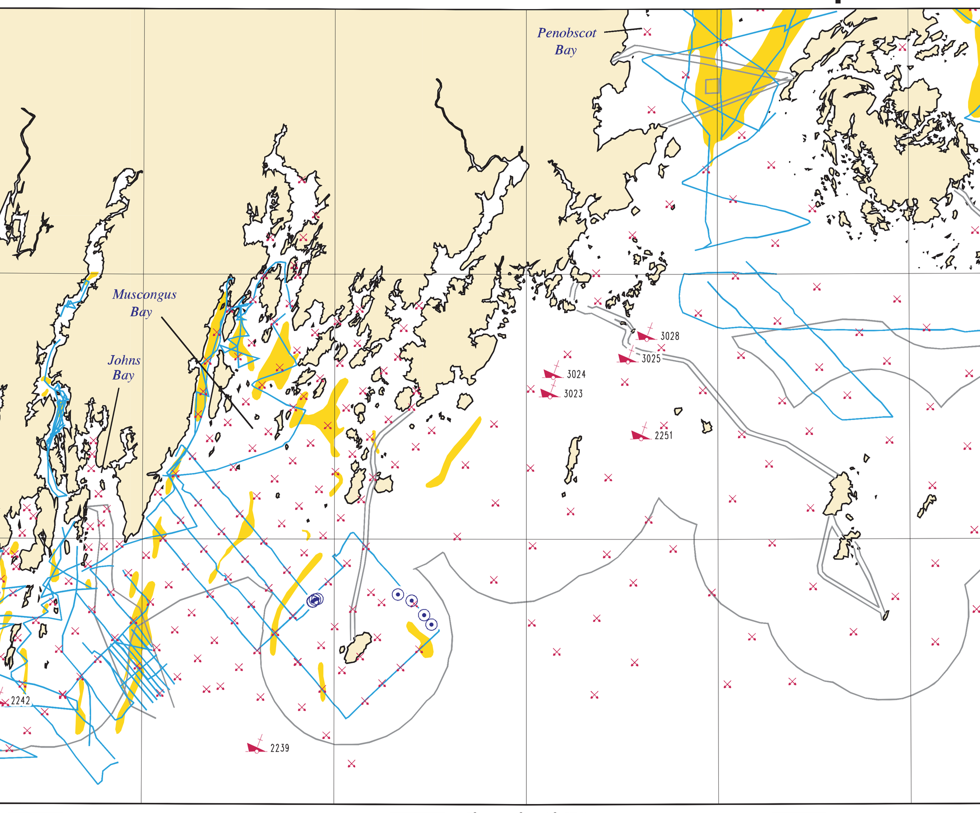


C. Side-scan sonar image (right) of **S, G,** and **R** with sharp boundaries and their interpretation (left). Ripples in the gravelly seabed produce alternating light and dark bands while the sandy surface is more uniformly gray. These ripples have a 2 m (6 ft) wavelength. The rocky outcrop rises above the surrounding seafloor.



D. Side-scan sonar image (right) of **M** and **Rg** seafloor types and their interpretation (left). Muddy seafloor is uniformly light gray although the tonal difference on the left edge is a recorder artifact. A mixture of rocky outcrops has an irregular dark gray appearance while gravelly troughs appear smooth and dark gray.

Features and Data Source Map



Samples, Smith-MacIntyre grabs and vibracores

Natural gas deposits, buried beneath the seafloor

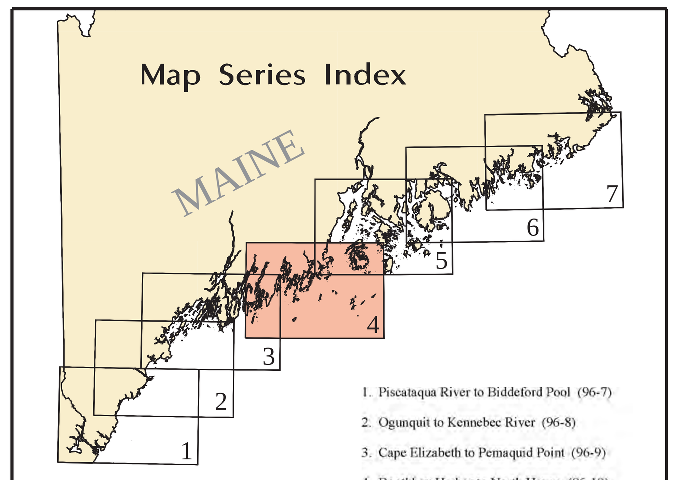
Shipwrecks with ID#, see: *The Seafloor Revealed* for more source information

Misc. features, dump sites, cable areas, Territorial Sea (3 nmi) limit

Seismic reflection profile tracklines

Submersible dives

Map Series Index



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6. Mt. Desert Island to Jonesport (96-12)
7. Petit Manan Pt. to West Quoddy Head (96-13)

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Web Site: http://www.maine.gov/doc/nrimc/nrimc.htm

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environments, but are most noticeable when carved into mud. Gas-escape pockmarks are generally hemispherical depressions that result from localized seabed disturbance. Where pockmarks occur in abundance, the seafloor is uneven. Thousands of pockmarks hundreds of meters (yards) in diameter and tens of meters (yards) deep make crater-like terrain in the muddy bottom in Belfast, Blue Hill, and Passamaquoddy Bays (**7,8**).

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(**1**) Kelley, J. T., Barnhardt, W. A., Belknap, D. F., Dickson, S. M., and Kelley, A. R., 1996, The seafloor revealed: the geology of the northwestern Gulf of Maine inner continental shelf: Maine Geological Survey, Open-File Report 96-06, 55 p.

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(**4**) Belknap, D. F., Shipp, R. C., Stuckenrath, R., Kelley, J. T. and Borns, H. W., Jr., 1989, Holocene sea level change in coastal Maine, *in* Anderson, W. A., and Borns, H. W., Jr. (editors), Neotectonics of Maine; Studies in seismicity, crustal warping, and sea-level change: Maine Geological Survey, Bulletin 40, p. 85-103.

(**5**) Kelley, J. T., Dickson, S. M., Belknap, D. F., and Stuckenrath, R., Jr., 1992, Sea-level change and late Quaternary sediment accumulation on the southern Maine inner continental shelf, *in* Fletcher, C. H., III, and Whemiller, J. F. (editors.), Quaternary coasts of the United States: marine and lacustrine systems: Society of Economic Paleontologists and Mineralogists, Special Publication No. 48, p. 23-34.

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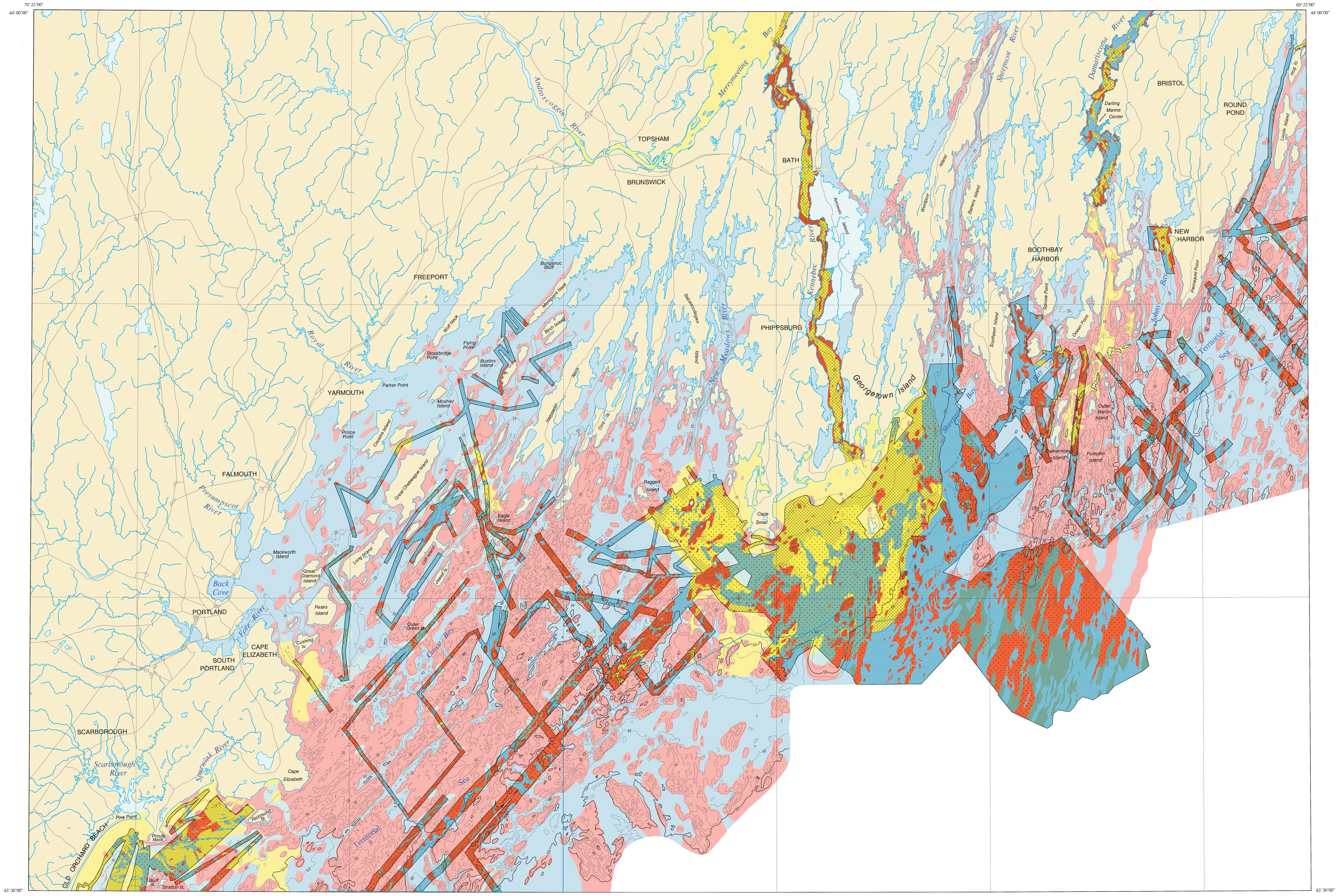
(**9**) Kelley, J. T., Dickson, S. M., Barnhardt, W. A., Belknap, D. F., and Kelley, A. R., in preparation, Physiographic map of the Maine inner continental shelf: Maine Geological Survey, Open-File Map.

(**10**) Osberg, P. H., Hussey, A. M., II, and Boone, G. M., 1985, Bedrock geologic map of Maine: Maine Geological Survey, scale 1:500,000.

ACKNOWLEDGMENTS

Funding for this compilation was provided by the Regional Marine Research Program of NOAA (Grant # NA46RM0451). We wish to thank Mr. Walter A. Anderson, former Director of the Maine Geological Survey, for more than ten years of unrelenting encouragement and support for our offshore research. In addition, we thank Dr. Robert E. Wall who directed the University of Maine Center for Marine Studies, which partly purchased the geophysical equipment and GIS used for this compilation. Most of the data collection was sponsored by the Maine-New Hampshire Sea Grant Program, the Continental Margins Program of the Minerals Management Service and Association of State Geologists, the National Science Foundation, the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Undersea Research Program, and the Maine Department of Marine Resources. We acknowledge many graduate students who assisted in the original collection and interpretation of much of the data, especially Dr. R. Craig Shipp. Finally, we acknowledge the able seamanship of Captain Michael Dunn, formerly of the Darling Marine Center, who participated in all bottom sampling and most geophysical expeditions.

Surficial Geology of the Maine Inner Continental Shelf



Map Projection: Universal Transverse Mercator, Zone 19
1927 North American Datum

Nautical Miles (nmi)

Map Scale 1:100,000

Kilometers (km)

National Geodetic Vertical Datum of 1929
Contour Interval 10 Meters

Cape Elizabeth to Pemaquid Point, Maine

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Published by:
DEPARTMENT OF CONSERVATION
Maine Geological Survey
Robert G. Marvinney, State Geologist

GEOLOGIC MAP NO. 96-9

1996

Funding for the preparation and publication of this map was provided by the Regional Marine Research Program (RMRP #NA46RM0451)

Digital cartographic production and design by:
Bennett J. Wilson, Jr.
Robert D. Tucker

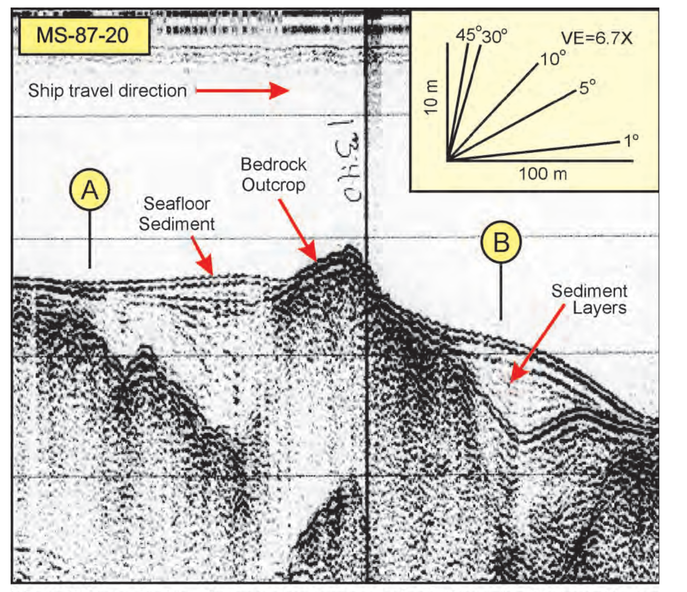
INTRODUCTION

Geological maps depicting topography, surficial materials, geomorphology, and bedrock play an important role in understanding the origin of, as well as the ongoing processes that shape and change the earth's surface. As in the terrestrial environment, maps are also instrumental in aiding the sound economic development of natural resources. They also provide guidance to natural hazards that exist within the landscape. As people increasingly work on, in, and beneath the sea, the need to better understand regional marine geology, just as we understand terrestrial geology, has grown. This map, and others in this series, are intended to provide a better picture of the northwestern Gulf of Maine. Additional information on specific locations and original field descriptions exists in the associated report: *The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf* (**Reference 1**).

Many reconnaissance surveys of the seafloor of the northwestern Gulf of Maine were conducted in the past decade. Recently that information, along with other previously published data, was compiled in a geographic information system (GIS) to produce this map. The data compiled for this series of maps were originally collected for a variety of research projects, government contracts, and student theses. For this reason there are varying amounts of geophysical data and bottom-sample coverage along the coast rather than a uniform grid. *The Seafloor Revealed* further explains the field techniques involved in data collection, the nature of the seafloor, the late Quaternary (glacial) geologic history of the Maine coast, previous studies, and sources of other information.

Bedrock geology defines the overall shape of the Maine coastline by controlling the location and orientation of islands, bays, and peninsulas. Bedrock relief is also primarily responsible for the variability in water depths of the inner shelf. Glacial deposits mantle the underlying bedrock and add complexity to regional geomorphology in forms that range from coarse ridges of boulders to basins filled with fine mud. Thick accumulations of glacial sediments (gravel, sand, and mud) often result in smoother areas of seafloor with less bathymetric relief. Almost all of the Holocene (postglacial) sedimentary material along the coast and offshore is derived from erosion and reworking of glacial deposits. Physical oceanographic processes, including waves and tides, continue to reshape the seafloor sediments and create productive marine habitats of the Gulf of Maine.

Sea-level change has had a profound effect on the location and duration of sediment reworking and deposition. During the complex changes of sea level over the last 14,000 years, coastal and terrestrial erosion stripped muddy glacial sediment from shoals and transferred the material to deeper basins. During deglaciation, the sea covered most of the coastal lowlands of Maine (**2**). A regression (sea-level lowering) until about 10,500 years ago was followed by a transgression (rising) that is still continuing (**3, 4**). Areas shallower than the maximum lowering of the sea (less than about 60 m (200 feet) water depth) are generally rockier than deeper regions. The shallower zone lost some of its sediment cover through wave reworking during both the late Pleistocene fall and the early Holocene rise of the sea. These areas also experienced at least a thousand years of subaerial erosion by rivers and streams. The marine geology of the Maine coast records these and many other changes that have taken place since glaciers retreated inland and the sea invaded the western Gulf of Maine (**4, 5, 6**).



Seismic Reflection Profile. The image above is a portion of an ORE seismic reflection profile from Muscongus Bay and shows a cross-section (side view) of the seafloor. The seafloor surface shape is analagous to a fathometer profile. A vertical exaggeration (VE) of 6.7 makes all slopes appear steeper than they really are. The subsurface reflectors are from sediment layers and buried bedrock surfaces. Positions A and B correspond to the same locations in both figures. A time mark is shown by the vertical line at 13:40.

METHODS

Navigation and Map Compilation

Navigation fixes in the outer estuaries and offshore areas were made at 2 to 5 minute intervals with LORAN-C, which provided an accuracy of $\pm$ 100 m (330 feet). In the upper reaches of the estuaries, radar and line-of-sight observations on buoys and landmarks provided navigational accuracy that varied from less than $\pm$ 10 m (33 feet) to around $\pm$ 200 m (660 feet). Recent work used the global positioning satellite system (GPS) for navigation and was accurate to $\pm$ 10 m (33 feet). All navigation was converted to Universal Transverse Mercator projection and plotted with a geographic information system (GIS).

Surficial geologic maps were prepared in six steps: (1) use a GIS to plot the geophysical tracklines, bottom sample locations, and bathymetry on large-scale maps, (2) interpret sonar records and geology based on other geophysical data and samples, (3) digitize the drafted interpretation into a GIS, (4) compile and edit the digital data to generate map polygons, (5) check the mapped geology, and (6) assemble the final product including geology, bathymetry, geographic names, and roads. The shoreline and roads are from the U.S. Geological Survey's 1:100,000 Digital Line Graph files.

Bathymetry

Bathymetry was digitized at a 10 m contour interval from preliminary National Ocean Service (NOS) Bathymetric and Fishing Maps at a 1:100,000 scale. The NOS bathymetric maps provide a 2 m contour interval in many locations that is too complex for inclusion on this map. Difficulty in interpretation of positive and negative changes in bathymetry on the poorly labeled NOS maps created many possible errors, especially in areas where accompanying geophysical data were lacking. For this reason, these maps should not be used for navigation. More detailed and accurate NOS conventional nautical charts should be used for navigation.

Bottom Samples

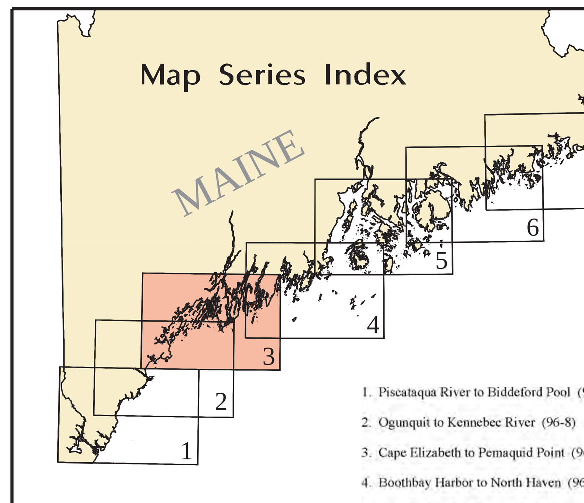
Between 1984 and 1991, 1,303 bottom sample stations were occupied (see the **Features and Data Source Map** for locations in this region). Two attempts were made at each station where the sampler initially returned empty, after which the site was considered a rock bottom. A Smith-McIntyre stainless steel grab sampler was used that nominally collected up to 0.016 m^3 (0.5 ft^3) of sediment. Southwest of Cape Small, samples were generally collected in a grid pattern with a 2 kilometer (1 nautical mile) distance between sample sites. Focus was placed on the large sandy embayments off Wells, Saco, and the Kennebec River mouth, as well as on muddy Casco Bay. Relatively few bottom samples were gathered off rocky areas such as Kennebunk or Kittery. Geophysical tracklines were later run over the sample stations to permit extrapolation of the bottom sediment data. North and east of Cape Small, geophysical data were generally gathered before bottom samples. This resulted in a need for fewer samples, and so fewer stations were occupied. Following collection, samples were stored in a freezer in the sedimentology laboratory at the University of Maine. Depending on the level of funding or specific needs of a particular project, samples were analyzed for grain size, organic carbon and nitrogen, carbonate content and/or heavy minerals (see Table 1 of **Reference 1**).

Side-Scan Sonar Profiles

Analog side-scan sonar records along 3358 km (1800 nmi) of the seafloor were gathered with an EG&G Model SMS 260 slant-range corrected sonar operating with a Model 272-T towfish at a nominal frequency of 105 kHz. The device was most often run at a 100 m (330 ft) range for each channel (200 m wide swath beneath the research vessel), although ranges from 25 to 300 m (80 to 1000 ft) were occasionally employed. The swaths of directly imaged and interpreted seafloor areas are depicted in brighter colors on the map. See the **Surficial Geology Legend** in the lower left corner of the map and the **Interpretation of Side-Scan Sonar Images** for further details.

Seismic Reflection Profiles

Seismic reflection profiles were gathered along 5011 km (2700 nmi) of tracklines, often in conjunction with side-scan sonar data (see simultaneous seismic and side-scan images above). A Raytheon RTT 1000a 3.5/7.0 kHz unit with a 200 kHz fathometer trace was used mainly in relatively shallow water (0 to 50 m; < 165 ft) over muddy bottoms. An ORE Geopulse "boomer" (0.5 to 200 kHz) seismic system was most effective in deeper water (15 to 150 m; 50 to 500 ft) over thicker deposits of sandy or gravelly sediment. Although seismic reflection profiles are most useful in constructing the geological history of an area, the bathymetry and stratigraphic context they provide, along with the strength of the surface return, also help identify the seafloor type (**6**). When used in conjunction with the side-scan sonar data, both the age and nature of the surficial sediment are easily interpreted.



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SURFICIAL GEOLOGY

Introduction

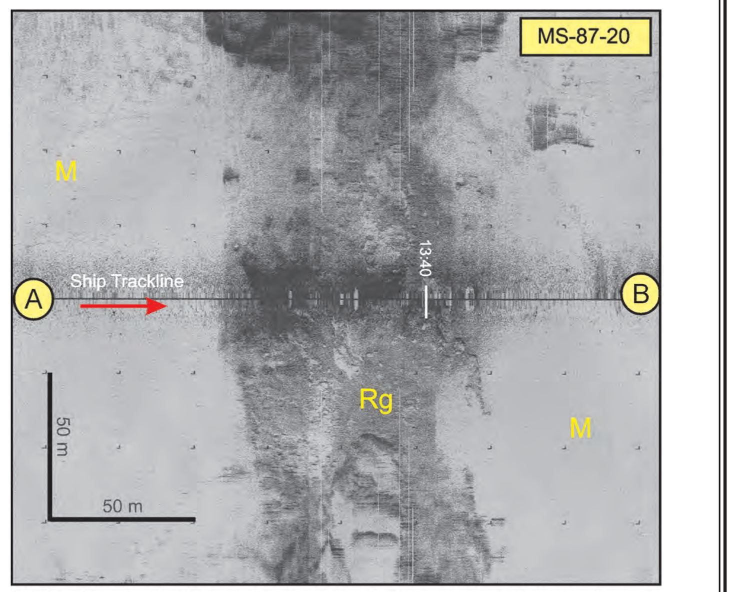
The surficial materials of the inner continental shelf of the northwestern Gulf of Maine are the most complex of any place along the Atlantic continental margin of the United States. Igneous, metamorphic, and sedimentary rocks spanning hundreds of millions of years of earth history form the regional basement. Glacial deposits, containing all clast sizes from boulders to mud, partially mantle the rocks. These materials, in turn, have been reworked by coastal processes during extreme fluctuations of sea level over the past few thousand years to create better-sorted modern deposits (**5**). Biological processes, including shell formation, bioturbation, and organic matter cycling have also altered the sediment composition and left geological imprints on the seafloor (**7, 8**). In addition to the surficial geology of this map, the geomorphology of the seafloor has also been mapped. The *Physiographic Map of the Maine Inner Continental Shelf* (**9**) shows the geomorphology of the offshore region covered by this series of surficial geologic maps in a single, smaller scale map.

Rocky Areas

Rocky seabed occupies approximately 41% of the inner continental shelf and is the most abundant seafloor type in this map series. Where little data exist and the seafloor relief is very irregular, a rocky bottom was inferred. By this inference, large areas of rocky bottom were mapped off extreme southern Maine, Penobscot Bay, and Petit Manan Point. Large areas of rock also occur surrounding the many granitic islands in Blue Hill and Frenchman Bays. Elongate, submerged rock ridges follow the linear trend of the Casco Bay peninsulas. Although common as nearshore shoals in water less than 10 m (33 ft) deep, large outcrops of rock are relatively rare in deep offshore basins.

The bedrock geology was not determined, but side-scan sonar images clearly depict parallel fractures and elongate outcrop patterns common in layered metamorphic rocks as well as more rounded bodies of rock often associated with plutonic (granitic) igneous rocks (**10**). In shallow water, rock outcrops are usually covered with algae (seaweed) and encrusting organisms. Below water depths of a few tens of meters (the photic zone), encrusting organisms and organic mats often cover bedrock outcrops. "Rock greater than mud" (**Rm**; for an explanation of abbreviations see **Interpretation of Side-Scan Sonar Images**) is most common in deep offshore basins where outcrops project up through the mud that mantles the seafloor. **Rm** also occurs as small areas seaward of tidal flats in nearshore basins. "Rock greater than sand" (**Rs**) exists only in a few locations offshore of beaches.

Areas adjacent to rock outcrops are commonly covered with shells of dead organisms. Formerly attached to the rock surface, these shelly remains are mixed with angular rock fragments that have fallen off the outcrop (**8**). Bedrock fractures and troughs also have a similar mixture of shell and rock clasts. For this reason, extensive, "pure" rock outcrops were infrequently mapped. Instead, fractured bedrock and small bodies of rock were most often mapped as "rock greater than gravel" (**Rg**) or "gravel greater than rock" (**Gr**), two of the most common seafloor types observed.



Side-Scan Sonar Profile. The image above is a portion of a side-scan sonar record taken simultaneously with the seismic reflection profile to the left. This image shows a plan view of the seafloor (much like an aerial photograph). The area shown is about the size of eight football fields. The darker area is a mixture of bedrock outcrop and gravel (**Rg**). The lighter areas on either side are flat, muddy seafloor (**M**). The ship track followed the black center line over the bottom. Both of these images were made using sound waves.

Gravelly Areas

Gravel is a common constituent of inner shelf sediment, but occupies only 12% of the seafloor itself. Gravel is abundant in only a few locations: off the Kennebec River mouth where deltaic sediments are exposed, off Wells and Saco Bays near reworked glacial moraines, and near the Canadian border. Frequently the gravel has a rippled surface, and may contain minor amounts of coarse sand. In areas where waves regularly scour the seabed, a gravel lag deposit armors the seafloor. Gravel also occurs in broad linear bands near submerged moraines.

As described above, "gravel greater than rock" (**Gr**) is a common feature adjacent to bedrock outcrops. Here the gravel may have a high shell content (calcium carbonate) because shells are often the only modern sediment introduced to an area. **Gr** and "gravel greater than sand" (**Gs**) are major features of the seafloor from the Canadian border to Englishman Bay. Here, low relief bedrock is mantled by till, which fills in rock depressions but lacks much relief itself. "Gravel greater than mud" (**Gm**) is very rare along the inner shelf. Gravel and mud are not deposited in the ocean under the same hydrodynamic conditions, but may be found just beneath the seafloor in till deposited by glaciers more than 13,000 years ago beneath glacial ice.

Sandy Areas

Sandy seafloor (**S**) occupies only 8% of the inner shelf of the northwestern Gulf of Maine. The sandiest regions are offshore of southern Maine beaches such as Old Orchard and Ogunquit. In the mid coast region, a large sandy area "sand greater than gravel" (**Sg**) occurs off the Kennebec River mouth. This **Sg** area, consisting of many small rippled gravel patches that are intermingled with sand, has not changed appreciably in a decade, although large winter storms resuspend sand and gravel in water depths down to at least 55 m (180 ft). Many smaller bodies of sand are scattered elsewhere throughout the coast, occasionally around the 50 to 60 m (165 to 200 ft) depth, near the lowest stand of sea level since the Ice Age.

Sandy material is acoustically uniform and strongly contrasts with bordering areas of gravel and rock. Although many sediment samples from shallow water contain well-sorted ("clean") sand, areas mapped "sand" or sand with other materials frequently contain sediment in which the sand is mixed with mud, gravel and a variety of shell fragments.

"Sand greater than rock" (**Sr**) is a minor component of the seafloor that exists adjacent to small bedrock outcrops scattered across the mapped area. It is possible that more **Sr** areas exist, especially in the southern shelf, but few observations were made in that region. "Sand greater than mud" (**Sm**) is a very difficult unit to map because mixtures of mud and sand look similar on acoustic images. The only mapped areas of "sand greater than mud" are located in Saco Bay, where bottom samples confirmed the presence of both particle sizes. Similar occurrences of **Sm** may occur at the seaward margin of other beaches.

Muddy Areas

Muddy regions cover 39% of the seafloor and are the second most abundant surficial material. Mud is the dominant seabed material in all nearshore areas except for southern Maine and near the Canadian border. It is also the major deep-water surficial material in all locations except off the southern Maine coast.

Mud accumulates near areas where there is an available supply of fine-grained sediment and there are quieter hydrodynamic conditions, which favor the slow settling of small particles, or their entrapment by organisms. In nearshore regions, mud comes from eroding glacial bluffs and seasonally from rivers. In deep water, mud must be derived from winnowing and erosion of deposits in shallow water.

Muddy seafloors are featureless on acoustic records unless they have been disturbed or contain anomalous "hard" objects. Drag marks left by fishing gear are common in most sedimentary environments, but are most noticeable when carved into mud. Gas-escape pockmarks are generally hemispherical depressions that result from localized seabed disturbance. Where pockmarks occur in abundance, the seafloor is uneven. Thousands of pockmarks hundreds of meters (yards) in diameter and tens of meters (yards) deep make crater-like terrain in the muddy bottom in Belfast, Blue Hill, and Passamaquoddy Bays (**7,8**).

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ACKNOWLEDGMENTS

Funding for this compilation was provided by the Regional Marine Research Program of NOAA (Grant # NA46RM0451). We wish to thank Mr. Walter A. Anderson, former Director of the Maine Geological Survey, for more than ten years of unrelenting encouragement and support for our offshore research. In addition, we thank Dr. Robert E. Wall who directed the University of Maine Center for Marine Studies, which partly purchased the geophysical equipment and GIS used for this compilation. Most of the data collection was sponsored by the Maine-New Hampshire Sea Grant Program, the Continental Margins Program of the Minerals Management Service and Association of State Geologists, the National Science Foundation, the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Undersea Research Program, and the Maine Department of Marine Resources. We acknowledge many graduate students who assisted in the original collection and interpretation of much of the data, especially Dr. R. Craig Shipp. Finally, we acknowledge the able seamanship of Captain Michael Dunn, formerly of the Darling Marine Center, who participated in all bottom sampling and most geophysical expeditions.

Surficial Geology Legend

The map above shows the geology of the surface of the ocean floor. This map of Maine's inner continental shelf is based on geophysical data, bottom samples, National Ocean Service provisional bathymetric maps and published nautical charts. These data were supplemented with bottom photographs and direct observations from submersibles. Experience with these data, together with side-scan sonar images (the underwater equivalent of aerial photographs), permitted generalized mapping of the inner continental shelf.

The map areas shown by the four colors below were not directly imaged with side-scan sonar. Contacts between these geologic units were inferred, based on bathymetry and other information (see **Features and Data Source Map**).

The bright colors on the map and in the **Interpretation of Side-Scan Sonar Images** legend to the right show areas of seafloor imaged by sonar. The linear colored swaths on the map above follow ship tracklines and have a width that represents the sonar swath to each side of the vessel.

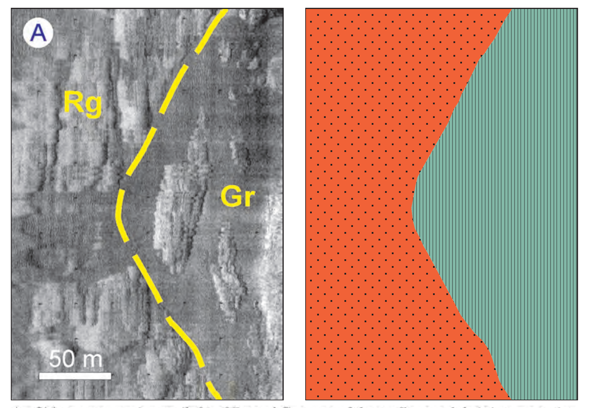
ROCKY - Rugged, high-relief seafloor is dominated by bedrock outcrops (ledge) and is the most common type on the Maine inner continental shelf, especially in depths of less than 60 m (~200 ft). Accumulations of coarse-grained sediment occur in low-lying areas and at the base of rock outcrops.

GRAVELLY - Generally flat-lying areas are covered by coarse-grained sediment, with clasts up to several meters (yards) in diameter. In some areas gravel and boulders directly overlie bedrock. These deposits are not presently accumulating on the shelf but represent Pleistocene (Ice Age) material. Ripples are common in well-sorted gravel, indicating that some of the older glacial sediments are presently being reworked by waves, currents, and tides.

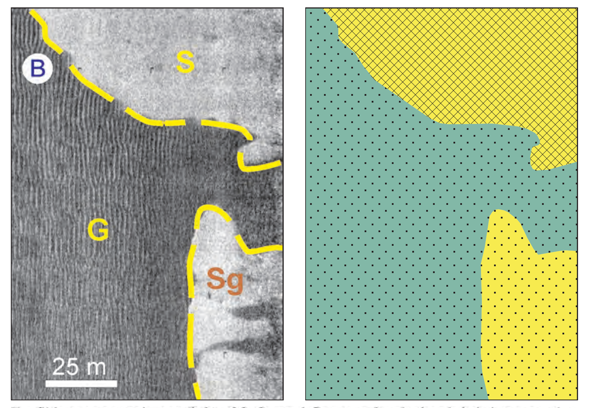
SANDY - Generally smooth seafloor consists primarily of sand-sized particles derived from rivers, reworked glacial deposits and/or biogenic shell production. This bottom type, although well represented in southwestern areas, is the least common on the Maine inner continental shelf.

MUDDY - Deposits of fine-grained material form a generally flat and smooth seabed commonly found in sheltered bays and estuaries and at depths of greater than 60 m (~200 ft). In some submarine valleys the mud may be meters (yards) thick. Deep depressions (gas-escape pockmarks) occur in some muddy bays.

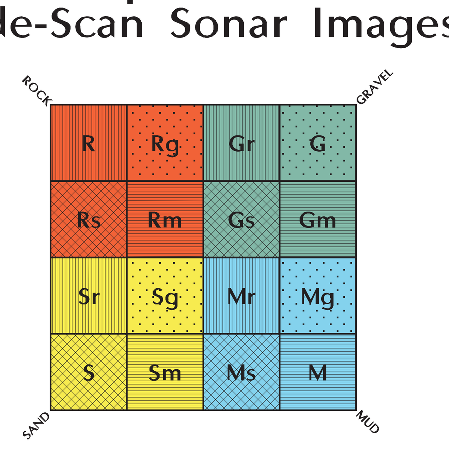
Interpretation of Side-Scan Sonar Images



A. Side-scan sonar image (left) of **Rg** and **Gr** areas of the seafloor and their interpretation (right). In the image, gravelly areas appear dark gray and bedrock outcrops show irregular perimeters, dark (sound reflective) streaks and light gray acoustic shadows. Fractures are prominent in the bedrock; gravelly areas have low relief.



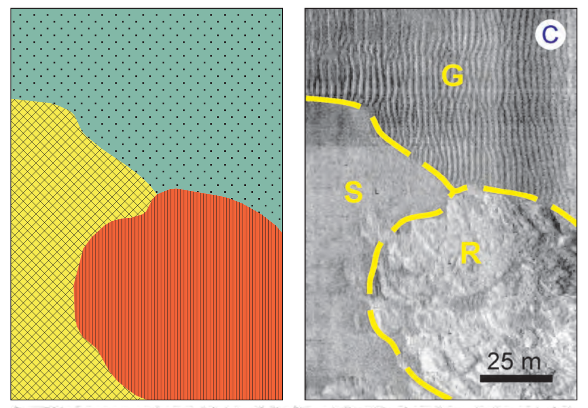
B. Side-scan sonar image (left) of **S, Sg,** and **G** areas of seabed and their interpretation (right). Sandy seafloor is lighter gray and appears smooth while the gravelly seafloor has wave ripples with straight crestlines about 1 m (3 ft) apart. **Sg** areas occur as a patchwork of **S** and **G** types, but are too small to discriminate at this map scale.



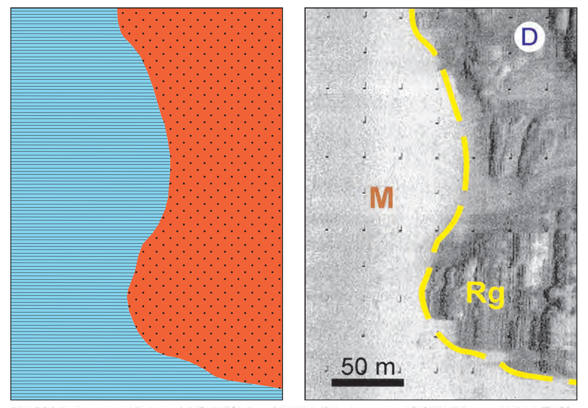
On side-scan sonar images, rock, gravel, sand, and mud reflect acoustic energy differently and appear as various shades of gray printed by the instrument's recorder. The classification scheme above is unique and based on the acoustic reflectivity of the Maine inner continental shelf. The dominant "end member" (**R**ock, **G**ravel, **S**and, or **M**ud) is abbreviated with a capitalized first letter. A less abundant, subordinate seafloor type is represented with a lower case letter (**r, g, s,** or **m**). For example, a predominantly rocky seabed with gravel infilling fractures is designated **Rg**. The sixteen combinations of seafloor types shown above are used for areas where side-scan sonar coverage exists and appear as bright colors on the map. In areas beyond the scan range only four generalized units were used (see the **Surficial Geology Legend**).

When individual units of rock, gravel, sand, and mud were greater than 10,000 m^2 in area (about the size of 3 football fields), they were mapped as separate features. In many places, however, a heterogeneous seabed composed of numerous small features required composite map units. In areas where no single seafloor type exceeded 10,000 m^2, a composite map unit was used. The selection of map units to describe this complexity involves a compromise between providing detailed information where it exists, and generalizing where data are scarce or absent. In many places the seabed is composed of numerous small features, none exceeding the minimum area of 10,000 m^2. Consequently, not all details in the sonar records could be presented on this map. It should be realized that spatial heterogeneity exists at all scales, even down to areas less than a square meter (ten square feet).

Rock yields a strong, dark, acoustic return. In areas with steep bathymetric relief and fractures, light acoustic shadows are visible within the dark areas of rock (see adjacent panels **A**, **C**, and **D**). Gravel deposits also produce a relatively strong acoustic return (black to dark gray), and are often closely associated with rock, but lack relief (**A**, **B**, **C**, **D**). Sand produces a much weaker acoustic return (light to dark gray) than either gravel or rock, and usually lacks local relief (**B**). Mud yields a very weak surface return (light gray to white) and, except where it accumulates on steep slopes or near gas-escape pockmarks, it is associated with a smooth seabed (**D**). The **Surficial Geology** section in the far right column describes the distribution and abundance of these areas on Maine's inner continental shelf.

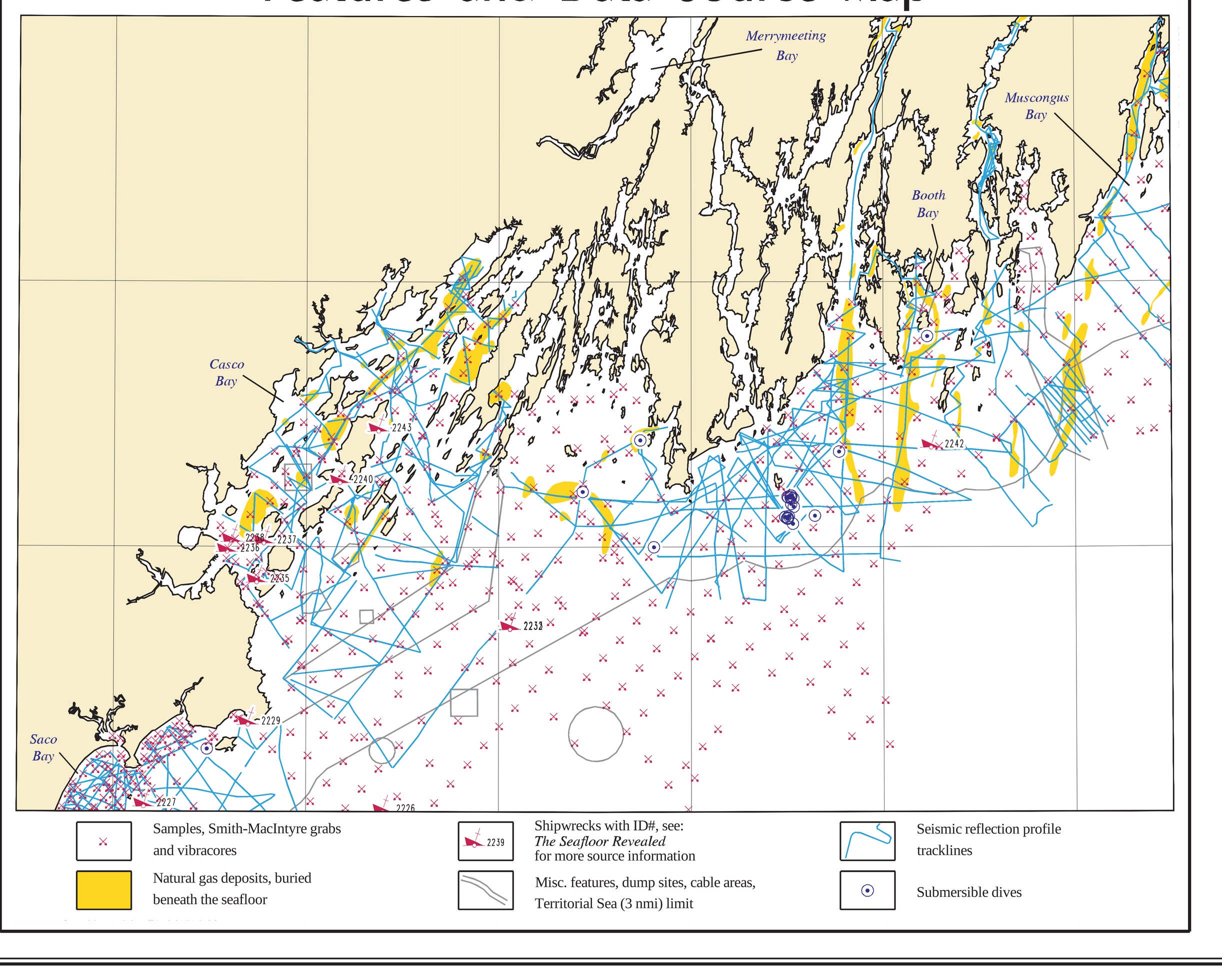


C. Side-scan sonar image (right) of **S, G,** and **R** with sharp boundaries and their interpretation (left). Ripples in the gravelly seabed produce alternating light and dark bands while the sandy surface is more uniformly gray. These ripples have a 2 m (6 ft) wavelength. The rocky outcrop rises above the surrounding seafloor.

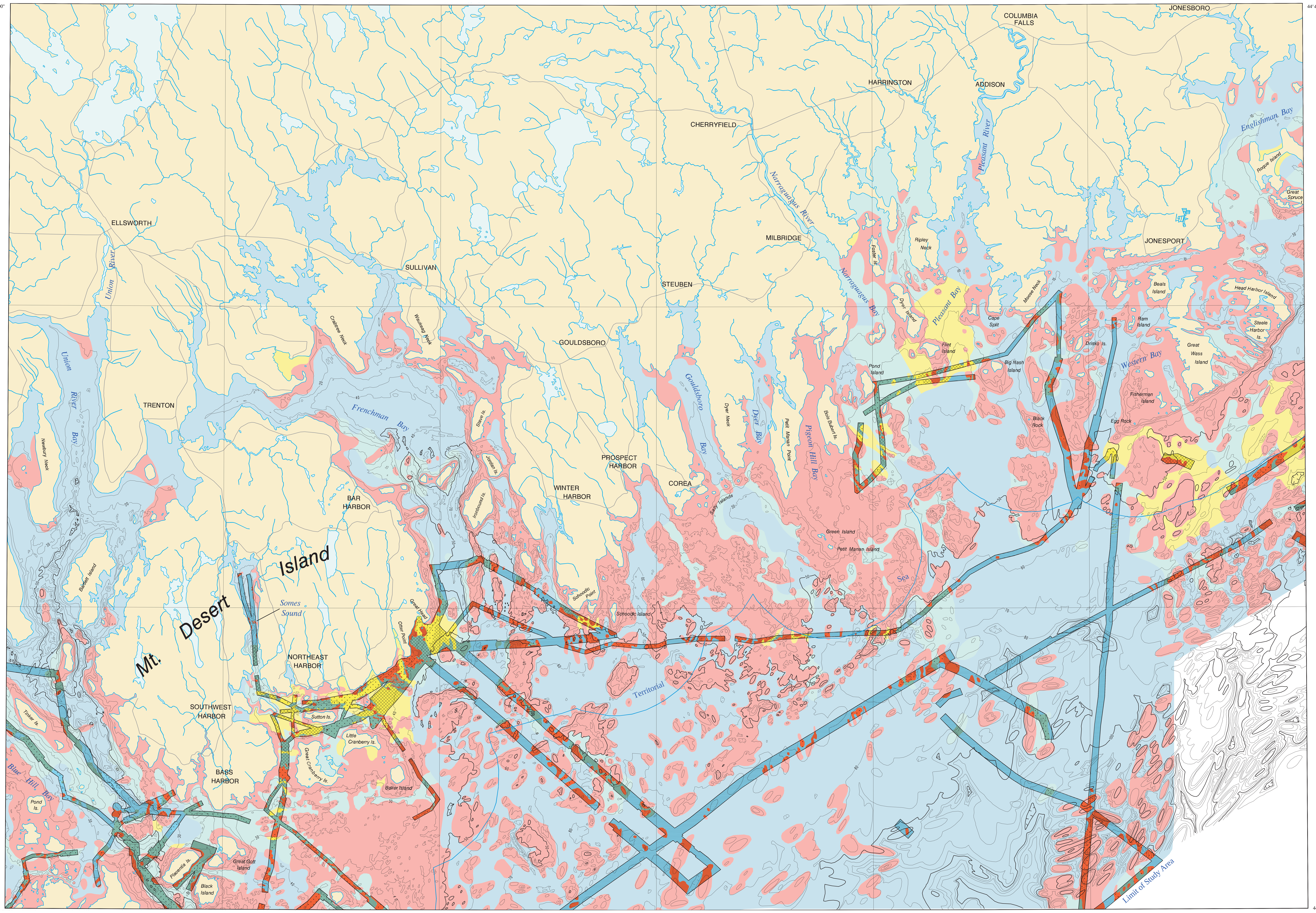


D. Side-scan sonar image (right) of **M** and **Rg** seafloor types and their interpretation (left). Muddy seafloor is uniformly light gray although the tonal difference on the left edge is a recorder artifact. A mixture of rocky outcrops has an irregular dark gray appearance while gravelly troughs appear smooth and dark gray.

Features and Data Source Map



Surficial Geology of the Maine Inner Continental Shelf



Map Projection: Universal Transverse Mercator, Zone 19
1927 North American Datum

Nautical Miles (nmi)

Map Scale 1:100,000

Kilometers (km)

National Geodetic Vertical Datum of 1929
Contour Interval 10 Meters

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GEOLOGIC MAP NO. 96-12
1996

Funding for the preparation and publication of this map was provided by the Regional Marine Research Program (RMRP #NA46RM0451)

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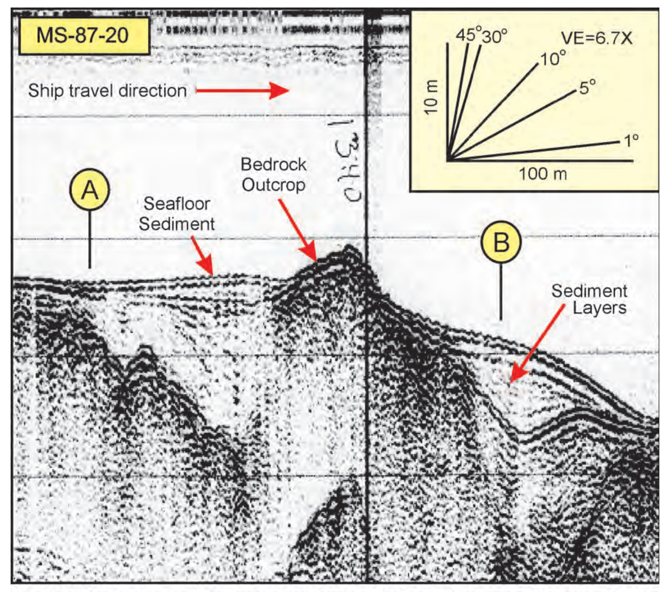
INTRODUCTION

Geological maps depicting topography, surficial materials, geomorphology, and bedrock play an important role in understanding the origin of, as well as the ongoing processes that shape and change the earth's surface. As in the terrestrial environment, maps are also instrumental in aiding the sound economic development of natural resources. They also provide guidance to natural hazards that exist within the landscape. As people increasingly work on, in, and beneath the sea, the need to better understand regional marine geology, just as we understand terrestrial geology, has grown. This map, and others in this series, are intended to provide a better picture of the northwestern Gulf of Maine. Additional information on specific locations and original field descriptions exists in the associated report: *The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf* (**Reference 1**).

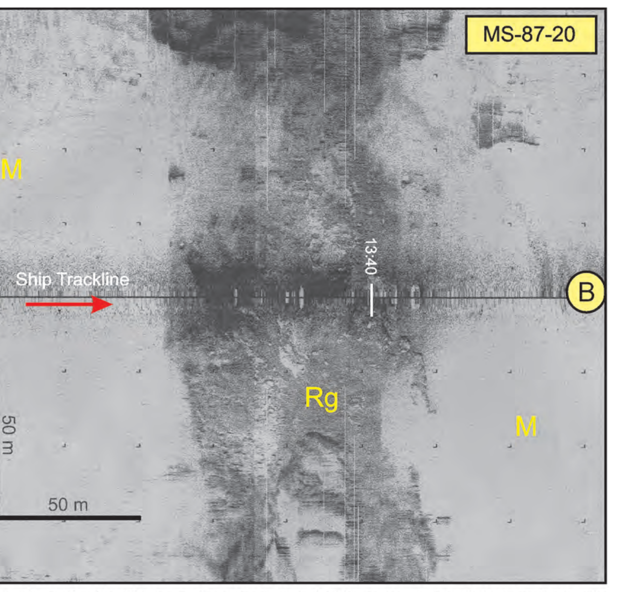
Many reconnaissance surveys of the seafloor of the northwestern Gulf of Maine were conducted in the past decade. Recently that information, along with other previously published data, was compiled in a geographic information system (GIS) to produce this map. The data compiled for this series of maps were originally collected for a variety of research projects, government contracts, and student theses. For this reason there are varying amounts of geophysical data and bottom-sample coverage along the coast rather than a uniform grid. *The Seafloor Revealed* further explains the field techniques involved in data collection, the nature of the seafloor, the late Quaternary (glacial) geologic history of the Maine coast, previous studies, and sources of other information.

Bedrock geology defines the overall shape of the Maine coastline by controlling the location and orientation of islands, bays, and peninsulas. Bedrock relief is also primarily responsible for the variability in water depths of the inner shelf. Glacial deposits mantle the underlying bedrock and add complexity to regional geomorphology in forms that range from coarse ridges of boulders to basins filled with fine mud. Thick accumulations of glacial sediments (gravel, sand, and mud) often result in smoother areas of seafloor with less bathymetric relief. Almost all of the Holocene (postglacial) sedimentary material along the coast and offshore is derived from erosion and reworking of glacial deposits. Physical oceanographic processes, including waves and tides, continue to reshape the seafloor sediments and create productive marine habitats of the Gulf of Maine.

Sea-level change has had a profound effect on the location and duration of sediment reworking and deposition. During the complex changes of sea level over the last 14,000 years, coastal and terrestrial erosion stripped muddy glacial sediment from shoals and transferred the material to deeper basins. During deglaciation, the sea covered most of the coastal lowlands of Maine (**2**). A regression (sea-level lowering) until about 10,500 years ago was followed by a transgression (rising) that is still continuing (**3**, **4**). Areas shallower than the maximum lowering of the sea (less than about 60 m (200 feet) water depth) are generally rockier than deeper regions. The shallower zone lost some of its sediment cover through wave reworking during both the late Pleistocene fall and the early Holocene rise of the sea. These areas also experienced at least a thousand years of subaerial erosion by rivers and streams. The marine geology of the Maine coast records these and many other changes that have taken place since glaciers retreated inland and the sea invaded the western Gulf of Maine (**4**, **5**, **6**).



Seismic Reflection Profile. The image above is a portion of an ORE seismic reflection profile from Muscongus Bay and shows a cross-section (side view) of the seafloor. The seafloor surface shape is analagous to a fathometer profile. A vertical exaggeration (VE) of 6.7 makes all slopes appear steeper than they really are. The subsurface reflectors are from sediment layers and buried bedrock surfaces. Positions A and B correspond to the same locations in both figures. A time mark is shown by the vertical line at 13:40.



Side-Scan Sonar Profile. The image above is a portion of a side-scan sonar record taken simultaneously with the seismic reflection profile to the left. This image shows a plan view of the seafloor (much like an aerial photograph). The area shown is about the size of eight football fields. The darker area is a mixture of bedrock outcrop and gravel (**Rg**). The lighter areas on either side are flat, muddy seafloor (**M**). The ship track followed the black center line over the bottom. Both of these images were made using sound waves.

METHODS

Navigation and Map Compilation

Navigation fixes in the outer estuaries and offshore areas were made at 2 to 5 minute intervals with LORAN-C, which provided an accuracy of ± 100 m (330 feet). In the upper reaches of the estuaries, radar and line-of-sight observations on buoys and landmarks provided navigational accuracy that varied from less than ± 10 m (33 feet) to around ± 200 m (660 feet). Recent work used the global positioning satellite system (GPS) for navigation and was accurate to ± 10 m (33 feet). All navigation was converted to Universal Transverse Mercator projection and plotted with a geographic information system (GIS).

Surficial geologic maps were prepared in six steps: (1) use a GIS to plot the geophysical tracklines, bottom sample locations, and bathymetry on large-scale maps, (2) interpret sonar records and geology based on other geophysical data and samples, (3) digitize the drafted interpretation into a GIS, (4) compile and edit the digital data to generate map polygons, (5) check the mapped geology, and (6) assemble the final product including geology, bathymetry, geographic names, and roads. The shoreline and roads are from the U.S. Geological Survey's 1:100,000 Digital Line Graph files.

Bathymetry

Bathymetry was digitized at a 10 m contour interval from preliminary National Ocean Service (NOS) Bathymetric and Fishing Maps at a 1:100,000 scale. The NOS bathymetric maps provide a 2 m contour interval in many locations that is too complex for inclusion on this map. Difficulty in interpretation of positive and negative changes in bathymetry on the poorly labeled NOS maps created many possible errors, especially in areas where accompanying geophysical data were lacking. For this reason, these maps should not be used for navigation. More detailed and accurate NOS conventional nautical charts should be used for navigation.

Bottom Samples

Between 1984 and 1991, 1,303 bottom sample stations were occupied (see the **Features and Data Source Map** for locations in this region). Two attempts were made at each station where the sampler initially returned empty, after which the site was considered a rock bottom. A Smith-McIntyre stainless steel grab sampler was used that nominally collected up to 0.016 m^3 (0.5 ft^3) of sediment. Southwest of Cape Small, samples were generally collected in a grid pattern with a 2 kilometer (1 nautical mile) distance between sample sites. Focus was placed on the large sandy embayments off Wells, Saco, and the Kennebec River mouth, as well as on muddy Casco Bay. Relatively few bottom samples were gathered off rocky areas such as Kennebunk or Kittery. Geophysical tracklines were later run over the sample stations to permit extrapolation of the bottom sediment data. North and east of Cape Small, geophysical data were generally gathered before bottom samples. This resulted in a need for fewer samples, and so fewer stations were occupied. Following collection, samples were stored in a freezer in the sedimentology laboratory at the University of Maine. Depending on the level of funding or specific needs of a particular project, samples were analyzed for grain size, organic carbon and nitrogen, carbonate content and/or heavy minerals (see Table 1 of **Reference 1**).

Side-Scan Sonar Profiles

Analog side-scan sonar records along 3358 km (1800 nmi) of the seafloor were gathered with an EG&G Model SMS 260 slant-range corrected sonar operating with a Model 272-T towfish at a nominal frequency of 105 kHz. The device was most often run at a 100 m (330 ft) range for each channel (200 m wide swath beneath the research vessel), although ranges from 25 to 300 m (80 to 1000 ft) were occasionally employed. The swaths of directly imaged and interpreted seafloor areas are depicted in brighter colors on the map. See the **Surficial Geology Legend** in the lower left corner of the map and the **Interpretation of Side-Scan Sonar Images** for further details.

Seismic Reflection Profiles

Seismic reflection profiles were gathered along 5011 km (2700 nmi) of tracklines, often in conjunction with side-scan sonar data (see simultaneous seismic and side-scan images above). A Raytheon RTT 1000a 3.5/7.0 kHz unit with a 200 kHz fathometer trace was used mainly in relatively shallow water (0 to 50 m; < 165 ft) over muddy bottoms. An ORE Geopulse "boomer" (0.5 to 200 kHz) seismic system was most effective in deeper water (15 to 150 m; 50 to 500 ft) over thicker deposits of sandy or gravelly sediment. Although seismic reflection profiles are most useful in constructing the geological history of an area, the bathymetry and stratigraphic context they provide, along with the strength of the surface return, also help identify the seafloor type (**6**). When used in conjunction with the side-scan sonar data, both the age and nature of the surficial sediment are easily interpreted.

SURFICIAL GEOLOGY

Introduction

The surficial materials of the inner continental shelf of the northwestern Gulf of Maine are the most complex of any place along the Atlantic continental margin of the United States. Igneous, metamorphic, and sedimentary rocks spanning hundreds of millions of years of earth history form the regional basement. Glacial deposits, containing all clast sizes from boulders to mud, partially mantle the rocks. These materials, in turn, have been reworked by coastal processes during extreme fluctuations of sea level over the past few thousand years to create better-sorted modern deposits (**5**). Biological processes, including shell formation, bioturbation, and organic matter cycling have also altered the sediment composition and left geological imprints on the seafloor (**7, 8**). In addition to the surficial geology of this map, the geomorphology of the seafloor has also been mapped. The *Physiographic Map of the Maine Inner Continental Shelf* (**9**) shows the geomorphology of the offshore region covered by this series of surficial geologic maps in a single, smaller scale map.

Rocky Areas

Rocky seabed occupies approximately 41% of the inner continental shelf and is the most abundant seafloor type in this map series. Where little data exist and the seafloor relief is very irregular, a rocky bottom was inferred. By this inference, large areas of rocky bottom were mapped off extreme southern Maine, Penobscot Bay, and Petit Manan Point. Large areas of rock also occur surrounding the many granitic islands in Blue Hill and Frenchman Bays. Elongate, submerged rock ridges follow the linear trend of the Casco Bay peninsulas. Although common as nearshore shoals in water less than 10 m (33 ft) deep, large outcrops of rock are relatively rare in deep offshore basins.

The bedrock geology was not determined, but side-scan sonar images clearly depict parallel fractures and elongate outcrop patterns common in layered metamorphic rocks as well as more rounded bodies of rock often associated with plutonic (granitic) igneous rocks (**10**). In shallow water, rock outcrops are usually covered with algae (seaweed) and encrusting organisms. Below water depths of a few tens of meters (the photic zone), encrusting organisms and organic mats often cover bedrock outcrops. "Rock greater than mud" (**Rm**; for an explanation of abbreviations see **Interpretation of Side-Scan Sonar Images**) is most common in deep offshore basins where outcrops project up through the mud that mantles the seafloor. **Rm** also occurs as small areas seaward of tidal flats in nearshore basins. "Rock greater than sand" (**Rs**) exists only in a few locations offshore of beaches.

Areas adjacent to rock outcrops are commonly covered with shells of dead organisms. Formerly attached to the rock surface, these shelly remains are mixed with angular rock fragments that have fallen off the outcrop (**8**). Bedrock fractures and troughs also have a similar mixture of shell and rock clasts. For this reason, extensive, "pure" rock outcrops were infrequently mapped. Instead, fractured bedrock and small bodies of rock were most often mapped as "rock greater than gravel" (**Rg**) or "gravel greater than rock" (**Gr**), two of the most common seafloor types observed.

Gravelly Areas

Gravel is a common constituent of inner shelf sediment, but occupies only 12% of the seafloor itself. Gravel is abundant in only a few locations: off the Kennebec River mouth where deltaic sediments are exposed, off Wells and Saco Bays near reworked glacial moraines, and near the Canadian border. Frequently the gravel has a rippled surface, and may contain minor amounts of coarse sand. In areas where waves regularly scour the seabed, a gravel lag deposit armors the seafloor. Gravel also occurs in broad linear bands near submerged moraines.

As described above, "gravel greater than rock" (**Gr**) is a common feature adjacent to bedrock outcrops. Here the gravel may have a high shell content (calcium carbonate) because shells are often the only modern sediment introduced to an area. **Gr** and "gravel greater than sand" (**Gs**) are major features of the seafloor from the Canadian border to Englishman Bay. Here, low relief bedrock is mantled by till, which fills in rock depressions but lacks much relief itself. "Gravel greater than mud" (**Gm**) is very rare along the inner shelf. Gravel and mud are not deposited in the ocean under the same hydrodynamic conditions, but may be found just beneath the seafloor in till deposited by glaciers more than 13,000 years ago beneath glacial ice.

Sandy Areas

Sandy seafloor (**S**) occupies only 8% of the inner shelf of the northwestern Gulf of Maine. The sandiest regions are offshore of southern Maine beaches such as Old Orchard and Ogunquit. In the mid coast region, a large sandy area "sand greater than gravel" (**Sg**) occurs off the Kennebec River mouth. This **Sg** area, consisting of many small rippled gravel patches that are intermingled with sand, has not changed appreciably in a decade, although large winter storms resuspend sand and gravel in water depths down to at least 55 m (180 ft). Many smaller bodies of sand are scattered elsewhere throughout the coast, occasionally around the 50 to 60 m (165 to 200 ft) depth, near the lowest stand of sea level since the Ice Age.

Sandy material is acoustically uniform and strongly contrasts with bordering areas of gravel and rock. Although many sediment samples from shallow water contain well-sorted ("clean") sand, areas mapped "sand" or sand with other materials frequently contain sediment in which the sand is mixed with mud, gravel and a variety of shell fragments.

"Sand greater than rock" (**Sr**) is a minor component of the seafloor that exists adjacent to small bedrock outcrops scattered across the mapped area. It is possible that more **Sr** areas exist, especially in the southern shelf, but few observations were made in that region. "Sand greater than mud" (**Sm**) is a very difficult unit to map because mixtures of mud and sand look similar on acoustic images. The only mapped areas of "sand greater than mud" are located in Saco Bay, where bottom samples confirmed the presence of both particle sizes. Similar occurrences of **Sm** may occur at the seaward margin of other beaches.

Muddy Areas

Muddy regions cover 39% of the seafloor and are the second most abundant surficial material. Mud is the dominant seabed material in all nearshore areas except for southern Maine and near the Canadian border. It is also the major deep-water surficial material in all locations except off the southern Maine coast.

Mud accumulates near areas where there is an available supply of fine-grained sediment and there are quieter hydrodynamic conditions, which favor the slow settling of small particles, or their entrapment by organisms. In nearshore regions, mud comes from eroding glacial bluffs and seasonally from rivers. In deep water, mud must be derived from winnowing and erosion of deposits in shallow water.

Muddy seafloors are featureless on acoustic records unless they have been disturbed or contain anomalous "hard" objects. Drag marks left by fishing gear are common in most sedimentary environments, but are most noticeable when carved into mud. Gas-escape pockmarks are generally hemispherical depressions that result from localized seabed disturbance. Where pockmarks occur in abundance, the seafloor is uneven. Thousands of pockmarks hundreds of meters (yards) in diameter and tens of meters (yards) deep make crater-like terrain in the muddy bottom in Belfast, Blue Hill, and Passamaquoddy Bays (**7,8**).

"Mud greater than rock" (**Mr**) occurs in some deepwater locations, but "mud greater than gravel" (**Mg**) is as rare as "gravel greater than mud" (**Gm**) because of the hydrodynamic differences between the sizes of materials. "Mud greater than sand" (**Ms**) occurs seaward of the sandy area of Saco Bay and is mapped on the basis of a large number of bottom samples that encountered this mixture in this region.

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(7) Kelley, J. T., Dickson, S. M., Belknap, D. F., Barnhardt, W. A., and Henderson, M., 1994, Giant sea-bed pockmarks: evidence for gas escape from Belfast Bay, Maine: Geology, v. 22, p. 59-62.

(**8**) Barnhardt, W. A., and Kelley, J. T., 1995, Carbonate accumulation on the inner continental shelf of Maine: a modern consequence of late Quaternary glaciation and sea level rise: Journal of Sedimentary Research, v. A65, p. 195-207.

(**9**) Kelley, J. T., Dickson, S. M., Barnhardt, W. A., Belknap, D. F., and Kelley, A. R., in preparation, Physiographic map of the Maine inner continental shelf: Maine Geological Survey, Open-File Map.

(**10**) Osberg, P. H., Hussey, A. M., II, and Boone, G. M., 1985, Bedrock geologic map of Maine: Maine Geological Survey, scale 1:500,000.

ACKNOWLEDGMENTS

Funding for this compilation was provided by the Regional Marine Research Program of NOAA (Grant # NA46RM0451). We wish to thank Mr. Walter A. Anderson, former Director of the Maine Geological Survey, for more than ten years of unrelenting encouragement and support for our offshore research. In addition, we thank Dr. Robert E. Wall who directed the University of Maine Center for Marine Studies, which partly purchased the geophysical equipment and GIS used for this compilation. Most of the data collection was sponsored by the Maine-New Hampshire Sea Grant Program, the Continental Margins Program of the Minerals Management Service and Association of State Geologists, the National Science Foundation, the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Undersea Research Program, and the Maine Department of Marine Resources. We acknowledge many graduate students who assisted in the original collection and interpretation of much of the data, especially Dr. R. Craig Shipp. Finally, we acknowledge the able seamanship of Captain Michael Dunn, formerly of the Darling Marine Center, who participated in all bottom sampling and most geophysical expeditions.

Surficial Geology Legend

The map above shows the geology of the surface of the ocean floor. This map of Maine's inner continental shelf is based on geophysical data, bottom samples, National Ocean Service provisional bathymetric maps and published nautical charts. These data were supplemented with bottom photographs and direct observations from submersibles. Experience with these data, together with side-scan sonar images (the underwater equivalent of aerial photographs), permitted generalized mapping of the inner continental shelf.

The map areas shown by the four colors below were not directly imaged with side-scan sonar. Contacts between these geologic units were inferred, based on bathymetry and other information (see **Features and Data Source Map**).

The bright colors on the map and in the **Interpretation of Side-Scan Sonar Images** legend to the right show areas of seafloor imaged by sonar. The linear colored swaths on the map above follow ship tracklines and have a width that represents the sonar swath to each side of the vessel.

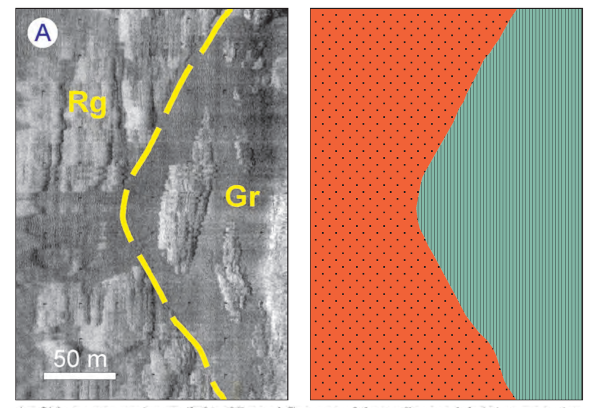
ROCKY - Rugged, high-relief seafloor is dominated by bedrock outcrops (ledge) and is the most common type on the Maine inner continental shelf, especially in depths of less than 60 m (~200 ft). Accumulations of coarse-grained sediment occur in low-lying areas and at the base of rock outcrops.

GRAVELLY - Generally flat-lying areas are covered by coarse-grained sediment, with clasts up to several meters (yards) in diameter. In some areas gravel and boulders directly overlie bedrock. These deposits are not presently accumulating on the shelf but represent Pleistocene (Ice Age) material. Ripples are common in well-sorted gravel, indicating that some of the older glacial sediments are presently being reworked by waves, currents, and tides.

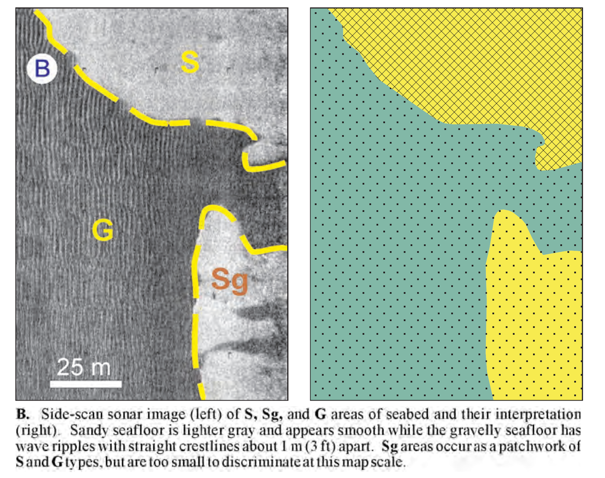
SANDY - Generally smooth seafloor consists primarily of sand-sized particles derived from rivers, reworked glacial deposits and/or biogenic shell production. This bottom type, although well represented in southwestern areas, is the least common on the Maine inner continental shelf.

MUDDY - Deposits of fine-grained material form a generally flat and smooth seabed commonly found in sheltered bays and estuaries and at depths of greater than 60 m (~200 ft). In some submarine valleys the mud may be meters (yards) thick. Deep depressions (gas-escape pockmarks) occur in some muddy bays.

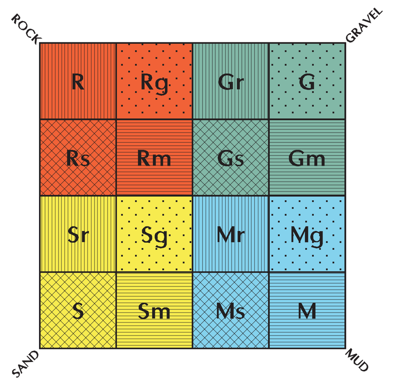
Interpretation of Side-Scan Sonar Images



A. Side-scan sonar image (left) of **Rg** and **Gr** areas of the seafloor and their interpretation (right). In the image, gravelly areas appear dark gray and bedrock outcrops show irregular perimeters, dark (sound reflective) streaks and light gray acoustic shadows. Fractures are prominent in the bedrock; gravelly areas have low relief.



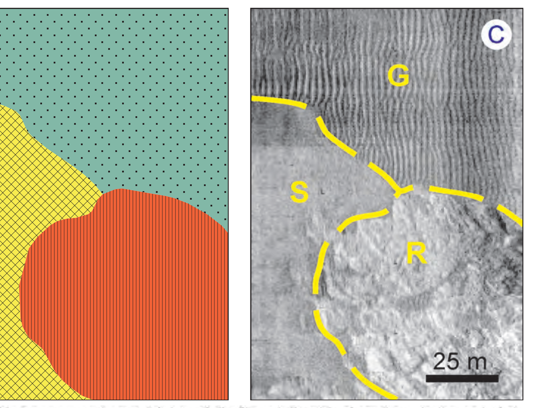
B. Side-scan sonar image (left) of **S, Sg,** and **G** areas of seabed and their interpretation (right). Sandy seafloor is lighter gray and appears smooth while the gravelly seafloor has wave ripples with straight crestlines about 1 m (3 ft) apart. **Sg** areas occur as a patchwork of **S** and **G** types, but are too small to discriminate at this map scale.



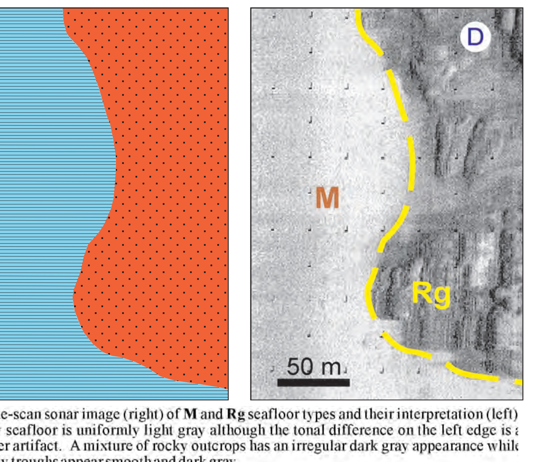
On side-scan sonar images, rock, gravel, sand, and mud reflect acoustic energy differently and appear as various shades of gray printed by the instrument's recorder. The classification scheme above is unique and based on the acoustic reflectivity of the Maine inner continental shelf. The dominant "end member" (**R**ock, **G**ravel, **S**and, or **M**ud) is abbreviated with a capitalized first letter. A less abundant, subordinate seafloor type is represented with a lower case letter (**r**, **g**, **s**, or **m**). For example, a predominantly rocky seabed with gravel infilling fractures is designated **Rg**. The sixteen combinations of seafloor types shown above are used for areas where side-scan sonar coverage exists and appear as bright colors on the map. In areas beyond the scan range only four generalized units were used (see the **Surficial Geology Legend**).

When individual units of rock, gravel, sand, and mud were greater than 10,000 m^2 in area (about the size of 3 football fields), they were mapped as separate features. In many places, however, a heterogeneous seabed composed of numerous small features required composite map units. In areas where no single seafloor type exceeded 10,000 m^2, a composite map unit was used. The selection of map units to describe this complexity involves a compromise between providing detailed information where it exists, and generalizing where data are scarce or absent. In many places the seabed is composed of numerous small features, none exceeding the minimum area of 10,000 m^2. Consequently, not all details in the sonar records could be presented on this map. It should be realized that spatial heterogeneity exists at all scales, even down to areas less than a square meter (ten square feet).

Rock yields a strong, dark, acoustic return. In areas with steep bathymetric relief and fractures, light acoustic shadows are visible within the dark areas of rock (see adjacent panels **A**, **C**, and **D**). Gravel deposits also produce a relatively strong acoustic return (black to dark gray), and are often closely associated with rock, but lack relief (**A**, **B**, **C**, **D**). Sand produces a much weaker acoustic return (light to dark gray) than either gravel or rock, and usually lacks local relief (**B**). Mud yields a very weak surface return (light gray to white) and, except where it accumulates on steep slopes or near gas-escape pockmarks, it is associated with a smooth seabed (**D**). The **Surficial Geology** section in the far right column describes the distribution and abundance of these areas on Maine's inner continental shelf.

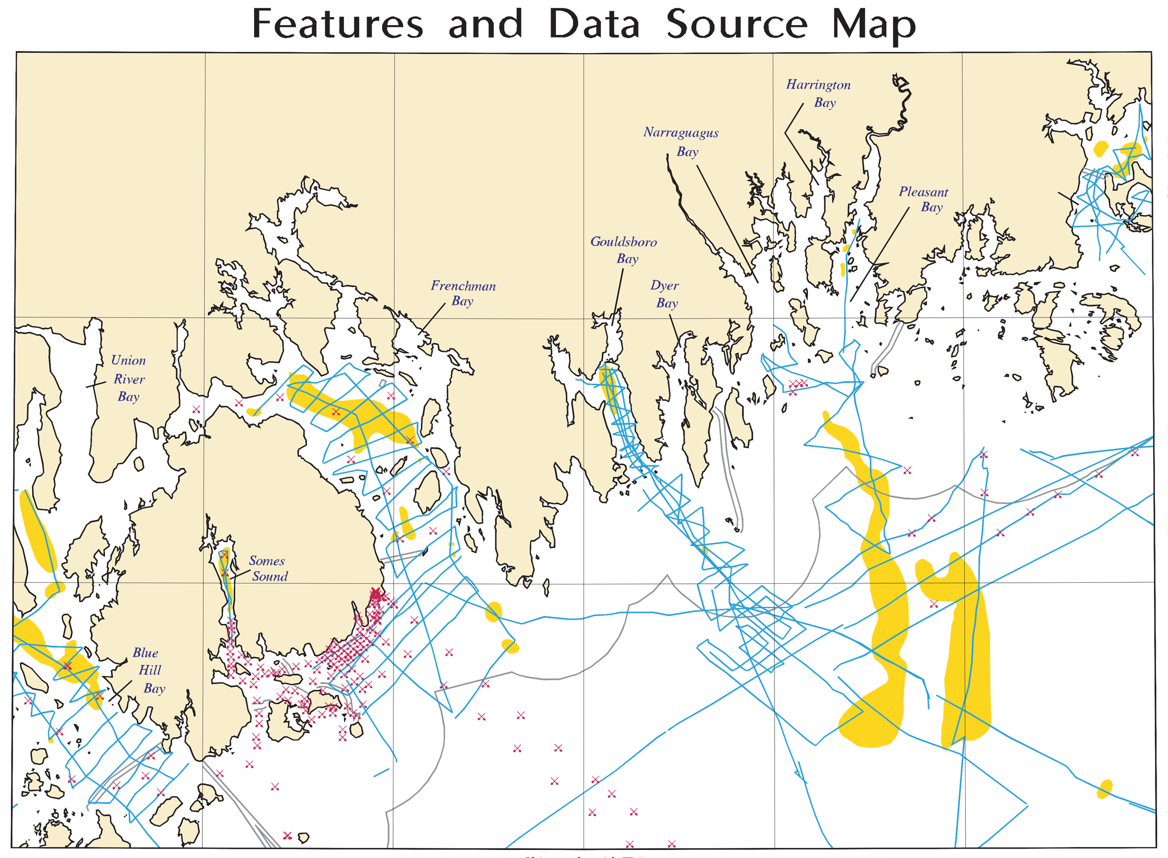


C. Side-scan sonar image (right) of **S**, **G**, and **R** with sharp boundaries and their interpretation (left). Ripples in the gravelly seabed produce alternating light and dark bands while the sandy surface is more uniformly gray. These ripples have a 2 m (6 ft) wavelength. The rocky outcrop rises above the surrounding seafloor.



D. Side-scan sonar image (right) of **M** and **Rg** seafloor types and their interpretation (left). Muddy seafloor is uniformly light gray although the tonal difference on the left edge is a recorder artifact. A mixture of rocky outcrops has an irregular dark gray appearance while gravelly troughs appear smooth and dark gray.

Features and Data Source Map



Samples, Smith-McIntyre grabs and vibracores

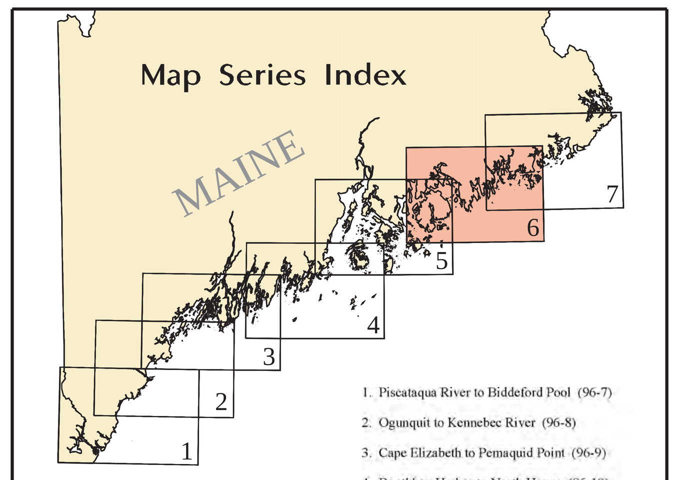
Natural gas deposits, buried beneath the seafloor

Shipwrecks with ID#, see: *The Seafloor Revealed* for more source information

Misc. features, dump sites, cable areas, Territorial Sea (3 nmi) limit

Seismic reflection profile tracklines

Submersible dives



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7. Petit Manan Pt. to West Quoddy Head (96-13)

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22 State House Station, Augusta, Me 04333.
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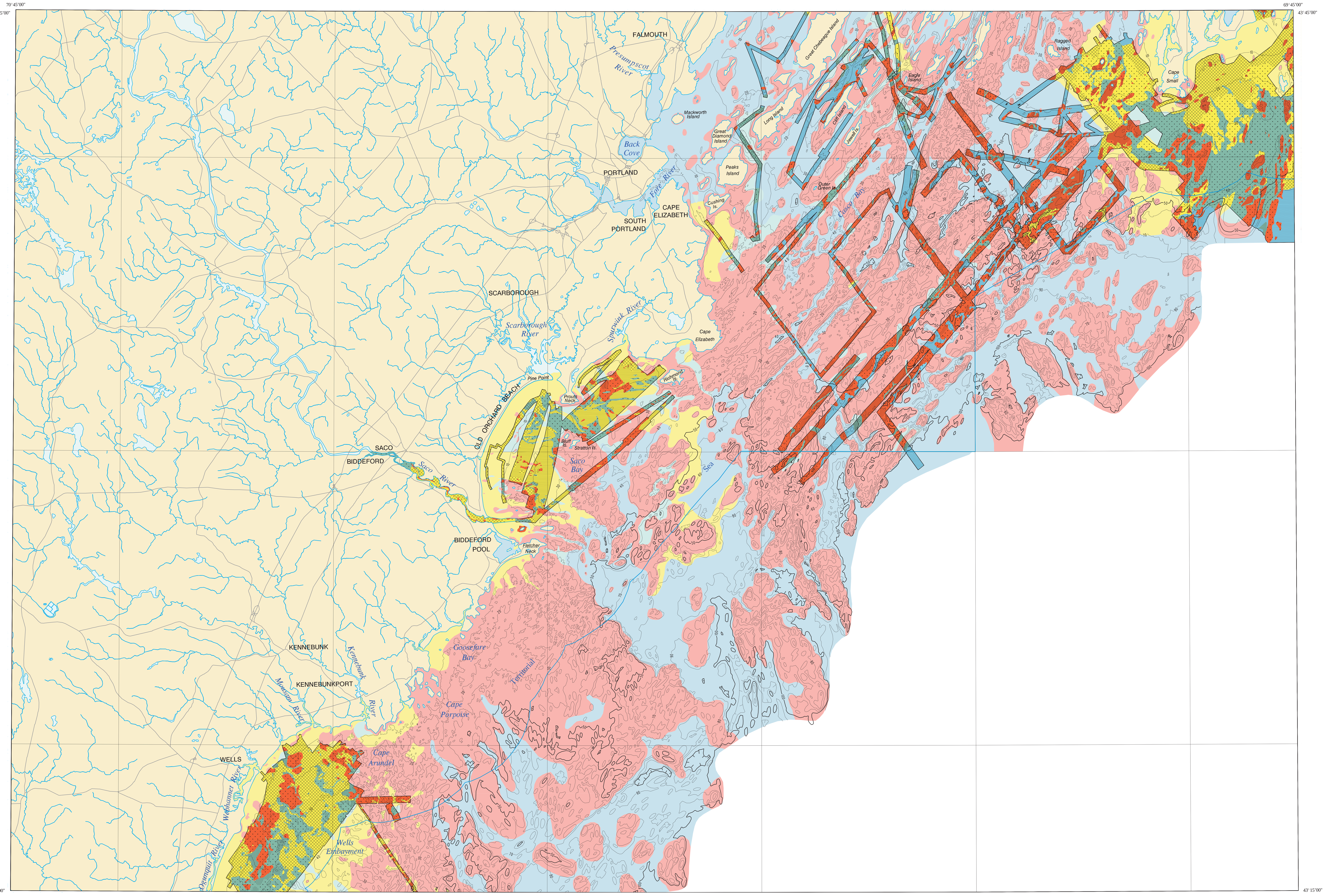
Surficial Geology of the Maine Inner Continental Shelf



Map Projection: Universal Transverse Mercator, Zone 19
1927 North American Datum

Map Scale 1:100,000

National Geodetic Vertical Datum of 1929
Contour Interval 10 Meters

Ogunquit to Kennebec River, Maine

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DEPARTMENT OF CONSERVATION
Maine Geological Survey
Robert G. Marvinney, State Geologist

GEOLOGIC MAP NO. 96-8
1996

Funding for the preparation and publication of this map was provided by the Regional Marine Research Program (RMRP #NA46RM0451)

Digital cartographic production and design by:
Bennett J. Wilson, Jr.
Robert D. Tucker

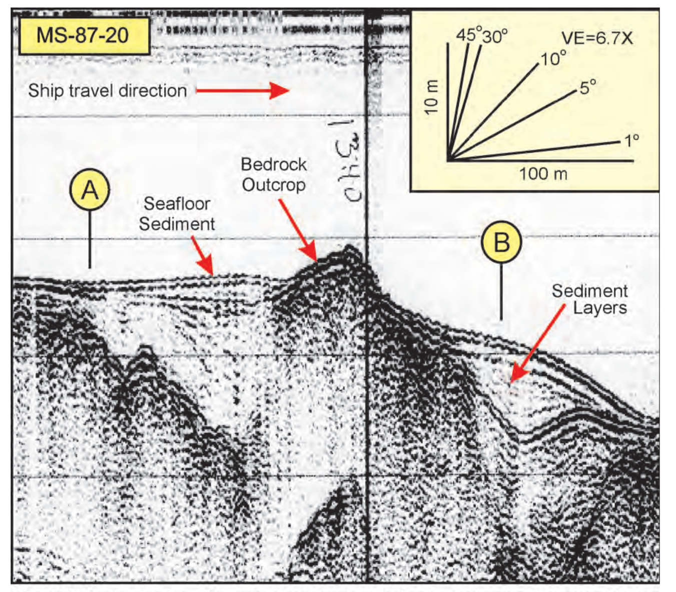
INTRODUCTION

Geological maps depicting topography, surficial materials, geomorphology, and bedrock play an important role in understanding the origin of, as well as the ongoing processes that shape and change the earth's surface. As in the terrestrial environment, maps are also instrumental in aiding the sound economic development of natural resources. They also provide guidance to natural hazards that exist within the landscape. As people increasingly work on, in, and beneath the sea, the need to better understand regional marine geology, just as we understand terrestrial geology, has grown. This map, and others in this series, are intended to provide a better picture of the northwestern Gulf of Maine. Additional information on specific locations and original field descriptions exists in the associated report: *The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf* (**Reference 1**).

Many reconnaissance surveys of the seafloor of the northwestern Gulf of Maine were conducted in the past decade. Recently that information, along with other previously published data, was compiled in a geographic information system (GIS) to produce this map. The data compiled for this series of maps were originally collected for a variety of research projects, government contracts, and student theses. For this reason there are varying amounts of geophysical data and bottom-sample coverage along the coast rather than a uniform grid. *The Seafloor Revealed* further explains the field techniques involved in data collection, the nature of the seafloor, the late Quaternary (glacial) geologic history of the Maine coast, previous studies, and sources of other information.

Bedrock geology defines the overall shape of the Maine coastline by controlling the location and orientation of islands, bays, and peninsulas. Bedrock relief is also primarily responsible for the variability in water depths of the inner shelf. Glacial deposits mantle the underlying bedrock and add complexity to regional geomorphology in forms that range from coarse ridges of boulders to basins filled with fine mud. Thick accumulations of glacial sediments (gravel, sand, and mud) often result in smoother areas of seafloor with less bathymetric relief. Almost all of the Holocene (postglacial) sedimentary material along the coast and offshore is derived from erosion and reworking of glacial deposits. Physical oceanographic processes, including waves and tides, continue to reshape the seafloor sediments and create productive marine habitats of the Gulf of Maine.

Sea-level change has had a profound effect on the location and duration of sediment reworking and deposition. During the complex changes of sea level over the last 14,000 years, coastal and terrestrial erosion stripped muddy glacial sediment from shoals and transferred the material to deeper basins. During deglaciation, the sea covered most of the coastal lowlands of Maine (**2**). A regression (sea-level lowering) until about 10,500 years ago was followed by a transgression (rising) that is still continuing (**3**, **4**). Areas shallower than the maximum lowering of the sea (less than about 60 m (200 feet) water depth) are generally rockier than deeper regions. The shallower zone lost some of its sediment cover through wave reworking during both the late Pleistocene fall and the early Holocene rise of the sea. These areas also experienced at least a thousand years of subaerial erosion by rivers and streams. The marine geology of the Maine coast records these and many other changes that have taken place since glaciers retreated inland and the sea invaded the western Gulf of Maine (**4**, **5**, **6**).



Seismic Reflection Profile. The image above is a portion of an ORE seismic reflection profile from Muscongus Bay and shows a cross-section (side view) of the seafloor. The seafloor surface shape is analagous to a fathometer profile. A vertical exaggeration (VE) of 6.7 makes all slopes appear steeper than they really are. The subsurface reflectors are from sediment layers and buried bedrock surfaces. Positions A and B correspond to the same locations in both figures. A time mark is shown by the vertical line at 13:40.

METHODS

Navigation and Map Compilation

Navigation fixes in the outer estuaries and offshore areas were made at 2 to 5 minute intervals with LORAN-C, which provided an accuracy of ± 100 m (330 feet). In the upper reaches of the estuaries, radar and line-of-sight observations on buoys and landmarks provided navigational accuracy that varied from less than ± 10 m (33 feet) to around ± 200 m (660 feet). Recent work used the global positioning satellite system (GPS) for navigation and was accurate to ± 10 m (33 feet). All navigation was converted to Universal Transverse Mercator projection and plotted with a geographic information system (GIS).

Surficial geologic maps were prepared in six steps: (1) use a GIS to plot the geophysical tracklines, bottom sample locations, and bathymetry on large-scale maps, (2) interpret sonar records and geology based on other geophysical data and samples, (3) digitize the drafted interpretation into a GIS, (4) compile and edit the digital data to generate map polygons, (5) check the mapped geology, and (6) assemble the final product including geology, bathymetry, geographic names, and roads. The shoreline and roads are from the U.S. Geological Survey's 1:100,000 Digital Line Graph files.

Bathymetry

Bathymetry was digitized at a 10 m contour interval from preliminary National Ocean Service (NOS) Bathymetric and Fishing Maps at a 1:100,000 scale. The NOS bathymetric maps provide a 2 m contour interval in many locations that is too complex for inclusion on this map. Difficulty in interpretation of positive and negative changes in bathymetry on the poorly labeled NOS maps created many possible errors, especially in areas where accompanying geophysical data were lacking. For this reason, these maps should not be used for navigation. More detailed and accurate NOS conventional nautical charts should be used for navigation.

Bottom Samples

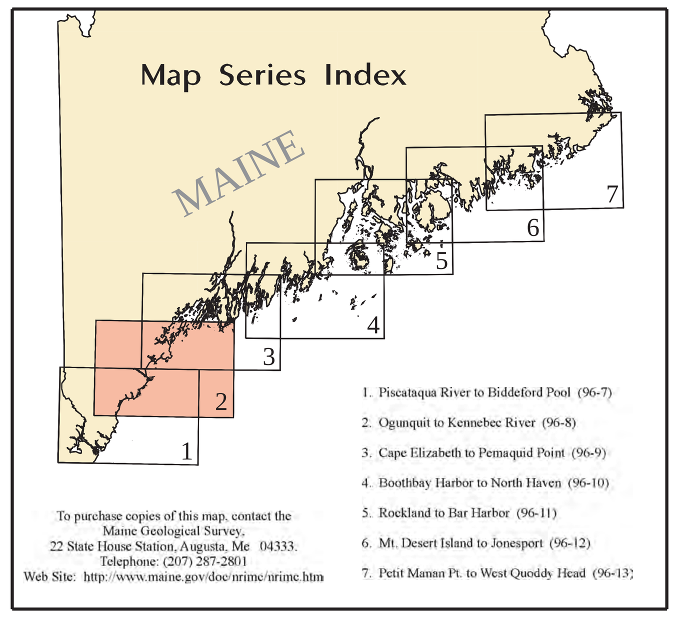
Between 1984 and 1991, 1,303 bottom sample stations were occupied (see the **Features and Data Source Map** for locations in this region). Two attempts were made at each station where the sampler initially returned empty, after which the site was considered a rock bottom. A Smith-McIntyre stainless steel grab sampler was used that nominally collected up to 0.016 m^3 (0.5 ft^3) of sediment. Southwest of Cape Small, samples were generally collected in a grid pattern with a 2 kilometer (1 nautical mile) distance between sample sites. Focus was placed on the large sandy embayments off Wells, Saco, and the Kennebec River mouth, as well as on muddy Casco Bay. Relatively few bottom samples were gathered off rocky areas such as Kennebunk or Kittery. Geophysical tracklines were later run over the sample stations to permit extrapolation of the bottom sediment data. North and east of Cape Small, geophysical data were generally gathered before bottom samples. This resulted in a need for fewer samples, and so fewer stations were occupied. Following collection, samples were stored in a freezer in the sedimentology laboratory at the University of Maine. Depending on the level of funding or specific needs of a particular project, samples were analyzed for grain size, organic carbon and nitrogen, carbonate content and/or heavy minerals (see Table 1 of **Reference 1**).

Side-Scan Sonar Profiles

Analog side-scan sonar records along 3358 km (1800 nmi) of the seafloor were gathered with an EG&G Model SMS 260 slant-range corrected sonar operating with a Model 272-T towfish at a nominal frequency of 105 kHz. The device was most often run at a 100 m (330 ft) range for each channel (200 m wide swath beneath the research vessel), although ranges from 25 to 300 m (80 to 1000 ft) were occasionally employed. The swaths of directly imaged and interpreted seafloor areas are depicted in brighter colors on the map. See the **Surficial Geology Legend** in the lower left corner of the map and the **Interpretation of Side-Scan Sonar Images** for further details.

Seismic Reflection Profiles

Seismic reflection profiles were gathered along 5011 km (2700 nmi) of tracklines, often in conjunction with side-scan sonar data (see simultaneous seismic and side-scan images above). A Raytheon RTT 1000a 3.5/7.0 kHz unit with a 200 kHz fathometer trace was used mainly in relatively shallow water (0 to 50 m; < 165 ft) over muddy bottoms. An ORE Geopulse "boomer" (0.5 to 200 kHz) seismic system was most effective in deeper water (15 to 150 m; 50 to 500 ft) over thicker deposits of sandy or gravelly sediment. Although seismic reflection profiles are most useful in constructing the geological history of an area, the bathymetry and stratigraphic context they provide, along with the strength of the surface return, also help identify the seafloor type (**6**). When used in conjunction with the side-scan sonar data, both the age and nature of the surficial sediment are easily interpreted.



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SURFICIAL GEOLOGY

Introduction

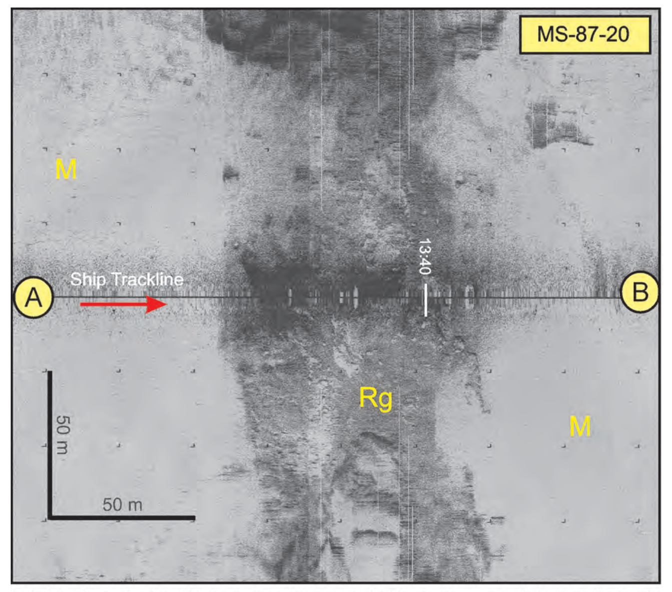
The surficial materials of the inner continental shelf of the northwestern Gulf of Maine are the most complex of any place along the Atlantic continental margin of the United States. Igneous, metamorphic, and sedimentary rocks spanning hundreds of millions of years of earth history form the regional basement. Glacial deposits, containing all clast sizes from boulders to mud, partially mantle the rocks. These materials, in turn, have been reworked by coastal processes during extreme fluctuations of sea level over the past few thousand years to create better-sorted modern deposits (**5**). Biological processes, including shell formation, bioturbation, and organic matter cycling have also altered the sediment composition and left geological imprints on the seafloor (**7, 8**). In addition to the surficial geology of this map, the geomorphology of the seafloor has also been mapped. The *Physiographic Map of the Maine Inner Continental Shelf* (**9**) shows the geomorphology of the offshore region covered by this series of surficial geologic maps in a single, smaller scale map.

Rocky Areas

Rocky seabed occupies approximately 41% of the inner continental shelf and is the most abundant seafloor type in this map series. Where little data exist and the seafloor relief is very irregular, a rocky bottom was inferred. By this inference, large areas of rocky bottom were mapped off extreme southern Maine, Penobscot Bay, and Petit Manan Point. Large areas of rock also occur surrounding the many granitic islands in Blue Hill and Frenchman Bays. Elongate, submerged rock ridges follow the linear trend of the Casco Bay peninsulas. Although common as nearshore shoals in water less than 10 m (33 ft) deep, large outcrops of rock are relatively rare in deep offshore basins.

The bedrock geology was not determined, but side-scan sonar images clearly depict parallel fractures and elongate outcrop patterns common in layered metamorphic rocks as well as more rounded bodies of rock often associated with plutonic (granitic) igneous rocks (**10**). In shallow water, rock outcrops are usually covered with algae (seaweed) and encrusting organisms. Below water depths of a few tens of meters (the photic zone), encrusting organisms and organic mats often cover bedrock outcrops. "Rock greater than mud" (**Rm**; for an explanation of abbreviations see **Interpretation of Side-Scan Sonar Images**) is most common in deep offshore basins where outcrops project up through the mud that mantles the seafloor. **Rm** also occurs as small areas seaward of tidal flats in nearshore basins. "Rock greater than sand" (**Rs**) exists only in a few locations offshore of beaches.

Areas adjacent to rock outcrops are commonly covered with shells of dead organisms. Formerly attached to the rock surface, these shelly remains are mixed with angular rock fragments that have fallen off the outcrop (**8**). Bedrock fractures and troughs also have a similar mixture of shell and rock clasts. For this reason, extensive, "pure" rock outcrops were infrequently mapped. Instead, fractured bedrock and small bodies of rock were most often mapped as "rock greater than gravel" (**Rg**) or "gravel greater than rock" (**Gr**), two of the most common seafloor types observed.



Side-Scan Sonar Profile. The image above is a portion of a side-scan sonar record taken simultaneously with the seismic reflection profile to the left. This image shows a plan view of the seafloor (much like an aerial photograph). The area shown is about the size of eight football fields. The darker area is a mixture of bedrock outcrop and gravel (**Rg**). The lighter areas on either side are flat, muddy seafloor (**M**). The ship track followed the black center line over the bottom. Both of these images were made using sound waves.

Gravelly Areas

Gravel is a common constituent of inner shelf sediment, but occupies only 12% of the seafloor itself. Gravel is abundant in only a few locations: off the Kennebec River mouth where deltaic sediments are exposed, off Wells and Saco Bays near reworked glacial moraines, and near the Canadian border. Frequently the gravel has a rippled surface, and may contain minor amounts of coarse sand. In areas where waves regularly scour the seabed, a gravel lag deposit armors the seafloor. Gravel also occurs in broad linear bands near submerged moraines.

As described above, "gravel greater than rock" (**Gr**) is a common feature adjacent to bedrock outcrops. Here the gravel may have a high shell content (calcium carbonate) because shells are often the only modern sediment introduced to an area. **Gr** and "gravel greater than sand" (**Gs**) are major features of the seafloor from the Canadian border to Englishman Bay. Here, low relief bedrock is mantled by till, which fills in rock depressions but lacks much relief itself. "Gravel greater than mud" (**Gm**) is very rare along the inner shelf. Gravel and mud are not deposited in the ocean under the same hydrodynamic conditions, but may be found just beneath the seafloor in till deposited by glaciers more than 13,000 years ago beneath glacial ice.

Sandy Areas

Sandy seafloor (**S**) occupies only 8% of the inner shelf of the northwestern Gulf of Maine. The sandiest regions are offshore of southern Maine beaches such as Old Orchard and Ogunquit. In the mid coast region, a large sandy area "sand greater than gravel" (**Sg**) occurs off the Kennebec River mouth. This **Sg** area, consisting of many small rippled gravel patches that are intermingled with sand, has not changed appreciably in a decade, although large winter storms resuspend sand and gravel in water depths down to at least 55 m (180 ft). Many smaller bodies of sand are scattered elsewhere throughout the coast, occasionally around the 50 to 60 m (165 to 200 ft) depth, near the lowest stand of sea level since the Ice Age.

Sandy material is acoustically uniform and strongly contrasts with bordering areas of gravel and rock. Although many sediment samples from shallow water contain well-sorted ("clean") sand, areas mapped "sand" or sand with other materials frequently contain sediment in which the sand is mixed with mud, gravel and a variety of shell fragments.

"Sand greater than rock" (**Sr**) is a minor component of the seafloor that exists adjacent to small bedrock outcrops scattered across the mapped area. It is possible that more **Sr** areas exist, especially in the southern shelf, but few observations were made in that region. "Sand greater than mud" (**Sm**) is a very difficult unit to map because mixtures of mud and sand look similar on acoustic images. The only mapped areas of "sand greater than mud" are located in Saco Bay, where bottom samples confirmed the presence of both particle sizes. Similar occurrences of **Sm** may occur at the seaward margin of other beaches.

Muddy Areas

Muddy regions cover 39% of the seafloor and are the second most abundant surficial material. Mud is the dominant seabed material in all nearshore areas except for southern Maine and near the Canadian border. It is also the major deep-water surficial material in all locations except off the southern Maine coast.

Mud accumulates near areas where there is an available supply of fine-grained sediment and there are quieter hydrodynamic conditions, which favor the slow settling of small particles, or their entrapment by organisms. In nearshore regions, mud comes from eroding glacial bluffs and seasonally from rivers. In deep water, mud must be derived from winnowing and erosion of deposits in shallow water.

Muddy seafloors are featureless on acoustic records unless they have been disturbed or contain anomalous "hard" objects. Drag marks left by fishing gear are common in most sedimentary environments, but are most noticeable when carved into mud. Gas-escape pockmarks are generally hemispherical depressions that result from localized seabed disturbance. Where pockmarks occur in abundance, the seafloor is uneven. Thousands of pockmarks hundreds of meters (yards) in diameter and tens of meters (yards) deep make crater-like terrain in the muddy bottom in Belfast, Blue Hill, and Passamaquoddy Bays (**7,8**).

"Mud greater than rock" (**Mr**) occurs in some deepwater locations, but "mud greater than gravel" (**Mg**) is as rare as "gravel greater than mud" (**Gm**) because of the hydrodynamic differences between the sizes of materials. "Mud greater than sand" (**Ms**) occurs seaward of the sandy area of Saco Bay and is mapped on the basis of a large number of bottom samples that encountered this mixture in this region.

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ACKNOWLEDGMENTS

Funding for this compilation was provided by the Regional Marine Research Program of NOAA (Grant # NA46RM0451). We wish to thank Mr. Walter A. Anderson, former Director of the Maine Geological Survey, for more than ten years of unrelenting encouragement and support for our offshore research. In addition, we thank Dr. Robert E. Wall who directed the University of Maine Center for Marine Studies, which partly purchased the geophysical equipment and GIS used for this compilation. Most of the data collection was sponsored by the Maine-New Hampshire Sea Grant Program, the Continental Margins Program of the Minerals Management Service and Association of State Geologists, the National Science Foundation, the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Undersea Research Program, and the Maine Department of Marine Resources. We acknowledge many graduate students who assisted in the original collection and interpretation of much of the data, especially Dr. R. Craig Shipp. Finally, we acknowledge the able seamanship of Captain Michael Dunn, formerly of the Darling Marine Center, who participated in all bottom sampling and most geophysical expeditions.

Surficial Geology Legend

The map above shows the geology of the surface of the ocean floor. This map of Maine's inner continental shelf is based on geophysical data, bottom samples, National Ocean Service provisional bathymetric maps and published nautical charts. These data were supplemented with bottom photographs and direct observations from submersibles. Experience with these data, together with side-scan sonar images (the underwater equivalent of aerial photographs), permitted generalized mapping of the inner continental shelf.

The map areas shown by the four colors below were not directly imaged with side-scan sonar. Contacts between these geologic units were inferred, based on bathymetry and other information (see **Features and Data Source Map**).

The bright colors on the map and in the **Interpretation of Side-Scan Sonar Images** legend to the right show areas of seafloor imaged by sonar. The linear colored swaths on the map above follow ship tracklines and have a width that represents the sonar swath to each side of the vessel.

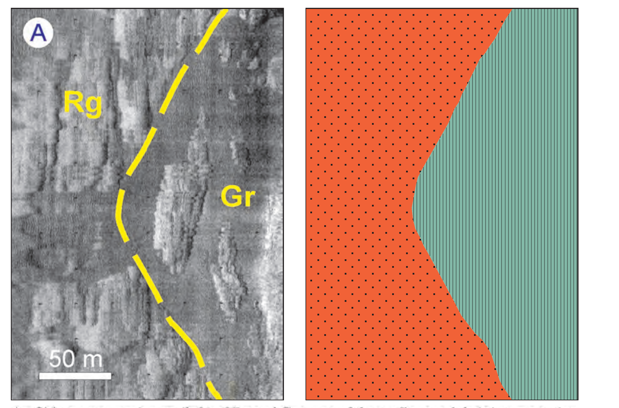
ROCKY - Rugged, high-relief seafloor is dominated by bedrock outcrops (ledge) and is the most common type on the Maine inner continental shelf, especially in depths of less than 60 m (~200 ft). Accumulations of coarse-grained sediment occur in low-lying areas and at the base of rock outcrops.

GRAVELLY - Generally flat-lying areas are covered by coarse-grained sediment, with clasts up to several meters (yards) in diameter. In some areas gravel and boulders directly overlie bedrock. These deposits are not presently accumulating on the shelf but represent Pleistocene (Ice Age) material. Ripples are common in well-sorted gravel, indicating that some of the older glacial sediments are presently being reworked by waves, currents, and tides.

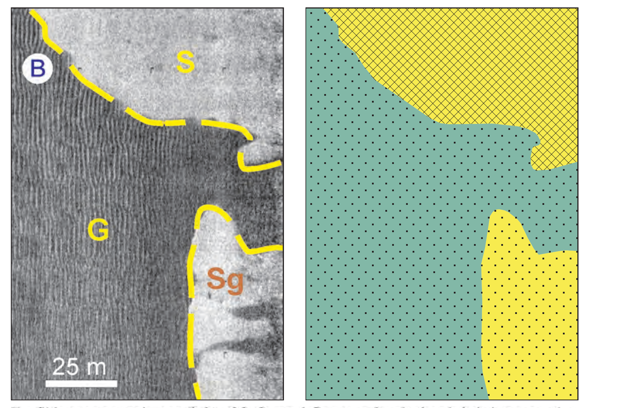
SANDY - Generally smooth seafloor consists primarily of sand-sized particles derived from rivers, reworked glacial deposits and/or biogenic shell production. This bottom type, although well represented in southwestern areas, is the least common on the Maine inner continental shelf.

MUDDY - Deposits of fine-grained material form a generally flat and smooth seabed commonly found in sheltered bays and estuaries and at depths of greater than 60 m (~200 ft). In some submarine valleys the mud may be meters (yards) thick. Deep depressions (gas-escape pockmarks) occur in some muddy bays.

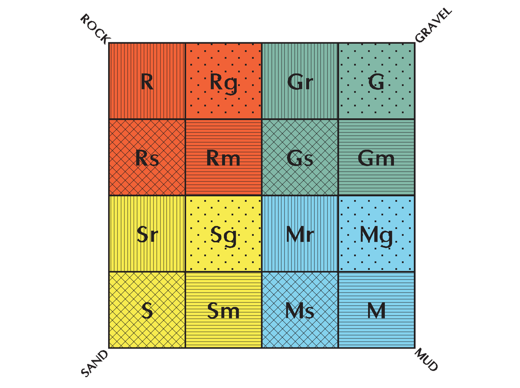
Interpretation of Side-Scan Sonar Images



A. Side-scan sonar image (left) of **Rg** and **Gr** areas of the seafloor and their interpretation (right). In the image, gravelly areas appear dark gray and bedrock outcrops show irregular perimeters, dark (sound reflective) streaks and light gray acoustic shadows. Fractures are prominent in the bedrock; gravelly areas have low relief.



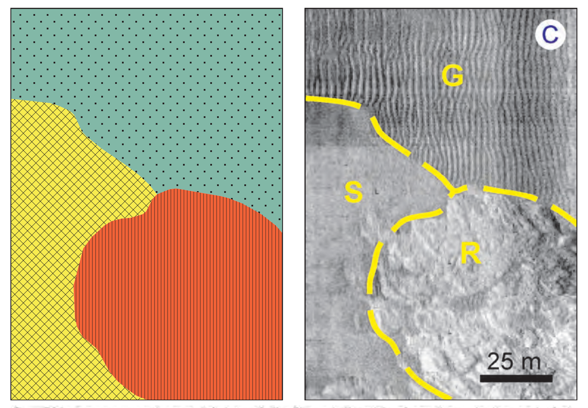
B. Side-scan sonar image (left) of **S, Sg,** and **G** areas of seabed and their interpretation (right). Sandy seafloor is lighter gray and appears smooth while the gravelly seafloor has wave ripples with straight crestlines about 1 m (3 ft) apart. **Sg** areas occur as a patchwork of **S** and **G** types, but are too small to discriminate at this map scale.



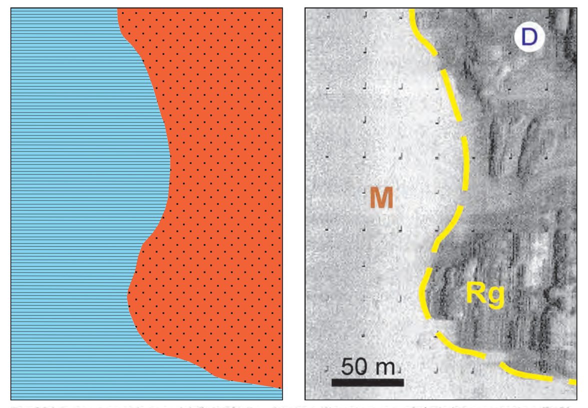
On side-scan sonar images, rock, gravel, sand, and mud reflect acoustic energy differently and appear as various shades of gray printed by the instrument's recorder. The classification scheme above is unique and based on the acoustic reflectivity of the Maine inner continental shelf. The dominant "end member" (**R**ock, **G**ravel, **S**and, or **M**ud) is abbreviated with a capitalized first letter. A less abundant, subordinate seafloor type is represented with a lower case letter (**r**, **g**, **s**, or **m**). For example, a predominantly rocky seabed with gravel infilling fractures is designated **Rg**. The sixteen combinations of seafloor types shown above are used for areas where side-scan sonar coverage exists and appear as bright colors on the map. In areas beyond the scan range only four generalized units were used (see the **Surficial Geology Legend**).

When individual units of rock, gravel, sand, and mud were greater than 10,000 m^2 in area (about the size of 3 football fields), they were mapped as separate features. In many places, however, a heterogeneous seabed composed of numerous small features required composite map units. In areas where no single seafloor type exceeded 10,000 m^2, a composite map unit was used. The selection of map units to describe this complexity involves a compromise between providing detailed information where it exists, and generalizing where data are scarce or absent. In many places the seabed is composed of numerous small features, none exceeding the minimum area of 10,000 m^2. Consequently, not all details in the sonar records could be presented on this map. It should be realized that spatial heterogeneity exists at all scales, even down to areas less than a square meter (ten square feet).

Rock yields a strong, dark, acoustic return. In areas with steep bathymetric relief and fractures, light acoustic shadows are visible within the dark areas of rock (see adjacent panels **A**, **C**, and **D**). Gravel deposits also produce a relatively strong acoustic return (black to dark gray), and are often closely associated with rock, but lack relief (**A**, **B**, **C**, **D**). Sand produces a much weaker acoustic return (light to dark gray) than either gravel or rock, and usually lacks local relief (**B**). Mud yields a very weak surface return (light gray to white) and, except where it accumulates on steep slopes or near gas-escape pockmarks, it is associated with a smooth seabed (**D**). The **Surficial Geology** section in the far right column describes the distribution and abundance of these areas on Maine's inner continental shelf.

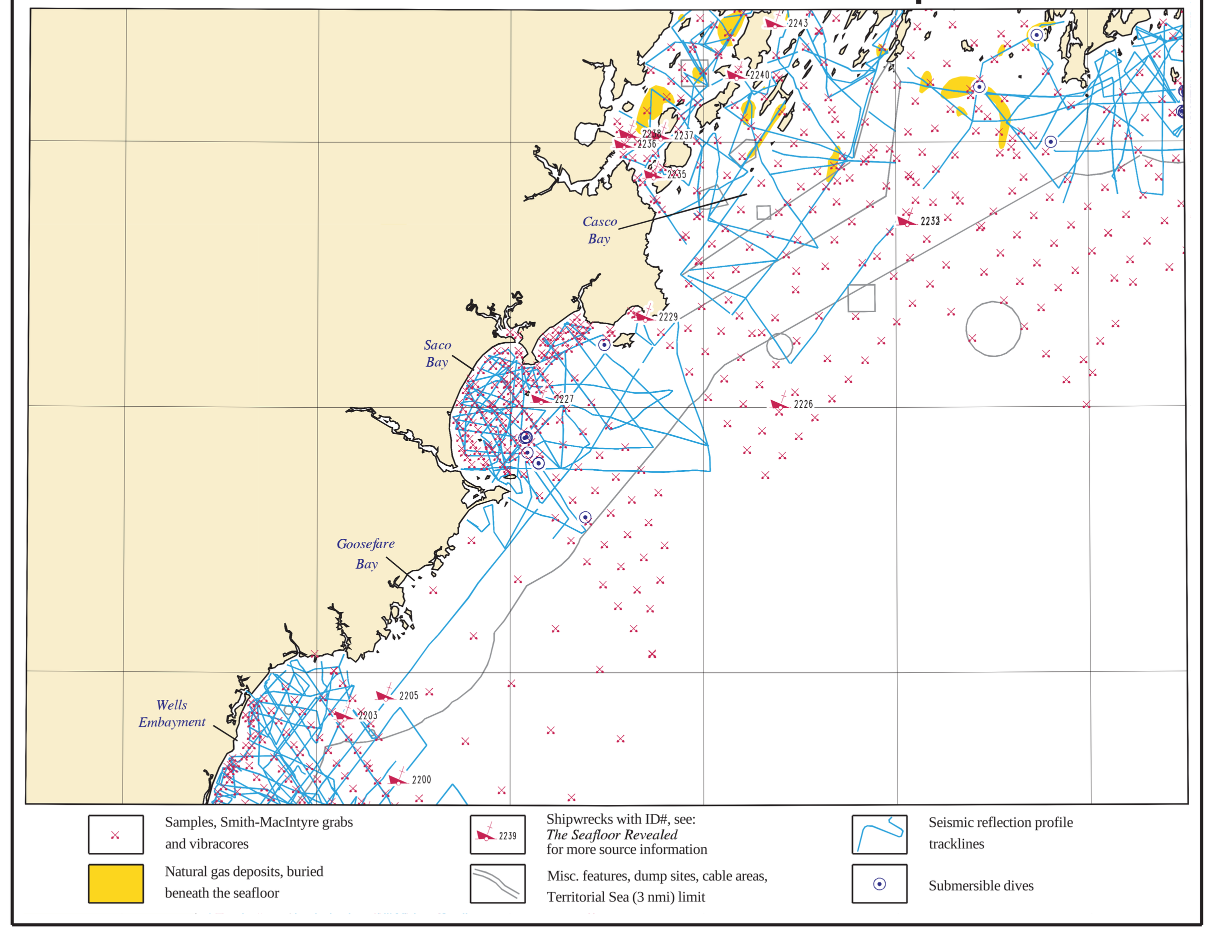


C. Side-scan sonar image (right) of **S, G,** and **R** with sharp boundaries and their interpretation (left). Ripples in the gravelly seabed produce alternating light and dark bands while the sandy surface is more uniformly gray. These ripples have a 2 m (6 ft) wavelength. The rocky outcrop rises above the surrounding seafloor.

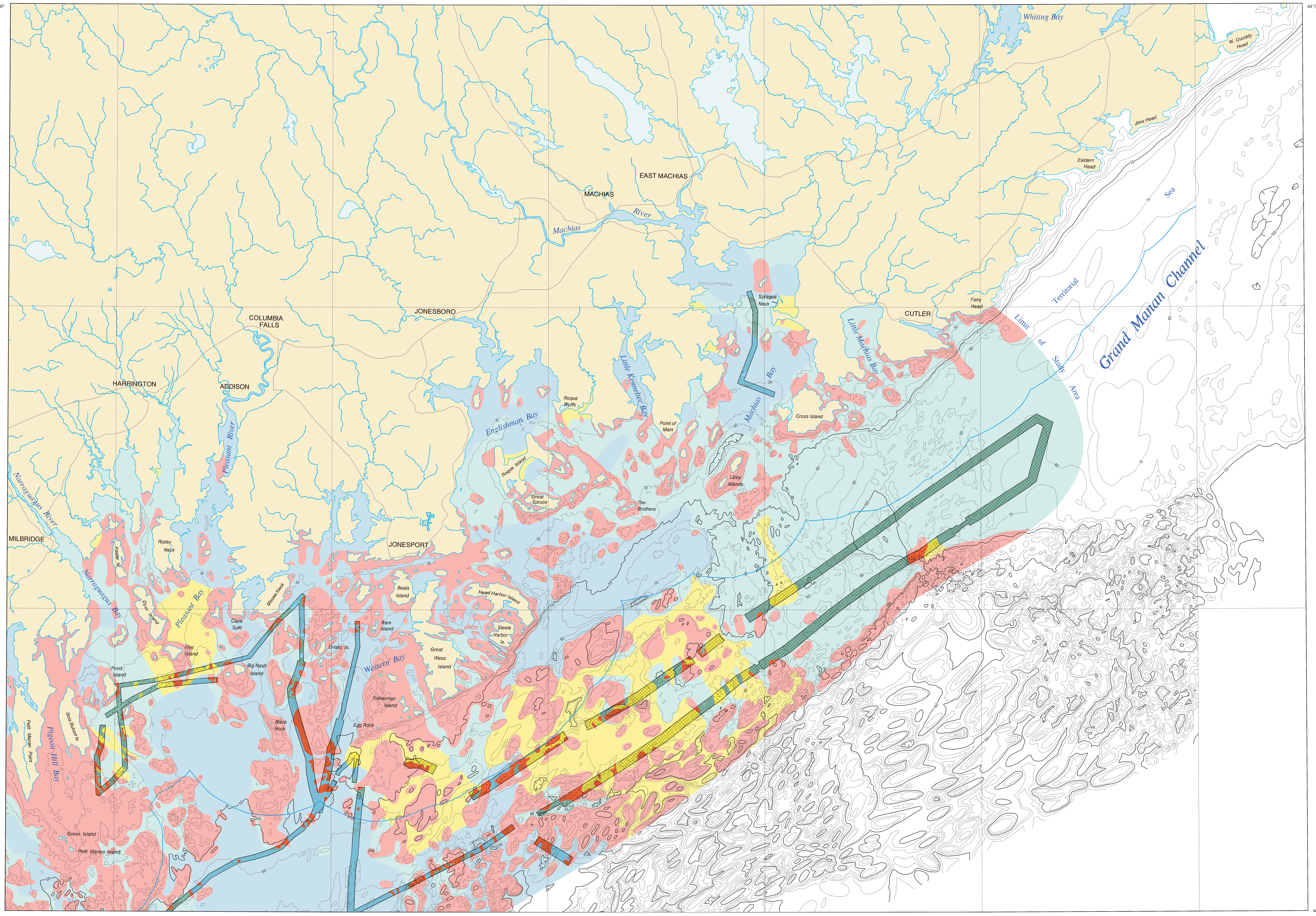


D. Side-scan sonar image (right) of **M** and **Rg** seafloor types and their interpretation (left). Muddy seafloor is uniformly light gray although the tonal difference on the left edge is a recorder artifact. A mixture of rocky outcrops has an irregular dark gray appearance while gravelly troughs appear smooth and dark gray.

Features and Data Source Map



Surficial Geology of the Maine Inner Continental Shelf



Map Projection: Universal Transverse Mercator, Zone 19
1927 North American Datum

Nautical Miles (nmi)

Map Scale 1:100,000

Kilometers (km)

National Geodetic Vertical Datum of 1929
Contour Interval 10 Meters

Petit Manan Point to West Quoddy Head, Maine

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GEOLOGIC MAP NO. 96-13
1996

Funding for the preparation and publication of this map was provided by the Regional Marine Research Program (RMRP #NA46RM0451)

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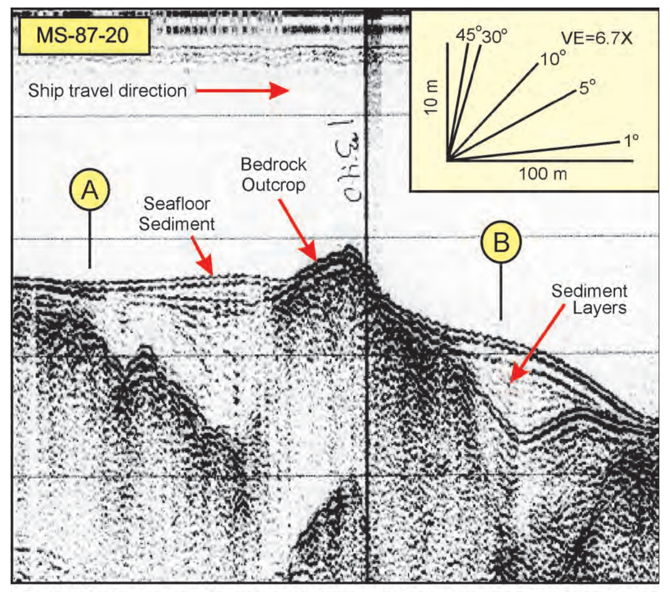
INTRODUCTION

Geological maps depicting topography, surficial materials, geomorphology, and bedrock play an important role in understanding the origin of, as well as the ongoing processes that shape and change the earth's surface. As in the terrestrial environment, maps are also instrumental in aiding the sound economic development of natural resources. They also provide guidance to natural hazards that exist within the landscape. As people increasingly work on, in, and beneath the sea, the need to better understand regional marine geology, just as we understand terrestrial geology, has grown. This map, and others in this series, are intended to provide a better picture of the northwestern Gulf of Maine. Additional information on specific locations and original field descriptions exists in the associated report: *The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf* (**Reference 1**).

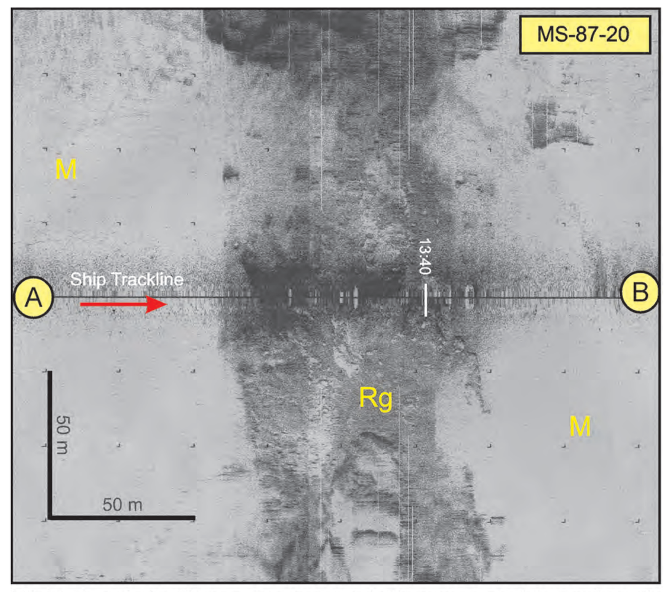
Many reconnaissance surveys of the seafloor of the northwestern Gulf of Maine were conducted in the past decade. Recently that information, along with other previously published data, was compiled in a geographic information system (GIS) to produce this map. The data compiled for this series of maps were originally collected for a variety of research projects, government contracts, and student theses. For this reason there are varying amounts of geophysical data and bottom-sample coverage along the coast rather than a uniform grid. *The Seafloor Revealed* further explains the field techniques involved in data collection, the nature of the seafloor, the late Quaternary (glacial) geologic history of the Maine coast, previous studies, and sources of other information.

Bedrock geology defines the overall shape of the Maine coastline by controlling the location and orientation of islands, bays, and peninsulas. Bedrock relief is also primarily responsible for the variability in water depths of the inner shelf. Glacial deposits mantle the underlying bedrock and add complexity to regional geomorphology in forms that range from coarse ridges of boulders to basins filled with fine mud. Thick accumulations of glacial sediments (gravel, sand, and mud) often result in smoother areas of seafloor with less bathymetric relief. Almost all of the Holocene (postglacial) sedimentary material along the coast and offshore is derived from erosion and reworking of glacial deposits. Physical oceanographic processes, including waves and tides, continue to reshape the seafloor sediments and create productive marine habitats of the Gulf of Maine.

Sea-level change has had a profound effect on the location and duration of sediment reworking and deposition. During the complex changes of sea level over the last 14,000 years, coastal and terrestrial erosion stripped muddy glacial sediment from shoals and transferred the material to deeper basins. During deglaciation, the sea covered most of the coastal lowlands of Maine (**2**). A regression (sea-level lowering) until about 10,500 years ago was followed by a transgression (rising) that is still continuing (**3**, **4**). Areas shallower than the maximum lowering of the sea (less than about 60 m (200 feet) water depth) are generally rockier than deeper regions. The shallower zone lost some of its sediment cover through wave reworking during both the late Pleistocene fall and the early Holocene rise of the sea. These areas also experienced at least a thousand years of subaerial erosion by rivers and streams. The marine geology of the Maine coast records these and many other changes that have taken place since glaciers retreated inland and the sea invaded the western Gulf of Maine (**4**, **5**, **6**).



Seismic Reflection Profile. The image above is a portion of an ORE seismic reflection profile from Muscongus Bay and shows a cross-section (side view) of the seafloor. The seafloor surface shape is analagous to a fathometer profile. A vertical exaggeration (VE) of 6.7 makes all slopes appear steeper than they really are. The subsurface reflectors are from sediment layers and buried bedrock surfaces. Positions A and B correspond to the same locations in both figures. A time mark is shown by the vertical line at 13:40.



Side-Scan Sonar Profile. The image above is a portion of a side-scan sonar record taken simultaneously with the seismic reflection profile to the left. This image shows a plan view of the seafloor (much like an aerial photograph). The area shown is about the size of eight football fields. The darker area is a mixture of bedrock outcrop and gravel (**Rg**). The lighter areas on either side are flat, muddy seafloor (**M**). The ship track followed the black center line over the bottom. Both of these images were made using sound waves.

METHODS

Navigation and Map Compilation

Navigation fixes in the outer estuaries and offshore areas were made at 2 to 5 minute intervals with LORAN-C, which provided an accuracy of $\pm$ 100 m (330 feet). In the upper reaches of the estuaries, radar and line-of-sight observations on buoys and landmarks provided navigational accuracy that varied from less than $\pm$ 10 m (33 feet) to around $\pm$ 200 m (660 feet). Recent work used the global positioning satellite system (GPS) for navigation and was accurate to $\pm$ 10 m (33 feet). All navigation was converted to Universal Transverse Mercator projection and plotted with a geographic information system (GIS).

Surficial geologic maps were prepared in six steps: (1) use a GIS to plot the geophysical tracklines, bottom sample locations, and bathymetry on large-scale maps, (2) interpret sonar records and geology based on other geophysical data and samples, (3) digitize the drafted interpretation into a GIS, (4) compile and edit the digital data to generate map polygons, (5) check the mapped geology, and (6) assemble the final product including geology, bathymetry, geographic names, and roads. The shoreline and roads are from the U.S. Geological Survey's 1:100,000 Digital Line Graph files.

Bathymetry

Bathymetry was digitized at a 10 m contour interval from preliminary National Ocean Service (NOS) Bathymetric and Fishing Maps at a 1:100,000 scale. The NOS bathymetric maps provide a 2 m contour interval in many locations that is too complex for inclusion on this map. Difficulty in interpretation of positive and negative changes in bathymetry on the poorly labeled NOS maps created many possible errors, especially in areas where accompanying geophysical data were lacking. For this reason, these maps should not be used for navigation. More detailed and accurate NOS conventional nautical charts should be used for navigation.

Bottom Samples

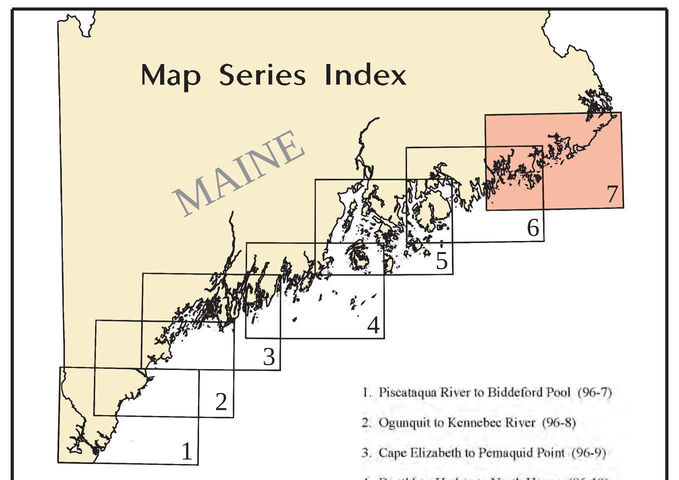
Between 1984 and 1991, 1,303 bottom sample stations were occupied (see the **Features and Data Source Map** for locations in this region). Two attempts were made at each station where the sampler initially returned empty, after which the site was considered a rock bottom. A Smith-McIntyre stainless steel grab sampler was used that nominally collected up to 0.016 m^3 (0.5 ft^3) of sediment. Southwest of Cape Small, samples were generally collected in a grid pattern with a 2 kilometer (1 nautical mile) distance between sample sites. Focus was placed on the large sandy embayments off Wells, Saco, and the Kennebec River mouth, as well as on muddy Casco Bay. Relatively few bottom samples were gathered off rocky areas such as Kennebunk or Kittery. Geophysical tracklines were later run over the sample stations to permit extrapolation of the bottom sediment data. North and east of Cape Small, geophysical data were generally gathered before bottom samples. This resulted in a need for fewer samples, and so fewer stations were occupied. Following collection, samples were stored in a freezer in the sedimentology laboratory at the University of Maine. Depending on the level of funding or specific needs of a particular project, samples were analyzed for grain size, organic carbon and nitrogen, carbonate content and/or heavy minerals (see Table 1 of **Reference 1**).

Side-Scan Sonar Profiles

Analog side-scan sonar records along 3358 km (1800 nmi) of the seafloor were gathered with an EG&G Model SMS 260 slant-range corrected sonar operating with a Model 272-T towfish at a nominal frequency of 105 kHz. The device was most often run at a 100 m (330 ft) range for each channel (200 m wide swath beneath the research vessel), although ranges from 25 to 300 m (80 to 1000 ft) were occasionally employed. The swaths of directly imaged and interpreted seafloor areas are depicted in brighter colors on the map. See the **Surficial Geology Legend** in the lower left corner of the map and the **Interpretation of Side-Scan Sonar Images** for further details.

Seismic Reflection Profiles

Seismic reflection profiles were gathered along 5011 km (2700 nmi) of tracklines, often in conjunction with side-scan sonar data (see simultaneous seismic and side-scan images above). A Raytheon RTT 1000a 3.5/7.0 kHz unit with a 200 kHz fathometer trace was used mainly in relatively shallow water (0 to 50 m; < 165 ft) over muddy bottoms. An ORE Geopulse "boomer" (0.5 to 200 kHz) seismic system was most effective in deeper water (15 to 150 m; 50 to 500 ft) over thicker deposits of sandy or gravelly sediment. Although seismic reflection profiles are most useful in constructing the geological history of an area, the bathymetry and stratigraphic context they provide, along with the strength of the surface return, also help identify the seafloor type (**6**). When used in conjunction with the side-scan sonar data, both the age and nature of the surficial sediment are easily interpreted.



1. Piscataqua River to Biddeford Pool (96-7)
2. Ogunquit to Kennebec River (96-8)
3. Cape Elizabeth to Pemaquid Point (96-9)
4. Boothbay Harbor to North Haven (96-10)
5. Rockland to Bar Harbor (96-11)
6. Mt. Desert Island to Jonesport (96-12)
7. Petit Manan Pt. to West Quoddy Head (96-13)

To purchase copies of this map, contact the Maine Geological Survey, 22 State House Station, Augusta, ME 04333. Telephone: (207) 287-2801. Web Site: http://www.state.me.us/doc/nrimc/mgs/mgs.htm

Not to be Used for Navigation
The information appearing on this map is not complete for navigation. Mariners are cautioned to use National Ocean Service nautical charts for navigation in this area.

SURFICIAL GEOLOGY

Introduction

The surficial materials of the inner continental shelf of the northwestern Gulf of Maine are the most complex of any place along the Atlantic continental margin of the United States. Igneous, metamorphic, and sedimentary rocks spanning hundreds of millions of years of earth history form the regional basement. Glacial deposits, containing all clast sizes from boulders to mud, partially mantle the rocks. These materials, in turn, have been reworked by coastal processes during extreme fluctuations of sea level over the past few thousand years to create better-sorted modern deposits (**5**). Biological processes, including shell formation, bioturbation, and organic matter cycling have also altered the sediment composition and left geological imprints on the seafloor (**7**, **8**). In addition to the surficial geology of this map, the geomorphology of the seafloor has also been mapped. The *Physiographic Map of the Maine Inner Continental Shelf* (**9**) shows the geomorphology of the offshore region covered by this series of surficial geologic maps in a single, smaller scale map.

Rocky Areas

Rocky seabed occupies approximately 41% of the inner continental shelf and is the most abundant seafloor type in this map series. Where little data exist and the seafloor relief is very irregular, a rocky bottom was inferred. By this inference, large areas of rocky bottom were mapped off extreme southern Maine, Penobscot Bay, and Petit Manan Point. Large areas of rock also occur surrounding the many granitic islands in Blue Hill and Frenchman Bays. Elongate, submerged rock ridges follow the linear trend of the Casco Bay peninsulas. Although common as nearshore shoals in water less than 10 m (33 ft) deep, large outcrops of rock are relatively rare in deep offshore basins.

The bedrock geology was not determined, but side-scan sonar images clearly depict parallel fractures and elongate outcrop patterns common in layered metamorphic rocks as well as more rounded bodies of rock often associated with plutonic (granitic) igneous rocks (**10**). In shallow water, rock outcrops are usually covered with algae (seaweed) and encrusting organisms. Below water depths of a few tens of meters (the photic zone), encrusting organisms and organic mats often cover bedrock outcrops. "Rock greater than mud" (**Rm**; for an explanation of abbreviations see **Interpretation of Side-Scan Sonar Images**) is most common in deep offshore basins where outcrops project up through the mud that mantles the seafloor. **Rm** also occurs as small areas seaward of tidal flats in nearshore basins. "Rock greater than sand" (**Rs**) exists only in a few locations offshore of beaches.

Areas adjacent to rock outcrops are commonly covered with shells of dead organisms. Formerly attached to the rock surface, these shelly remains are mixed with angular rock fragments that have fallen off the outcrop (**8**). Bedrock fractures and troughs also have a similar mixture of shell and rock clasts. For this reason, extensive, "pure" rock outcrops were infrequently mapped. Instead, fractured bedrock and small bodies of rock were most often mapped as "rock greater than gravel" (**Rg**) or "gravel greater than rock" (**Gr**), two of the most common seafloor types observed.

Gravelly Areas

Gravel is a common constituent of inner shelf sediment, but occupies only 12% of the seafloor itself. Gravel is abundant in only a few locations: off the Kennebec River mouth where deltaic sediments are exposed, off Wells and Saco Bays near reworked glacial moraines, and near the Canadian border. Frequently the gravel has a rippled surface, and may contain minor amounts of coarse sand. In areas where waves regularly scour the seabed, a gravel lag deposit armors the seafloor. Gravel also occurs in broad linear bands near submerged moraines.

As described above, "gravel greater than rock" (**Gr**) is a common feature adjacent to bedrock outcrops. Here the gravel may have a high shell content (calcium carbonate) because shells are often the only modern sediment introduced to an area. **Gr** and "gravel greater than sand" (**Gs**) are major features of the seafloor from the Canadian border to Englishman Bay. Here, low relief bedrock is mantled by till, which fills in rock depressions but lacks much relief itself. "Gravel greater than mud" (**Gm**) is very rare along the inner shelf. Gravel and mud are not deposited in the ocean under the same hydrodynamic conditions, but may be found just beneath the seafloor in till deposited by glaciers more than 13,000 years ago beneath glacial ice.

Sandy Areas

Sandy seafloor (**S**) occupies only 8% of the inner shelf of the northwestern Gulf of Maine. The sandiest regions are offshore of southern Maine beaches such as Old Orchard and Ogunquit. In the mid coast region, a large sandy area "sand greater than gravel" (**Sg**) occurs off the Kennebec River mouth. This **Sg** area, consisting of many small rippled gravel patches that are intermingled with sand, has not changed appreciably in a decade, although large winter storms resuspend sand and gravel in water depths down to at least 55 m (180 ft). Many smaller bodies of sand are scattered elsewhere throughout the coast, occasionally around the 50 to 60 m (165 to 200 ft) depth, near the lowest stand of sea level since the Ice Age.

Sandy material is acoustically uniform and strongly contrasts with bordering areas of gravel and rock. Although many sediment samples from shallow water contain well-sorted ("clean") sand, areas mapped "sand" or sand with other materials frequently contain sediment in which the sand is mixed with mud, gravel and a variety of shell fragments.

"Sand greater than rock" (**Sr**) is a minor component of the seafloor that exists adjacent to small bedrock outcrops scattered across the mapped area. It is possible that more **Sr** areas exist, especially in the southern shelf, but few observations were made in that region. "Sand greater than mud" (**Sm**) is a very difficult unit to map because mixtures of mud and sand look similar on acoustic images. The only mapped areas of "sand greater than mud" are located in Saco Bay, where bottom samples confirmed the presence of both particle sizes. Similar occurrences of **Sm** may occur at the seaward margin of other beaches.

Muddy Areas

Muddy regions cover 39% of the seafloor and are the second most abundant surficial material. Mud is the dominant seabed material in all nearshore areas except for southern Maine and near the Canadian border. It is also the major deep-water surficial material in all locations except off the southern Maine coast.

Mud accumulates near areas where there is an available supply of fine-grained sediment and there are quieter hydrodynamic conditions, which favor the slow settling of small particles, or their entrapment by organisms. In nearshore regions, mud comes from eroding glacial bluffs and seasonally from rivers. In deep water, mud must be derived from winnowing and erosion of deposits in shallow water.

Muddy seafloors are featureless on acoustic records unless they have been disturbed or contain anomalous "hard" objects. Drag marks left by fishing gear are common in most sedimentary environments, but are most noticeable when carved into mud. Gas-escape pockmarks are generally hemispherical depressions that result from localized seabed disturbance. Where pockmarks occur in abundance, the seafloor is uneven. Thousands of pockmarks hundreds of meters (yards) in diameter and tens of meters (yards) deep make crater-like terrain in the muddy bottom in Belfast, Blue Hill, and Passamaquoddy Bays (**7**,**8**).

"Mud greater than rock" (**Mr**) occurs in some deepwater locations, but "mud greater than gravel" (**Mg**) is as rare as "gravel greater than mud" (**Gm**) because of the hydrodynamic differences between the sizes of materials. "Mud greater than sand" (**Ms**) occurs seaward of the sandy area of Saco Bay and is mapped on the basis of a large number of bottom samples that encountered this mixture in this region.

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(**4**) Belknap, D. F., Shipp, R. C., Stuckenrath, R., Kelley, J. T. and Borns, H. W., Jr., 1989, Holocene sea level change in coastal Maine, *in* Anderson, W. A., and Borns, H. W., Jr. (editors), Neotectonics of Maine; Studies in seismicity, crustal warping, and sea-level change: Maine Geological Survey, Bulletin 40, p. 85-103.

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ACKNOWLEDGMENTS

Funding for this compilation was provided by the Regional Marine Research Program of NOAA (Grant # NA46RM0451). We wish to thank Mr. Walter A. Anderson, former Director of the Maine Geological Survey, for more than ten years of unrelenting encouragement and support for our offshore research. In addition, we thank Dr. Robert E. Wall who directed the University of Maine Center for Marine Studies, which partly purchased the geophysical equipment and GIS used for this compilation. Most of the data collection was sponsored by the Maine-New Hampshire Sea Grant Program, the Continental Margins Program of the Minerals Management Service and Association of State Geologists, the National Science Foundation, the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Undersea Research Program, and the Maine Department of Marine Resources. We acknowledge many graduate students who assisted in the original collection and interpretation of much of the data, especially Dr. R. Craig Shipp. Finally, we acknowledge the able seamanship of Captain Michael Dunn, formerly of the Darling Marine Center, who participated in all bottom sampling and most geophysical expeditions.

Surficial Geology Legend

The map above shows the geology of the surface of the ocean floor. This map of Maine's inner continental shelf is based on geophysical data, bottom samples, National Ocean Service provisional bathymetric maps and published nautical charts. These data were supplemented with bottom photographs and direct observations from submersibles. Experience with these data, together with side-scan sonar images (the underwater equivalent of aerial photographs), permitted generalized mapping of the inner continental shelf.

The map areas shown by the four colors below were not directly imaged with side-scan sonar. Contacts between these geologic units were inferred, based on bathymetry and other information (see **Features and Data Source Map**).

The bright colors on the map and in the **Interpretation of Side-Scan Sonar Images** legend to the right show areas of seafloor imaged by sonar. The linear colored swaths on the map above follow ship tracklines and have a width that represents the sonar swath to each side of the vessel.

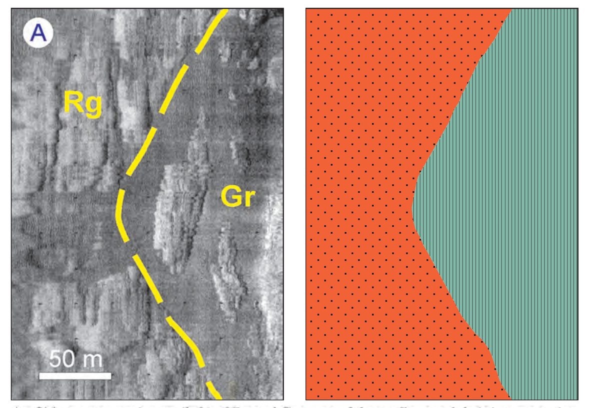
ROCKY - Rugged, high-relief seafloor is dominated by bedrock outcrops (ledge) and is the most common type on the Maine inner continental shelf, especially in depths of less than 60 m (~200 ft). Accumulations of coarse-grained sediment occur in low-lying areas and at the base of rock outcrops.

GRAVELLY - Generally flat-lying areas are covered by coarse-grained sediment, with clasts up to several meters (yards) in diameter. In some areas gravel and boulders directly overlie bedrock. These deposits are not presently accumulating on the shelf but represent Pleistocene (Ice Age) material. Ripples are common in well-sorted gravel, indicating that some of the older glacial sediments are presently being reworked by waves, currents, and tides.

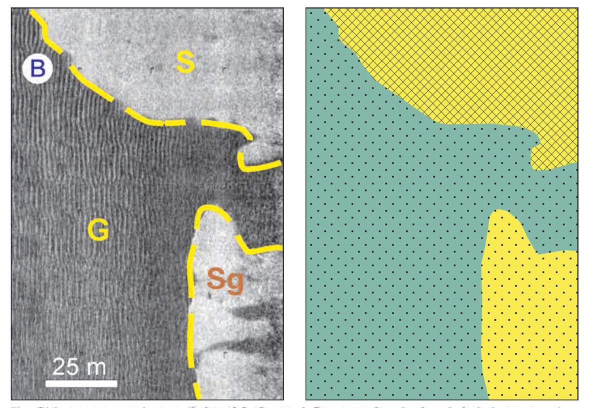
SANDY - Generally smooth seafloor consists primarily of sand-sized particles derived from rivers, reworked glacial deposits and/or biogenic shell production. This bottom type, although well represented in southwestern areas, is the least common on the Maine inner continental shelf.

MUDDY - Deposits of fine-grained material form a generally flat and smooth seabed commonly found in sheltered bays and estuaries and at depths of greater than 60 m (~200 ft). In some submarine valleys the mud may be meters (yards) thick. Deep depressions (gas-escape pockmarks) occur in some muddy bays.

Interpretation of Side-Scan Sonar Images



A. Side-scan sonar image (left) of **Rg** and **Gr** areas of the seafloor and their interpretation (right). In the image, gravelly areas appear dark gray and bedrock outcrops show irregular perimeters, dark (sound reflective) streaks and light gray acoustic shadows. Fractures are prominent in the bedrock; gravelly areas have low relief.



B. Side-scan sonar image (left) of **S**, **Sg**, and **G** areas of seabed and their interpretation (right). Sandy seafloor is lighter gray and appears smooth while the gravelly seafloor has wave ripples with straight crestlines about 1 m (3 ft) apart. **Sg** areas exist as a patchwork of **S** and **G** types, but are too small to discriminate at this map scale.

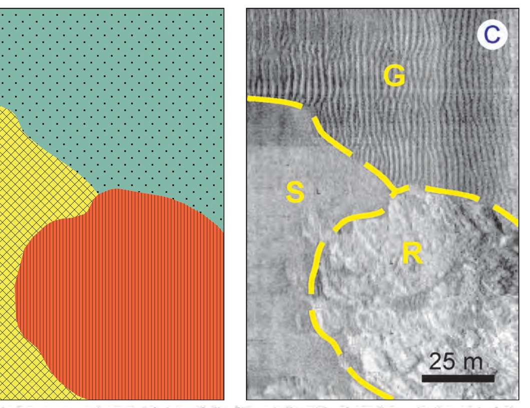
ROCK — GRAVEL — SAND — MUD

R	Rg	Gr	G
Rs	Rm	Gs	Gm
Sr	Sg	Mr	Mg
S	Sm	Ms	M

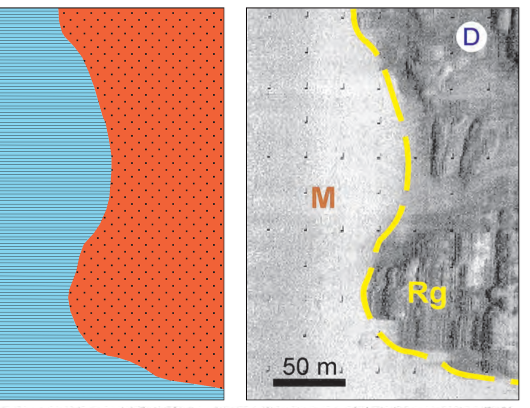
On side-scan sonar images, rock, gravel, sand, and mud reflect acoustic energy differently and appear as various shades of gray printed by the instrument's recorder. The classification scheme above is unique and based on the acoustic reflectivity of the Maine inner continental shelf. The dominant "end member" (**R**ock, **G**ravel, **S**and, or **M**ud) is abbreviated with a capitalized first letter. A less abundant, subordinate seafloor type is represented with a lower case letter (**r**, **g**, **s**, or **m**). For example, a predominantly rocky seabed with gravel infilling fractures is designated **Rg**. The sixteen combinations of seafloor types shown above are used for areas where side-scan sonar coverage exists and appear as bright colors on the map. In areas beyond the scan range only four generalized units were used (see the **Surficial Geology Legend**).

When individual units of rock, gravel, sand, and mud were greater than 10,000 m^2 in area (about the size of 3 football fields), they were mapped as separate features. In many places, however, a heterogeneous seabed composed of numerous small features required composite map units. In areas where no single seafloor type exceeded 10,000 m^2, a composite map unit was used. The selection of map units to describe this complexity involves a compromise between providing detailed information where it exists, and generalizing where data are scarce or absent. In many places the seabed is composed of numerous small features, none exceeding the minimum area of 10,000 m^2. Consequently, not all details in the sonar records could be presented on this map. It should be realized that spatial heterogeneity exists at all scales, even down to areas less than a square meter (ten square feet).

Rock yields a strong, dark, acoustic return. In areas with steep bathymetric relief and fractures, light acoustic shadows are visible within the dark areas of rock (see adjacent panels **A**, **C**, and **D**). Gravel deposits also produce a relatively strong acoustic return (black to dark gray), and are often closely associated with rock, but lack relief (**A**, **B**, **C**, **D**). Sand produces a much weaker acoustic return (light to dark gray) than either gravel or rock, and usually lacks local relief (**B**). Mud yields a very weak surface return (light gray to white) and, except where it accumulates on steep slopes or near gas-escape pockmarks, it is associated with a smooth seabed (**D**). The **Surficial Geology** section in the far right column describes the distribution and abundance of these areas on Maine's inner continental shelf.

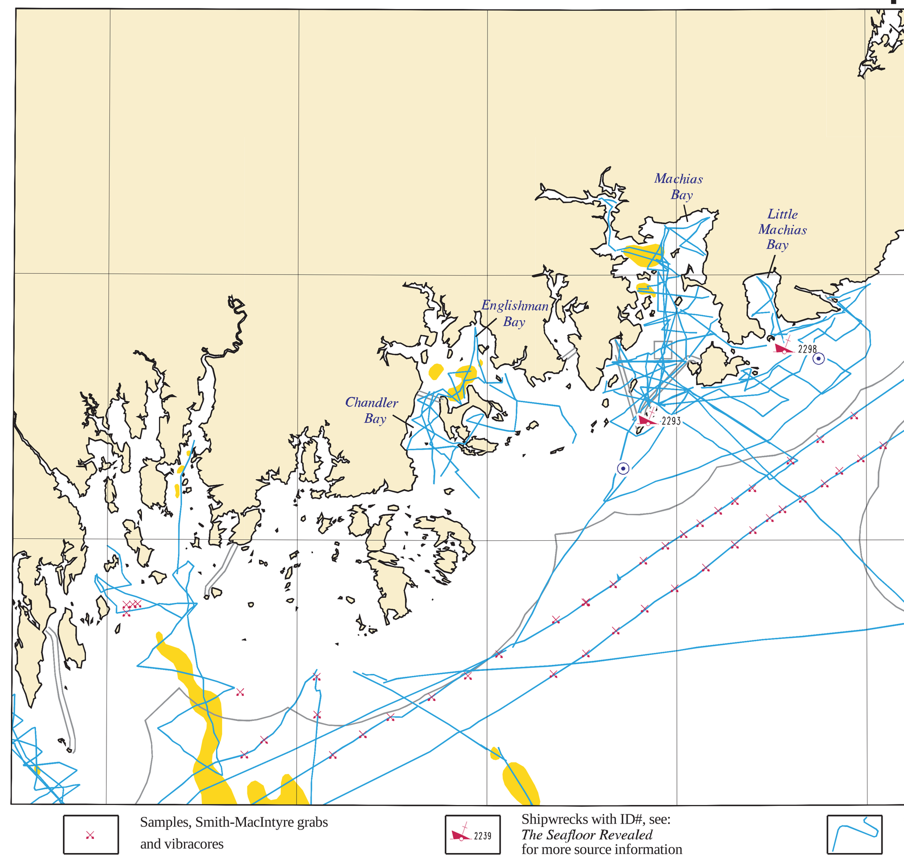


C. Side-scan sonar image (right) of **S**, **G**, and **R** with sharp boundaries and their interpretation (left). Ripples in the gravelly seabed produce alternating light and dark bands while the sandy surface is more uniformly gray. These ripples have a 2 m (6 ft) wavelength. The rocky outcrop rises above the surrounding seafloor.



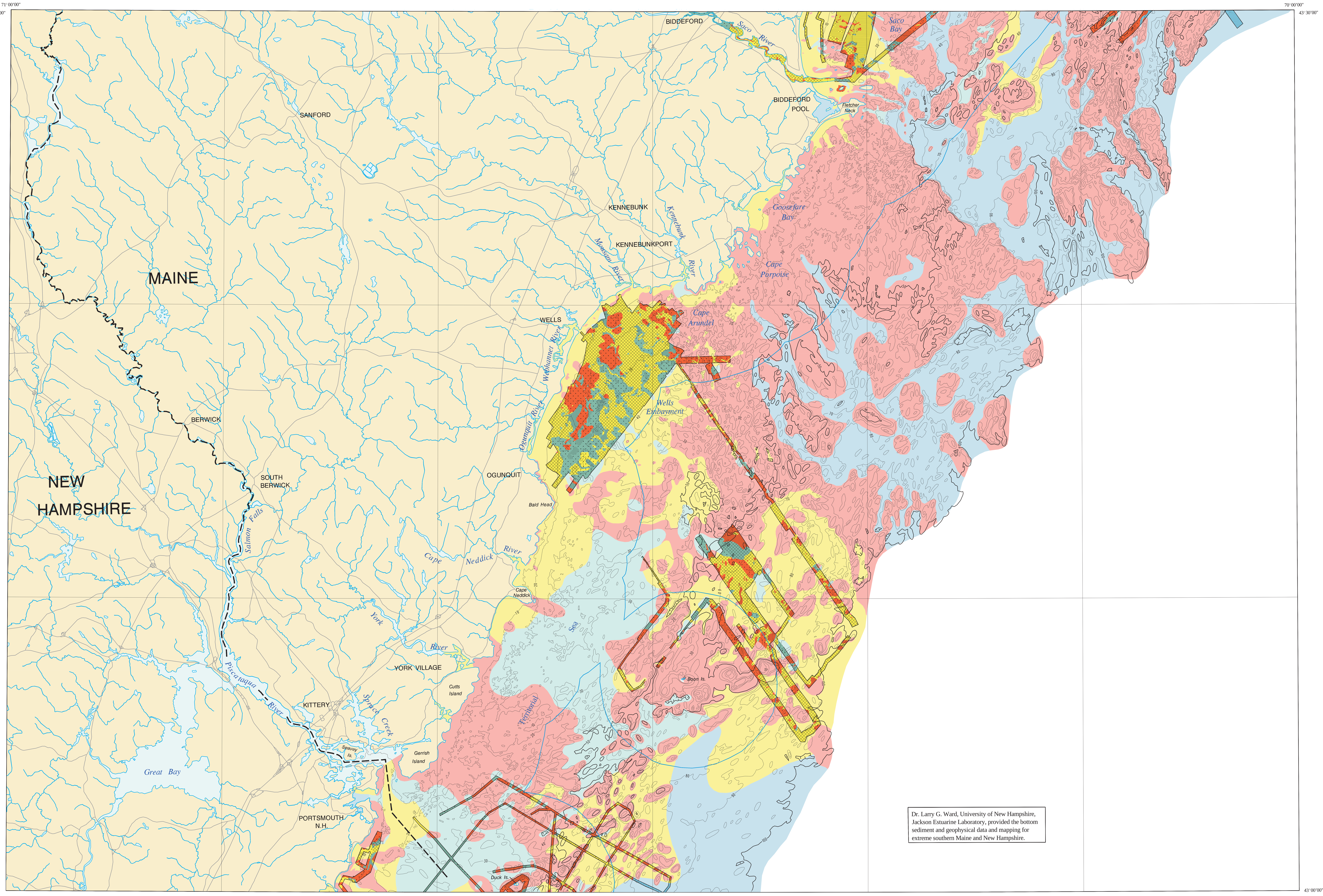
D. Side-scan sonar image (right) of **M** and **Rg** seafloor types and their interpretation (left). Muddy seafloor is uniformly light gray although the tonal difference on the left edge is a recorder artifact. A mixture of rocky outcrops has an irregular dark gray appearance while gravelly troughs appear smooth and dark gray.

Features and Data Source Map



Samples, Smith-Maclntyre grabs and vibracores
Natural gas deposits, buried beneath the seafloor
Shipwrecks with ID#, see: *The Seafloor Revealed* for more source information
Misc. features, dump sites, cable areas, Territorial Sea (3 nmi) limit
Seismic reflection profile tracklines
Submersible dives

Surficial Geology of the Maine Inner Continental Shelf



Map Projection: Universal Transverse Mercator, Zone 19
1927 North American Datum

Nautical Miles (nmi) 0 1 2 3 4 5 6 7 8 9 10

Map Scale 1:100,000

Kilometers (km) 0 2 4 6 8 10 12 14 16 18 20

National Geodetic Vertical Datum of 1929
Contour Interval 10 Meters

Piscataqua River to Biddeford Pool, Maine

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GEOLOGIC MAP NO. 96-7
1996

Funding for the preparation and publication of this map was provided by the Regional Marine Research Program (RMRP #NA46RM0451)

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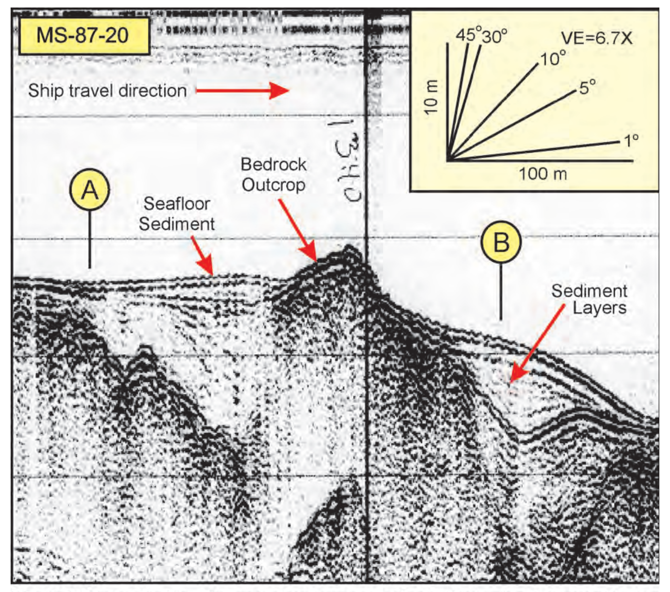
INTRODUCTION

Geological maps depicting topography, surficial materials, geomorphology, and bedrock play an important role in understanding the origin of, as well as the ongoing processes that shape and change the earth's surface. As in the terrestrial environment, maps are also instrumental in aiding the sound economic development of natural resources. They also provide guidance to natural hazards that exist within the landscape. As people increasingly work on, in, and beneath the sea, the need to better understand regional marine geology, just as we understand terrestrial geology, has grown. This map, and others in this series, are intended to provide a better picture of the northwestern Gulf of Maine. Additional information on specific locations and original field descriptions exists in the associated report: *The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf* (**Reference 1**).

Many reconnaissance surveys of the seafloor of the northwestern Gulf of Maine were conducted in the past decade. Recently that information, along with other previously published data, was compiled in a geographic information system (GIS) to produce this map. The data compiled for this series of maps were originally collected for a variety of research projects, government contracts, and student theses. For this reason there are varying amounts of geophysical data and bottom-sample coverage along the coast rather than a uniform grid. *The Seafloor Revealed* further explains the field techniques involved in data collection, the nature of the seafloor, the late Quaternary (glacial) geologic history of the Maine coast, previous studies, and sources of other information.

Bedrock geology defines the overall shape of the Maine coastline by controlling the location and orientation of islands, bays, and peninsulas. Bedrock relief is also primarily responsible for the variability in water depths of the inner shelf. Glacial deposits mantle the underlying bedrock and add complexity to regional geomorphology in forms that range from coarse ridges of boulders to basins filled with fine mud. Thick accumulations of glacial sediments (gravel, sand, and mud) often result in smoother areas of seafloor with less bathymetric relief. Almost all of the Holocene (postglacial) sedimentary material along the coast and offshore is derived from erosion and reworking of glacial deposits. Physical oceanographic processes, including waves and tides, continue to reshape the seafloor sediments and create productive marine habitats of the Gulf of Maine.

Sea-level change has had a profound effect on the location and duration of sediment reworking and deposition. During the complex changes of sea level over the last 14,000 years, coastal and terrestrial erosion stripped muddy glacial sediment from shoals and transferred the material to deeper basins. During deglaciation, the sea covered most of the coastal lowlands of Maine (**2**). A regression (sea-level lowering) until about 10,500 years ago was followed by a transgression (rising) that is still continuing (**3**, **4**). Areas shallower than the maximum lowering of the sea (less than about 60 m (200 feet) water depth) are generally rockier than deeper regions. The shallower zone lost some of its sediment cover through wave reworking during both the late Pleistocene fall and the early Holocene rise of the sea. These areas also experienced at least a thousand years of subaerial erosion by rivers and streams. The marine geology of the Maine coast records these and many other changes that have taken place since glaciers retreated inland and the sea invaded the western Gulf of Maine (**4**, **5**, **6**).



Seismic Reflection Profile. The image above is a portion of an ORE seismic reflection profile from Muscongus Bay and shows a cross-section (side view) of the seafloor. The seafloor surface shape is analagous to a fathometer profile. A vertical exaggeration (VE) of 6.7 makes all slopes appear steeper than they really are. The subsurface reflectors are from sediment layers and buried bedrock surfaces. Positions A and B correspond to the same locations in both figures. A time mark is shown by the vertical line at 13:40.

METHODS

Navigation and Map Compilation

Navigation fixes in the outer estuaries and offshore areas were made at 2 to 5 minute intervals with LORAN-C, which provided an accuracy of $\pm$ 100 m (330 feet). In the upper reaches of the estuaries, radar and line-of-sight observations on buoys and landmarks provided navigational accuracy that varied from less than $\pm$ 10 m (33 feet) to around $\pm$ 200 m (660 feet). Recent work used the global positioning satellite system (GPS) for navigation and was accurate to $\pm$ 10 m (33 feet). All navigation was converted to Universal Transverse Mercator projection and plotted with a geographic information system (GIS).

Surficial geologic maps were prepared in six steps: (1) use a GIS to plot the geophysical tracklines, bottom sample locations, and bathymetry on large-scale maps, (2) interpret sonar records and geology based on other geophysical data and samples, (3) digitize the drafted interpretation into a GIS, (4) compile and edit the digital data to generate map polygons, (5) check the mapped geology, and (6) assemble the final product including geology, bathymetry, geographic names, and roads. The shoreline and roads are from the U.S. Geological Survey's 1:100,000 Digital Line Graph files.

Bathymetry

Bathymetry was digitized at a 10 m contour interval from preliminary National Ocean Service (NOS) Bathymetric and Fishing Maps at a 1:100,000 scale. The NOS bathymetric maps provide a 2 m contour interval in many locations that is too complex for inclusion on this map. Difficulty in interpretation of positive and negative changes in bathymetry on the poorly labeled NOS maps created many possible errors, especially in areas where accompanying geophysical data were lacking. For this reason, these maps should not be used for navigation. More detailed and accurate NOS conventional nautical charts should be used for navigation.

Bottom Samples

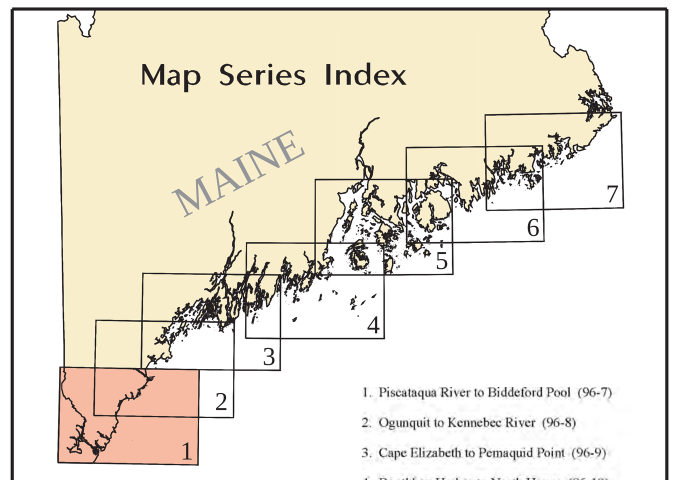
Between 1984 and 1991, 1,303 bottom sample stations were occupied (see the **Features and Data Source Map** for locations in this region). Two attempts were made at each station where the sampler initially returned empty, after which the site was considered a rock bottom. A Smith-McIntyre stainless steel grab sampler was used that nominally collected up to 0.016 m^3 (0.5 ft^3) of sediment. Southwest of Cape Small, samples were generally collected in a grid pattern with a 2 kilometer (1 nautical mile) distance between sample sites. Focus was placed on the large sandy embayments off Wells, Saco, and the Kennebec River mouth, as well as on muddy Casco Bay. Relatively few bottom samples were gathered off rocky areas such as Kennebunk or Kittery. Geophysical tracklines were later run over the sample stations to permit extrapolation of the bottom sediment data. North and east of Cape Small, geophysical data were generally gathered before bottom samples. This resulted in a need for fewer samples, and so fewer stations were occupied. Following collection, samples were stored in a freezer in the sedimentology laboratory at the University of Maine. Depending on the level of funding or specific needs of a particular project, samples were analyzed for grain size, organic carbon and nitrogen, carbonate content and/or heavy minerals (see Table 1 of **Reference 1**).

Side-Scan Sonar Profiles

Analog side-scan sonar records along 3358 km (1800 nmi) of the seafloor were gathered with an EG&G Model SMS 260 slant-range corrected sonar operating with a Model 272-T towfish at a nominal frequency of 105 kHz. The device was most often run at a 100 m (330 ft) range for each channel (200 m wide swath beneath the research vessel), although ranges from 25 to 300 m (80 to 1000 ft) were occasionally employed. The swaths of directly imaged and interpreted seafloor areas are depicted in brighter colors on the map. See the **Surficial Geology Legend** in the lower left corner of the map and the **Interpretation of Side-Scan Sonar Images** for further details.

Seismic Reflection Profiles

Seismic reflection profiles were gathered along 5011 km (2700 nmi) of tracklines, often in conjunction with side-scan sonar data (see simultaneous seismic and side-scan images above). A Raytheon RTT 1000a 3.5/7.0 kHz unit with a 200 kHz fathometer trace was used mainly in relatively shallow water (0 to 50 m; < 165 ft) over muddy bottoms. An ORE Geopulse "boomer" (0.5 to 200 kHz) seismic system was most effective in deeper water (15 to 150 m; 50 to 500 ft) over thicker deposits of sandy or gravelly sediment. Although seismic reflection profiles are most useful in constructing the geological history of an area, the bathymetry and stratigraphic context they provide, along with the strength of the surface return, also help identify the seafloor type (**6**). When used in conjunction with the side-scan sonar data, both the age and nature of the surficial sediment are easily interpreted.



1. Piscataqua River to Biddeford Pool (96-7)
2. Ogunquit to Kennebec River (96-8)
3. Cape Elizabeth to Pemaquid Point (96-9)
4. Boothbay Harbor to North Haven (96-10)
5. Rockland to Bar Harbor (96-11)
6. Mt. Desert Island to Jonesport (96-12)
7. Petit Manan Pt. to West Quoddy Head (96-13)

To purchase copies of this map, contact the: Maine Geological Survey, 22 State House Station, Augusta, Maine 04333. Telephone: (207) 287-2801. Web Site: http://www.state.me.us/doc/nrimc/nrimc.htm

Not to be Used for Navigation

The information appearing on this map is not complete for navigation. Mariners are cautioned to use National Ocean Service nautical charts for navigation in this area.

SURFICIAL GEOLOGY

Introduction

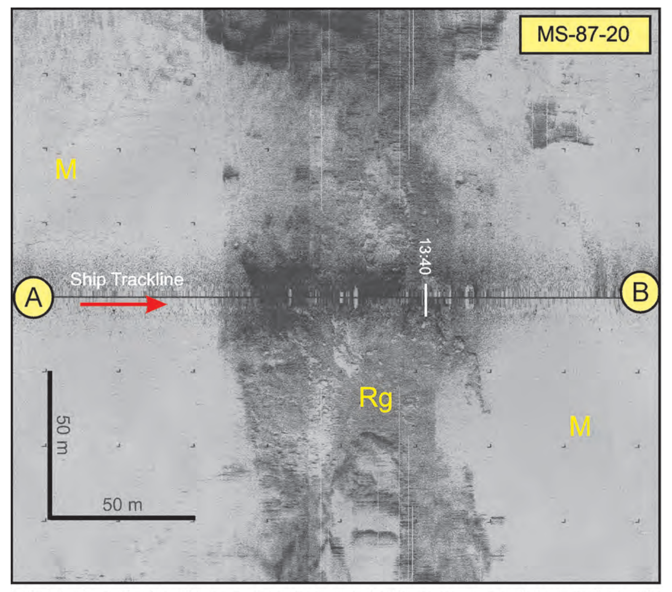
The surficial materials of the inner continental shelf of the northwestern Gulf of Maine are the most complex of any place along the Atlantic continental margin of the United States. Igneous, metamorphic, and sedimentary rocks spanning hundreds of millions of years of earth history form the regional basement. Glacial deposits, containing all clast sizes from boulders to mud, partially mantle the rocks. These materials, in turn, have been reworked by coastal processes during extreme fluctuations of sea level over the past few thousand years to create better-sorted modern deposits (**5**). Biological processes, including shell formation, bioturbation, and organic matter cycling have also altered the sediment composition and left geological imprints on the seafloor (**7, 8**). In addition to the surficial geology of this map, the geomorphology of the seafloor has also been mapped. The *Physiographic Map of the Maine Inner Continental Shelf* (**9**) shows the geomorphology of the offshore region covered by this series of surficial geologic maps in a single, smaller scale map.

Rocky Areas

Rocky seabed occupies approximately 41% of the inner continental shelf and is the most abundant seafloor type in this map series. Where little data exist and the seafloor relief is very irregular, a rocky bottom was inferred. By this inference, large areas of rocky bottom were mapped off extreme southern Maine, Penobscot Bay, and Petit Manan Point. Large areas of rock also occur surrounding the many granitic islands in Blue Hill and Frenchman Bays. Elongate, submerged rock ridges follow the linear trend of the Casco Bay peninsulas. Although common as nearshore shoals in water less than 10 m (33 ft) deep, large outcrops of rock are relatively rare in deep offshore basins.

The bedrock geology was not determined, but side-scan sonar images clearly depict parallel fractures and elongate outcrop patterns common in layered metamorphic rocks as well as more rounded bodies of rock often associated with plutonic (granitic) igneous rocks (**10**). In shallow water, rock outcrops are usually covered with algae (seaweed) and encrusting organisms. Below water depths of a few tens of meters (the photic zone), encrusting organisms and organic mats often cover bedrock outcrops. "Rock greater than mud" (**Rm**; for an explanation of abbreviations see **Interpretation of Side-Scan Sonar Images**) is most common in deep offshore basins where outcrops project up through the mud that mantles the seafloor. **Rm** also occurs as small areas seaward of tidal flats in nearshore basins. "Rock greater than sand" (**Rs**) exists only in a few locations offshore of beaches.

Areas adjacent to rock outcrops are commonly covered with shells of dead organisms. Formerly attached to the rock surface, these shelly remains are mixed with angular rock fragments that have fallen off the outcrop (**8**). Bedrock fractures and troughs also have a similar mixture of shell and rock clasts. For this reason, extensive, "pure" rock outcrops were infrequently mapped. Instead, fractured bedrock and small bodies of rock were most often mapped as "rock greater than gravel" (**Rg**) or "gravel greater than rock" (**Gr**), two of the most common seafloor types observed.



Side-Scan Sonar Profile. The image above is a portion of a side-scan sonar record taken simultaneously with the seismic reflection profile to the left. This image shows a plan view of the seafloor (much like an aerial photograph). The area shown is about the size of eight football fields. The darker area is a mixture of bedrock outcrop and gravel (**Rg**). The lighter areas on either side are flat, muddy seafloor (**M**). The ship track followed the black center line over the bottom. Both of these images were made using sound waves.

Gravelly Areas

Gravel is a common constituent of inner shelf sediment, but occupies only 12% of the seafloor itself. Gravel is abundant in only a few locations: off the Kennebec River mouth where deltaic sediments are exposed, off Wells and Saco Bays near reworked glacial moraines, and near the Canadian border. Frequently the gravel has a rippled surface, and may contain minor amounts of coarse sand. In areas where waves regularly scour the seabed, a gravel lag deposit armors the seafloor. Gravel also occurs in broad linear bands near submerged moraines.

As described above, "gravel greater than rock" (**Gr**) is a common feature adjacent to bedrock outcrops. Here the gravel may have a high shell content (calcium carbonate) because shells are often the only modern sediment introduced to an area. **Gr** and "gravel greater than sand" (**Gs**) are major features of the seafloor from the Canadian border to Englishman Bay. Here, low relief bedrock is mantled by till, which fills in rock depressions but lacks much relief itself. "Gravel greater than mud" (**Gm**) is very rare along the inner shelf. Gravel and mud are not deposited in the ocean under the same hydrodynamic conditions, but may be found just beneath the seafloor in till deposited by glaciers more than 13,000 years ago beneath glacial ice.

Sandy Areas

Sandy seafloor (**S**) occupies only 8% of the inner shelf of the northwestern Gulf of Maine. The sandiest regions are offshore of southern Maine beaches such as Old Orchard and Ogunquit. In the mid coast region, a large sandy area "sand greater than gravel" (**Sg**) occurs off the Kennebec River mouth. This **Sg** area, consisting of many small rippled gravel patches that are intermingled with sand, has not changed appreciably in a decade, although large winter storms resuspend sand and gravel in water depths down to at least 55 m (180 ft). Many smaller bodies of sand are scattered elsewhere throughout the coast, occasionally around the 50 to 60 m (165 to 200 ft) depth, near the lowest stand of sea level since the Ice Age.

Sandy material is acoustically uniform and strongly contrasts with bordering areas of gravel and rock. Although many sediment samples from shallow water contain well-sorted ("clean") sand, areas mapped "sand" or sand with other materials frequently contain sediment in which the sand is mixed with mud, gravel and a variety of shell fragments.

"Sand greater than rock" (**Sr**) is a minor component of the seafloor that exists adjacent to small bedrock outcrops scattered across the mapped area. It is possible that more **Sr** areas exist, especially in the southern shelf, but few observations were made in that region. "Sand greater than mud" (**Sm**) is a very difficult unit to map because mixtures of mud and sand look similar on acoustic images. The only mapped areas of "sand greater than mud" are located in Saco Bay, where bottom samples confirmed the presence of both particle sizes. Similar occurrences of **Sm** may occur at the seaward margin of other beaches.

Muddy Areas

Muddy regions cover 39% of the seafloor and are the second most abundant surficial material. Mud is the dominant seabed material in all nearshore areas except for southern Maine and near the Canadian border. It is also the major deep-water surficial material in all locations except off the southern Maine coast.

Mud accumulates near areas where there is an available supply of fine-grained sediment and there are quieter hydrodynamic conditions, which favor the slow settling of small particles, or their entrapment by organisms. In nearshore regions, mud comes from eroding glacial bluffs and seasonally from rivers. In deep water, mud must be derived from winnowing and erosion of deposits in shallow water.

Muddy seafloors are featureless on acoustic records unless they have been disturbed or contain anomalous "hard" objects. Drag marks left by fishing gear are common in most sedimentary environments, but are most noticeable when carved into mud. Gas-escape pockmarks are generally hemispherical depressions that result from localized seabed disturbance. Where pockmarks occur in abundance, the seafloor is uneven. Thousands of pockmarks hundreds of meters (yards) in diameter and tens of meters (yards) deep make crater-like terrain in the muddy bottom in Belfast, Blue Hill, and Passamaquoddy Bays (**7,8**).

"Mud greater than rock" (**Mr**) occurs in some deepwater locations, but "mud greater than gravel" (**Mg**) is as rare as "gravel greater than mud" (**Gm**) because of the hydrodynamic differences between the sizes of materials. "Mud greater than sand" (**Ms**) occurs seaward of the sandy area of Saco Bay and is mapped on the basis of a large number of bottom samples that encountered this mixture in this region.

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(**2**) Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, 1:500,000 scale.

(**3**) Barnhardt, W. A., Gehrels, W. R., Belknap, D. F., and Kelley, J. T., 1995, Late Quaternary relative sea level change in the western Gulf of Maine: evidence for a migrating glacial forebulge: Geology, v. 23, p. 317-320.

(**4**) Belknap, D. F., Shipp, R. C., Stuckenrath, R., Kelley, J. T. and Borns, H. W., Jr., 1989, Holocene sea level change in coastal Maine, *in* Anderson, W. A., and Borns, H. W., Jr. (editors), Neotectonics of Maine; Studies in seismicity, crustal warping, and sea-level change: Maine Geological Survey, Bulletin 40, p. 85-103.

(**5**) Kelley, J. T., Dickson, S. M., Belknap, D. F., and Stuckenrath, R., Jr., 1992, Sea-level change and late Quaternary sediment accumulation on the southern Maine inner continental shelf, *in* Fletcher, C. H., III, and Whemiller, J. F. (editors.), Quaternary coasts of the United States: marine and lacustrine systems: Society of Economic Paleontologists and Mineralogists, Special Publication No. 48, p. 23-34.

(**6**) Belknap, D. F., Shipp, R. C., Kelley J. T., and Schnitker, D., 1989, Depositional sequence modeling of Quaternary geologic history, west central Maine coast, *in* Tucker, R. D., and Marvinney, R. G., (editors), Studies in Maine geology, Volume 5 - Quaternary geology: Maine Geological Survey, p. 29-46.

(**7**) Kelley, J. T., Dickson, S. M., Belknap, D. F., Barnhardt, W. A., and Henderson, M., 1994, Giant sea-bed pockmarks: evidence for gas escape from Belfast Bay, Maine: Geology, v. 22, p. 59-62.

(**8**) Barnhardt, W. A., and Kelley, J. T., 1995, Carbonate accumulation on the inner continental shelf of Maine: a modern consequence of late Quaternary glaciation and sea level rise: Journal of Sedimentary Research, v. A65, p. 195-207.

(**9**) Kelley, J. T., Dickson, S. M., Barnhardt, W. A., Belknap, D. F., and Kelley, A. R., in preparation, Physiographic map of the Maine inner continental shelf: Maine Geological Survey, Open-File Map.

(**10**) Osberg, P. H., Hussey, A. M., II, and Boone, G. M., 1985, Bedrock geologic map of Maine: Maine Geological Survey, scale 1:500,000.

ACKNOWLEDGMENTS

Funding for this compilation was provided by the Regional Marine Research Program of NOAA (Grant # NA46RM0451). We wish to thank Mr. Walter A. Anderson, former Director of the Maine Geological Survey, for more than ten years of unrelenting encouragement and support for our offshore research. In addition, we thank Dr. Robert E. Wall who directed the University of Maine Center for Marine Studies, which partly purchased the geophysical equipment and GIS used for this compilation. Most of the data collection was sponsored by the Maine-New Hampshire Sea Grant Program, the Continental Margins Program of the Minerals Management Service and Association of State Geologists, the National Science Foundation, the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Undersea Research Program, and the Maine Department of Marine Resources. We acknowledge many graduate students who assisted in the original collection and interpretation of much of the data, especially Dr. R. Craig Shipp. Finally, we acknowledge the able seamanship of Captain Michael Dunn, formerly of the Darling Marine Center, who participated in all bottom sampling and most geophysical expeditions.

Surficial Geology Legend

The map above shows the geology of the surface of the ocean floor. This map of Maine's inner continental shelf is based on geophysical data, bottom samples, National Ocean Service provisional bathymetric maps and published nautical charts. These data were supplemented with bottom photographs and direct observations from submersibles. Experience with these data, together with side-scan sonar images (the underwater equivalent of aerial photographs), permitted generalized mapping of the inner continental shelf.

The map areas shown by the four colors below were not directly imaged with side-scan sonar. Contacts between these geologic units were inferred, based on bathymetry and other information (see **Features and Data Source Map**).

The bright colors on the map and in the **Interpretation of Side-Scan Sonar Images** legend to the right show areas of seafloor imaged by sonar. The linear colored swaths on the map above follow ship tracklines and have a width that represents the sonar swath to each side of the vessel.

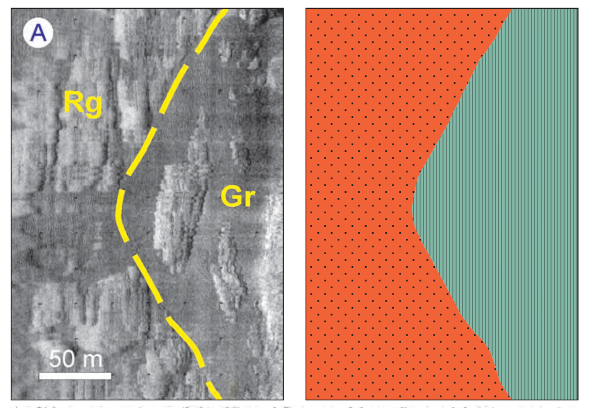
ROCKY - Rugged, high-relief seafloor is dominated by bedrock outcrops (ledge) and is the most common type on the Maine inner continental shelf, especially in depths of less than 60 m (~200 ft). Accumulations of coarse-grained sediment occur in low-lying areas and at the base of rock outcrops.

GRAVELLY - Generally flat-lying areas are covered by coarse-grained sediment, with clasts up to several meters (yards) in diameter. In some areas gravel and boulders directly overlie bedrock. These deposits are not presently accumulating on the shelf but represent Pleistocene (Ice Age) material. Ripples are common in well-sorted gravel, indicating that some of the older glacial sediments are presently being reworked by waves, currents, and tides.

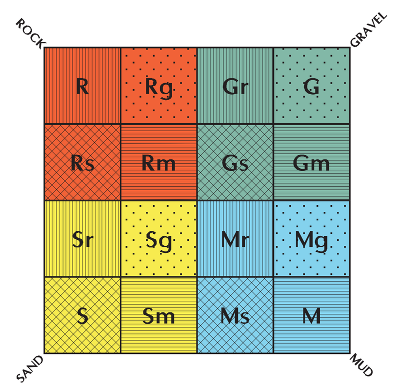
SANDY - Generally smooth seafloor consists primarily of sand-sized particles derived from rivers, reworked glacial deposits and/or biogenic shell production. This bottom type, although well represented in southwestern areas, is the least common on the Maine inner continental shelf.

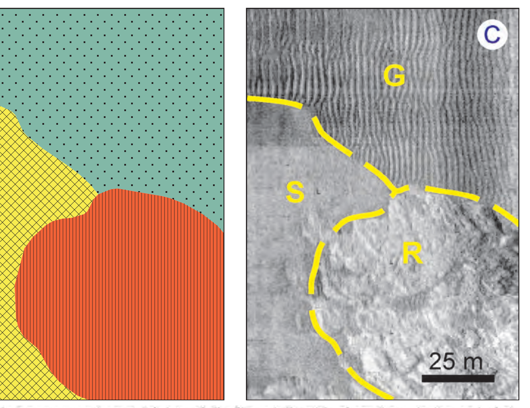
MUDDY - Deposits of fine-grained material form a generally flat and smooth seabed commonly found in sheltered bays and estuaries and at depths of greater than 60 m (~200 ft). In some submarine valleys the mud may be meters (yards) thick. Deep depressions (gas-escape pockmarks) occur in some muddy bays.

Interpretation of Side-Scan Sonar Images

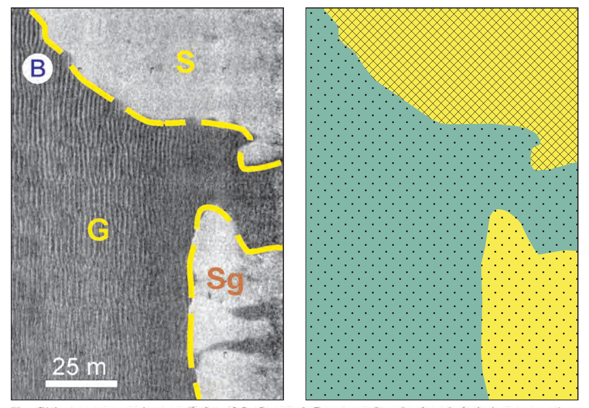


A. Side-scan sonar image (left) of **Rg** and **Gr** areas of the seafloor and their interpretation (right). In the image, gravelly areas appear dark gray and bedrock outcrops show irregular perimeters, dark (sound reflective) streaks and light gray acoustic shadows. Fractures are prominent in the bedrock; gravelly areas have low relief.





C. Side-scan sonar image (right) of **S**, **G**, and **R** with sharp boundaries and their interpretation (left). Ripples in the gravelly seabed produce alternating light and dark bands while the sandy surface is more uniformly gray. These ripples have a 2 m (6 ft) wavelength. The rocky outcrop rises above the surrounding seafloor.

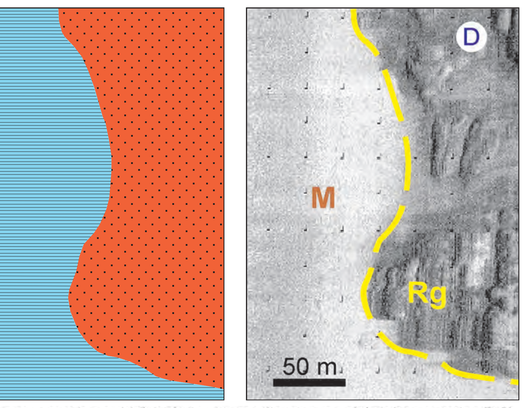


B. Side-scan sonar image (left) of **S**, **Sg**, and **G** areas of seabed and their interpretation (right). Sandy seafloor is lighter gray and appears smooth while the gravelly seafloor has wave ripples with straight crestlines about 1 m (3 ft) apart. **Sg** areas occur as a patchwork of **S** and **G** types, but are too small to discriminate at this map scale.

On side-scan sonar images, rock, gravel, sand, and mud reflect acoustic energy differently and appear as various shades of gray printed by the instrument's recorder. The classification scheme above is unique and based on the acoustic reflectivity of the Maine inner continental shelf. The dominant "end member" (**R**ock, **G**ravel, **S**and, or **M**ud) is abbreviated with a capitalized first letter. A less abundant, subordinate seafloor type is represented with a lower case letter (**r**, **g**, **s**, or **m**). For example, a predominantly rocky seabed with gravel infilling fractures is designated **Rg**. The sixteen combinations of seafloor types shown above are used for areas where side-scan sonar coverage exists and appear as bright colors on the map. In areas beyond the scan range only four generalized units were used (see the **Surficial Geology Legend**).

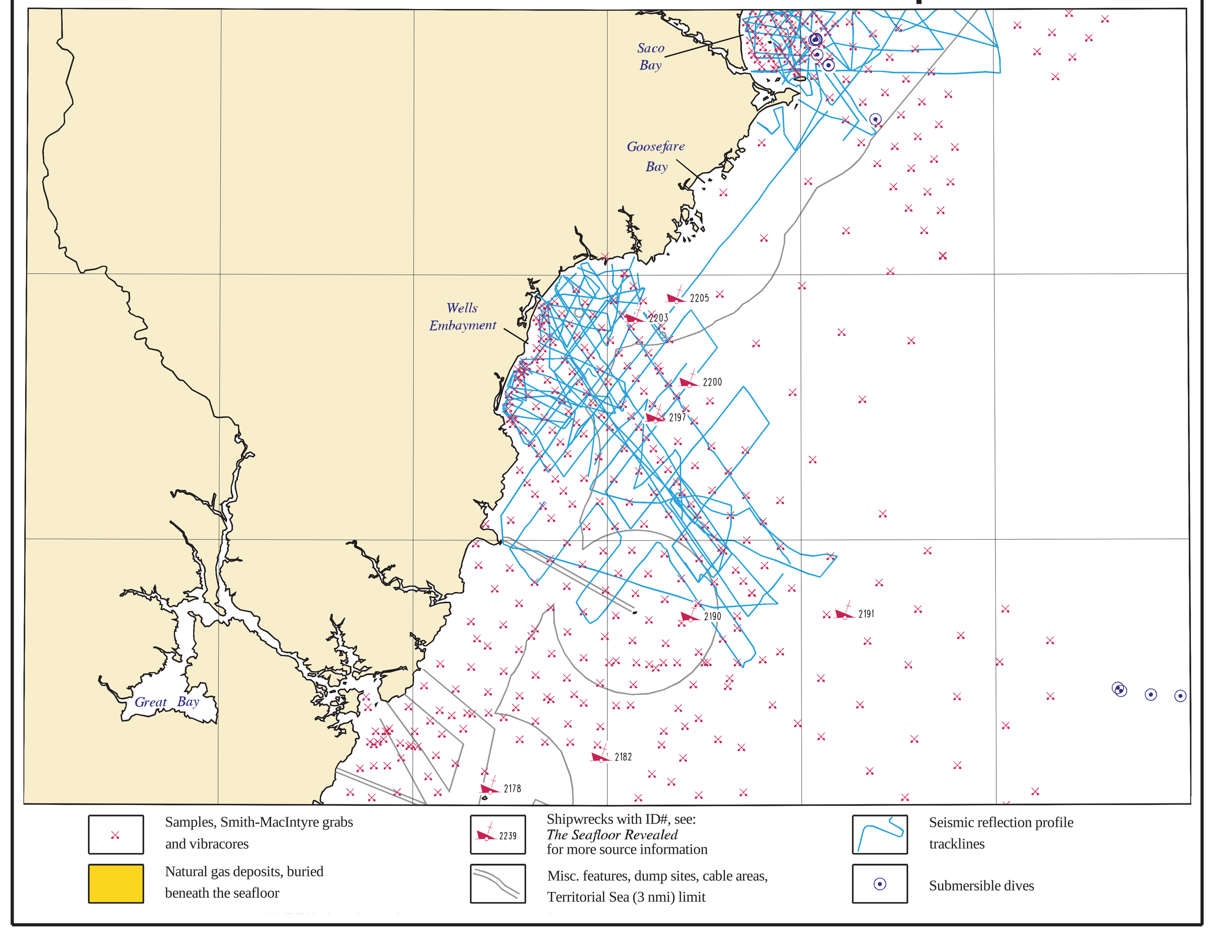
When individual units of rock, gravel, sand, and mud were greater than 10,000 m^2 in area (about the size of 3 football fields), they were mapped as separate features. In many places, however, a heterogeneous seabed composed of numerous small features required composite map units. In areas where no single seafloor type exceeded 10,000 m^2, a composite map unit was used. The selection of map units to describe this complexity involves a compromise between providing detailed information where it exists, and generalizing where data are scarce or absent. In many places the seabed is composed of numerous small features, none exceeding the minimum area of 10,000 m^2. Consequently, not all details in the sonar records could be presented on this map. It should be realized that spatial heterogeneity exists at all scales, even down to areas less than a square meter (ten square feet).

Rock yields a strong, dark, acoustic return. In areas with steep bathymetric relief and fractures, light acoustic shadows are visible within the dark areas of rock (see adjacent panels **A**, **C**, and **D**). Gravel deposits also produce a relatively strong acoustic return (black to dark gray), and are often closely associated with rock, but lack relief (**A**, **B**, **C**, **D**). Sand produces a much weaker acoustic return (light to dark gray) than either gravel or rock, and usually lacks local relief (**B**). Mud yields a very weak surface return (light gray to white) and, except where it accumulates on steep slopes or near gas-escape pockmarks, it is associated with a smooth seabed (**D**). The **Surficial Geology** section in the far right column describes the distribution and abundance of these areas on Maine's inner continental shelf.

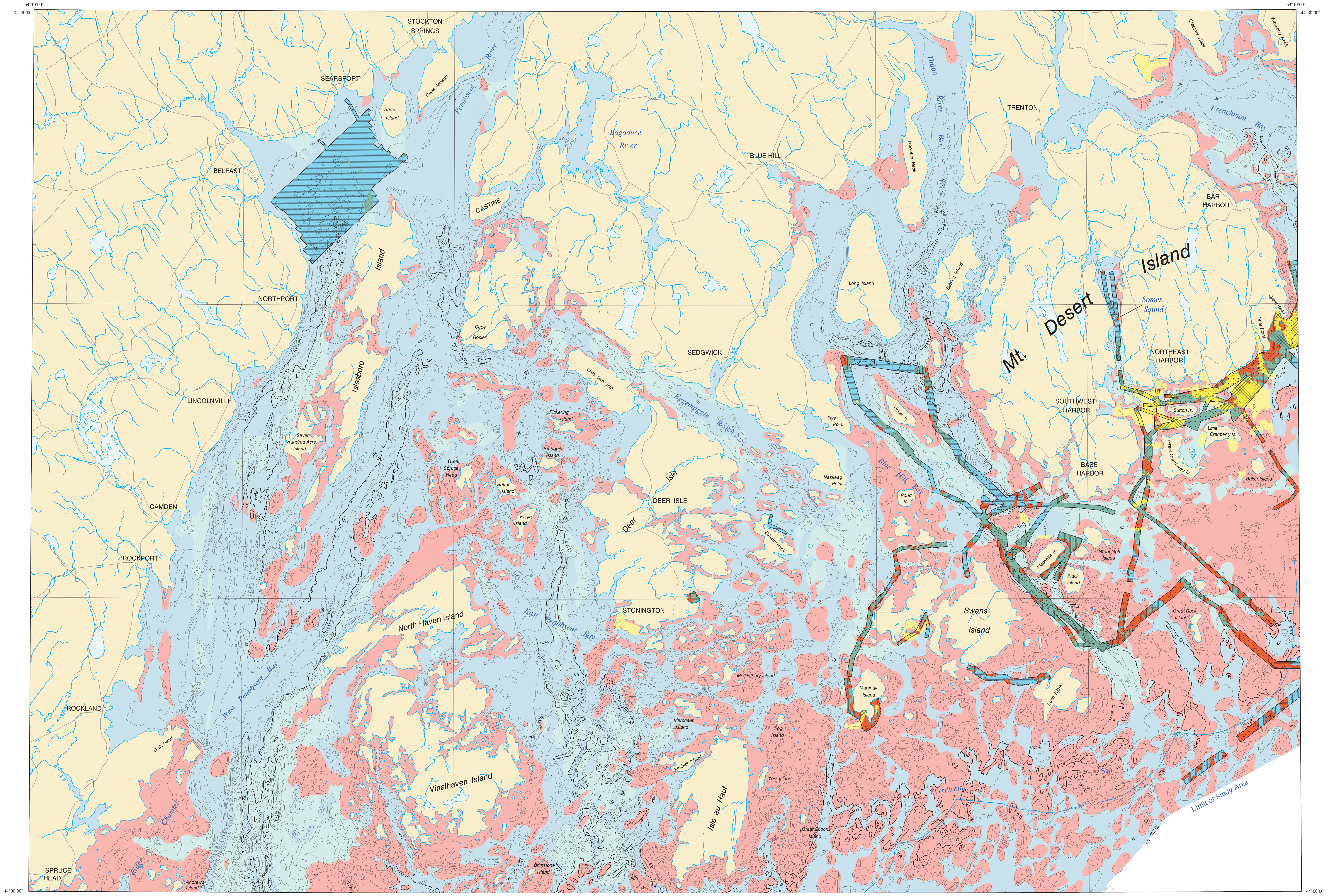


D. Side-scan sonar image (right) of **M** and **Rg** seafloor types and their interpretation (left). Muddy seafloor is uniformly light gray although the tonal difference on the left edge is a recorder artifact. A mixture of rocky outcrops has an irregular dark gray appearance while gravelly troughs appear smooth and dark gray.

Features and Data Source Map



Surficial Geology of the Maine Inner Continental Shelf



Map Projection: Universal Transverse Mercator, Zone 19
1927 North American Datum

Nautical Miles (nmi) 0 1 2 3 4 5 6 7 8 9 10

Map Scale 1:100,000

Kilometers (km) 0 2 4 6 8 10 12 14 16 18 20

National Geodetic Vertical Datum of 1929
Contour Interval 10 Meters

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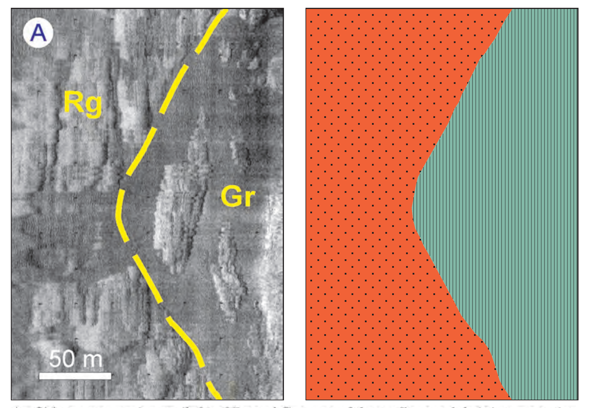

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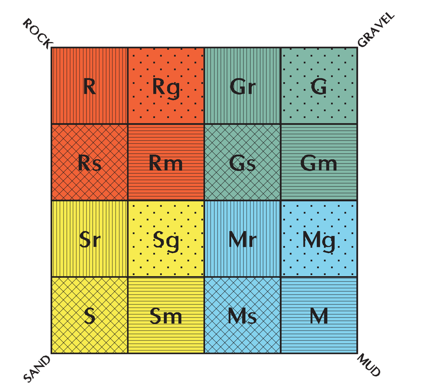

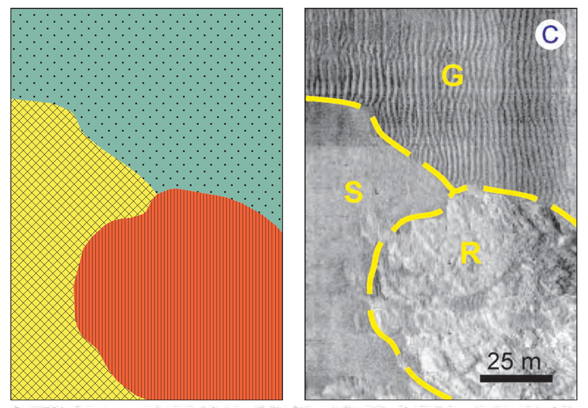

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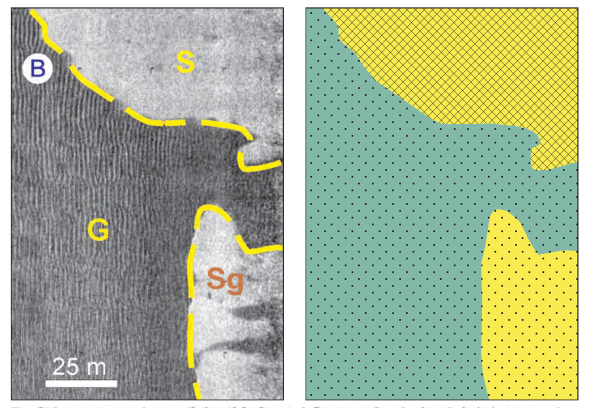

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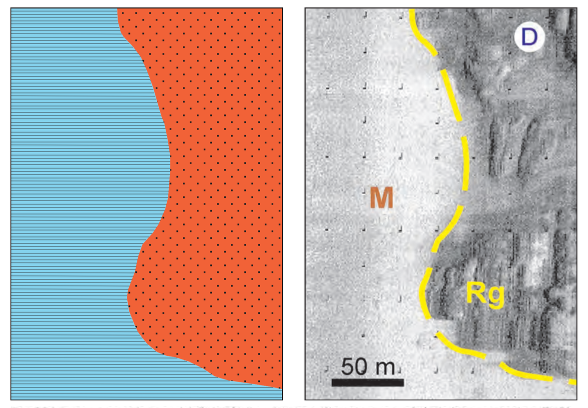
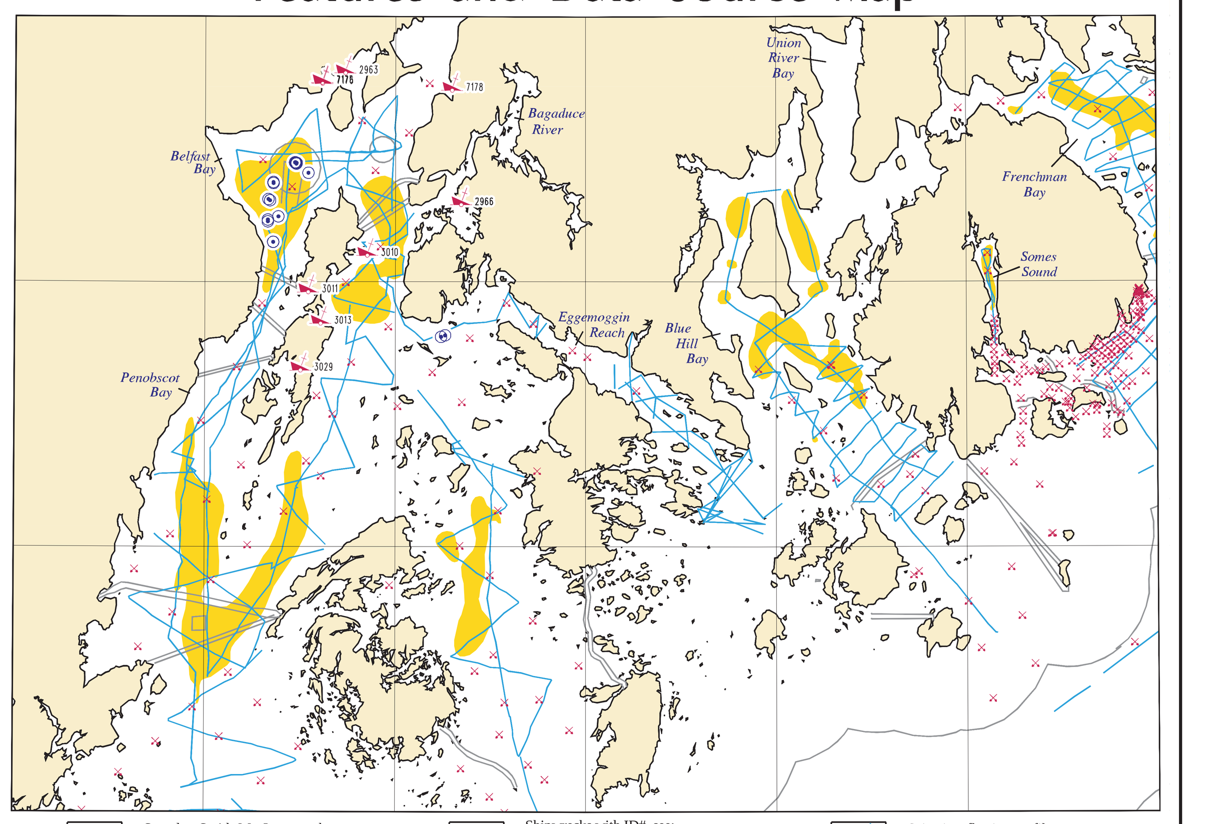


D. Side-scan sonar image (right) of **M** and **Rg** seafloor types and their interpretation (left). Muddy seafloor is uniformly light gray although the tonal difference on the left edge is a recorder artifact. A mixture of rocky outcrops has an irregular dark gray appearance while gravelly troughs appear smooth and dark gray.

Features and Data Source Map



Samples, Smith-MacIntyre grabs and vibracores

Natural gas deposits, buried beneath the seafloor

Shipwrecks with ID#, see: *The Seafloor Revealed* for more source information

Misc. features, dump sites, cable areas, Territorial Sea (3 nmi) limit

Seismic reflection profile tracklines

Submersible dives

Rockland to Bar Harbor, Maine

Walter A. Barnhardt
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Published by:
DEPARTMENT OF CONSERVATION
Maine Geological Survey
Robert G. Marvinney, State Geologist

GEOLOGIC MAP NO. 96-11
1996

Funding for the preparation and publication of this map was provided by the Regional Marine Research Program (RMRP #NA46RM0451)

Digital cartographic production and design by:
Bennett J. Wilson, Jr.
Robert D. Tucker

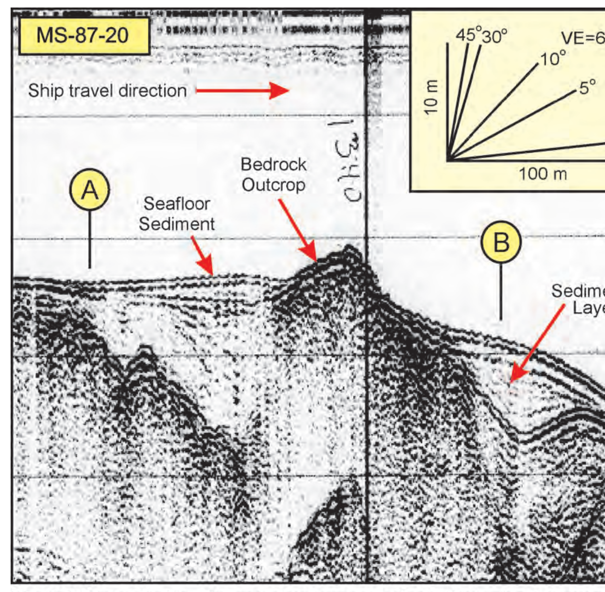
INTRODUCTION

Geological maps depicting topography, surficial materials, geomorphology, and bedrock play an important role in understanding the origin of, as well as the ongoing processes that shape and change the earth's surface. As in the terrestrial environment, maps are also instrumental in aiding the sound economic development of natural resources. They also provide guidance to natural hazards that exist within the landscape. As people increasingly work on, in, and beneath the sea, the need to better understand regional marine geology, just as we understand terrestrial geology, has grown. This map, and others in this series, are intended to provide a better picture of the northwestern Gulf of Maine. Additional information on specific locations and original field descriptions exists in the associated report: *The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf* (**Reference 1**).

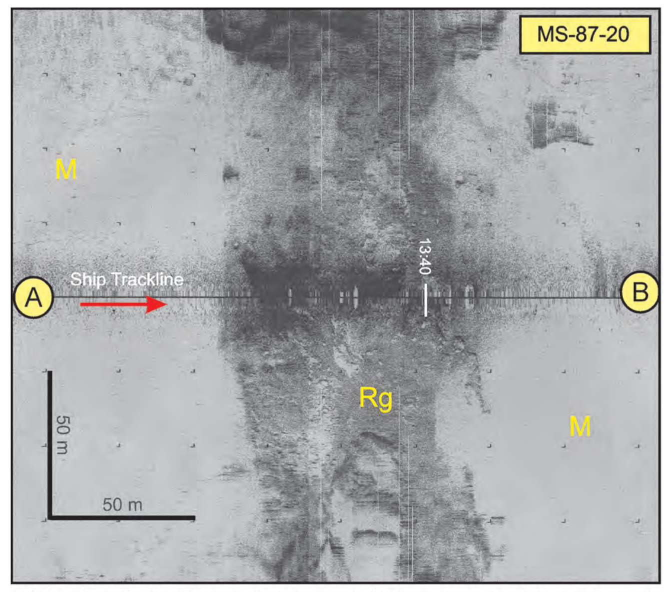
Many reconnaissance surveys of the seafloor of the northwestern Gulf of Maine were conducted in the past decade. Recently that information, along with other previously published data, was compiled in a geographic information system (GIS) to produce this map. The data compiled for this series of maps were originally collected for a variety of research projects, government contracts, and student theses. For this reason there are varying amounts of geophysical data and bottom-sample coverage along the coast rather than a uniform grid. *The Seafloor Revealed* further explains the field techniques involved in data collection, the nature of the seafloor, the late Quaternary (glacial) geologic history of the Maine coast, previous studies, and sources of other information.

Bedrock geology defines the overall shape of the Maine coastline by controlling the location and orientation of islands, bays, and peninsulas. Bedrock relief is also primarily responsible for the variability in water depths of the inner shelf. Glacial deposits mantle the underlying bedrock and add complexity to regional geomorphology in forms that range from coarse ridges of boulders to basins filled with fine mud. Thick accumulations of glacial sediments (gravel, sand, and mud) often result in smoother areas of seafloor with less bathymetric relief. Almost all of the Holocene (postglacial) sedimentary material along the coast and offshore is derived from erosion and reworking of glacial deposits. Physical oceanographic processes, including waves and tides, continue to reshape the seafloor sediments and create productive marine habitats of the Gulf of Maine.

Sea-level change has had a profound effect on the location and duration of sediment reworking and deposition. During the complex changes of sea level over the last 14,000 years, coastal and terrestrial erosion stripped muddy glacial sediment from shoals and transferred the material to deeper basins. During deglaciation, the sea covered most of the coastal lowlands of Maine (**2**). A regression (sea-level lowering) until about 10,500 years ago was followed by a transgression (rising) that is still continuing (**3**, **4**). Areas shallower than the maximum lowering of the sea (less than about 60 m (200 feet) water depth) are generally rockier than deeper regions. The shallower zone lost some of its sediment cover through wave reworking during both the late Pleistocene fall and the early Holocene rise of the sea. These areas also experienced at least a thousand years of subaerial erosion by rivers and streams. The marine geology of the Maine coast records these and many other changes that have taken place since glaciers retreated inland and the sea invaded the western Gulf of Maine (**4**, **5**, **6**).



Seismic Reflection Profile. The image above is a portion of an ORE seismic reflection profile from Muscongus Bay and shows a cross-section (side view) of the seafloor. The seafloor surface shape is analagous to a fathometer profile. A vertical exaggeration (VE) of 6.7 makes all slopes appear steeper than they really are. The subsurface reflectors are from sediment layers and buried bedrock surfaces. Positions A and B correspond to the same locations in both figures. A time mark is shown by the vertical line at 13:40.



Side-Scan Sonar Profile. The image above is a portion of a side-scan sonar record taken simultaneously with the seismic reflection profile to the left. This image shows a plan view of the seafloor (much like an aerial photograph). The area shown is about the size of eight football fields. The darker area is a mixture of bedrock outcrop and gravel (**Rg**). The lighter areas on either side are flat, muddy seafloor (**M**). The ship track followed the black center line over the bottom. Both of these images were made using sound waves.

METHODS

Navigation and Map Compilation

Navigation fixes in the outer estuaries and offshore areas were made at 2 to 5 minute intervals with LORAN-C, which provided an accuracy of ± 100 m (330 feet). In the upper reaches of the estuaries, radar and line-of-sight observations on buoys and landmarks provided navigational accuracy that varied from less than ± 10 m (33 feet) to around ± 200 m (660 feet). Recent work used the global positioning satellite system (GPS) for navigation and was accurate to ± 10 m (33 feet). All navigation was converted to Universal Transverse Mercator projection and plotted with a geographic information system (GIS).

Surficial geologic maps were prepared in six steps: (1) use a GIS to plot the geophysical tracklines, bottom sample locations, and bathymetry on large-scale maps, (2) interpret sonar records and geology based on other geophysical data and samples, (3) digitize the drafted interpretation into a GIS, (4) compile and edit the digital data to generate map polygons, (5) check the mapped geology, and (6) assemble the final product including geology, bathymetry, geographic names, and roads. The shoreline and roads are from the U.S. Geological Survey's 1:100,000 Digital Line Graph files.

Bathymetry

Bathymetry was digitized at a 10 m contour interval from preliminary National Ocean Service (NOS) Bathymetric and Fishing Maps at a 1:100,000 scale. The NOS bathymetric maps provide a 2 m contour interval in many locations that is too complex for inclusion on this map. Difficulty in interpretation of positive and negative changes in bathymetry on the poorly labeled NOS maps created many possible errors, especially in areas where accompanying geophysical data were lacking. For this reason, these maps should not be used for navigation. More detailed and accurate NOS conventional nautical charts should be used for navigation.

Bottom Samples

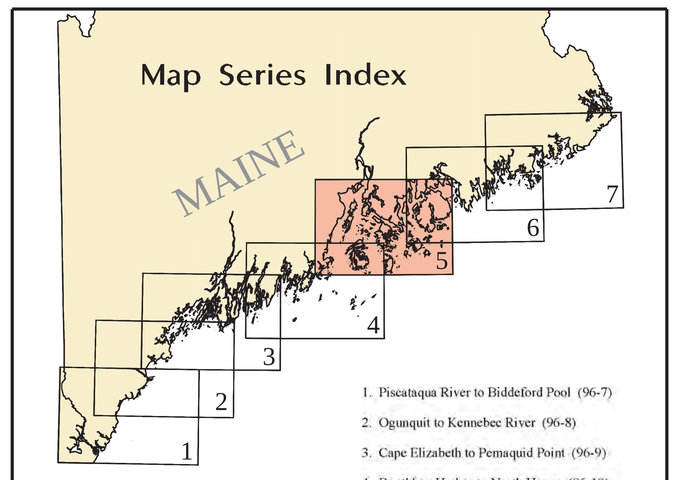
Between 1984 and 1991, 1,303 bottom sample stations were occupied (see the **Features and Data Source Map** for locations in this region). Two attempts were made at each station where the sampler initially returned empty, after which the site was considered a rock bottom. A Smith-McIntyre stainless steel grab sampler was used that nominally collected up to 0.016 m^3 (0.5 ft^3) of sediment. Southwest of Cape Small, samples were generally collected in a grid pattern with a 2 kilometer (1 nautical mile) distance between sample sites. Focus was placed on the large sandy embayments off Wells, Saco, and the Kennebec River mouth, as well as on muddy Casco Bay. Relatively few bottom samples were gathered off rocky areas such as Kennebunk or Kittery. Geophysical tracklines were later run over the sample stations to permit extrapolation of the bottom sediment data. North and east of Cape Small, geophysical data were generally gathered before bottom samples. This resulted in a need for fewer samples, and so fewer stations were occupied. Following collection, samples were stored in a freezer in the sedimentology laboratory at the University of Maine. Depending on the level of funding or specific needs of a particular project, samples were analyzed for grain size, organic carbon and nitrogen, carbonate content and/or heavy minerals (see Table 1 of **Reference 1**).

Side-Scan Sonar Profiles

Analog side-scan sonar records along 3358 km (1800 nmi) of the seafloor were gathered with an EG&G Model SMS 260 slant-range corrected sonar operating with a Model 272-T towfish at a nominal frequency of 105 kHz. The device was most often run at a 100 m (330 ft) range for each channel (200 m wide swath beneath the research vessel), although ranges from 25 to 300 m (80 to 1000 ft) were occasionally employed. The swaths of directly imaged and interpreted seafloor areas are depicted in brighter colors on the map. See the **Surficial Geology Legend** in the lower left corner of the map and the **Interpretation of Side-Scan Sonar Images** for further details.

Seismic Reflection Profiles

Seismic reflection profiles were gathered along 5011 km (2700 nmi) of tracklines, often in conjunction with side-scan sonar data (see simultaneous seismic and side-scan images above). A Raytheon RTT 1000a 3.5/7.0 kHz unit with a 200 kHz fathometer trace was used mainly in relatively shallow water (0 to 50 m; < 165 ft) over muddy bottoms. An ORE Geopulse "boomer" (0.5 to 200 kHz) seismic system was most effective in deeper water (15 to 150 m; 50 to 500 ft) over thicker deposits of sandy or gravelly sediment. Although seismic reflection profiles are most useful in constructing the geological history of an area, the bathymetry and stratigraphic context they provide, along with the strength of the surface return, also help identify the seafloor type (**6**). When used in conjunction with the side-scan sonar data, both the age and nature of the surficial sediment are easily interpreted.



1. Piscataqua River to Biddeford Pool (96-7)
2. Ogunquit to Kennebec River (96-8)
3. Cape Elizabeth to Pemaquid Point (96-9)
4. Boothbay Harbor to North Haven (96-10)
5. Rockland to Bar Harbor (96-11)
6. Mt. Desert Island to Jonesport (96-12)
7. Petit Manan Pt. to West Quoddy Head (96-13)

To purchase copies of this map, contact the Maine Geological Survey, 22 State House Station, Augusta, Me 04333. Telephone: (207) 287-2801 Web Site: http://www.maine.gov/doc/nrimc/nrimc.htm

Not to be Used for Navigation

The information appearing on this map is not complete for navigation. Mariners are cautioned to use National Ocean Service nautical charts for navigation in this area.

SURFICIAL GEOLOGY

Introduction

The surficial materials of the inner continental shelf of the northwestern Gulf of Maine are the most complex of any place along the Atlantic continental margin of the United States. Igneous, metamorphic, and sedimentary rocks spanning hundreds of millions of years of earth history form the regional basement. Glacial deposits, containing all clast sizes from boulders to mud, partially mantle the rocks. These materials, in turn, have been reworked by coastal processes during extreme fluctuations of sea level over the past few thousand years to create better-sorted modern deposits (**5**). Biological processes, including shell formation, bioturbation, and organic matter cycling have also altered the sediment composition and left geological imprints on the seafloor (**7, 8**). In addition to the surficial geology of this map, the geomorphology of the seafloor has also been mapped. The *Physiographic Map of the Maine Inner Continental Shelf* (**9**) shows the geomorphology of the offshore region covered by this series of surficial geologic maps in a single, smaller scale map.

Rocky Areas

Rocky seabed occupies approximately 41% of the inner continental shelf and is the most abundant seafloor type in this map series. Where little data exist and the seafloor relief is very irregular, a rocky bottom was inferred. By this inference, large areas of rocky bottom were mapped off extreme southern Maine, Penobscot Bay, and Petit Manan Point. Large areas of rock also occur surrounding the many granitic islands in Blue Hill and Frenchman Bays. Elongate, submerged rock ridges follow the linear trend of the Casco Bay peninsulas. Although common as nearshore shoals in water less than 10 m (33 ft) deep, large outcrops of rock are relatively rare in deep offshore basins.

The bedrock geology was not determined, but side-scan sonar images clearly depict parallel fractures and elongate outcrop patterns common in layered metamorphic rocks as well as more rounded bodies of rock often associated with plutonic (granitic) igneous rocks (**10**). In shallow water, rock outcrops are usually covered with algae (seaweed) and encrusting organisms. Below water depths of a few tens of meters (the photic zone), encrusting organisms and organic mats often cover bedrock outcrops. "Rock greater than mud" (**Rm**; for an explanation of abbreviations see **Interpretation of Side-Scan Sonar Images**) is most common in deep offshore basins where outcrops project up through the mud that mantles the seafloor. **Rm** also occurs as small areas seaward of tidal flats in nearshore basins. "Rock greater than sand" (**Rs**) exists only in a few locations offshore of beaches.

Areas adjacent to rock outcrops are commonly covered with shells of dead organisms. Formerly attached to the rock surface, these shelly remains are mixed with angular rock fragments that have fallen off the outcrop (**8**). Bedrock fractures and troughs also have a similar mixture of shell and rock clasts. For this reason, extensive, "pure" rock outcrops were infrequently mapped. Instead, fractured bedrock and small bodies of rock were most often mapped as "rock greater than gravel" (**Rg**) or "gravel greater than rock" (**Gr**), two of the most common seafloor types observed.

Gravelly Areas

Gravel is a common constituent of inner shelf sediment, but occupies only 12% of the seafloor itself. Gravel is abundant in only a few locations: off the Kennebec River mouth where deltaic sediments are exposed, off Wells and Saco Bays near reworked glacial moraines, and near the Canadian border. Frequently the gravel has a rippled surface, and may contain minor amounts of coarse sand. In areas where waves regularly scour the seabed, a gravel lag deposit armors the seafloor. Gravel also occurs in broad linear bands near submerged moraines.

As described above, "gravel greater than rock" (**Gr**) is a common feature adjacent to bedrock outcrops. Here the gravel may have a high shell content (calcium carbonate) because shells are often the only modern sediment introduced to an area. **Gr** and "gravel greater than sand" (**Gs**) are major features of the seafloor from the Canadian border to Englishman Bay. Here, low relief bedrock is mantled by till, which fills in rock depressions but lacks much relief itself. "Gravel greater than mud" (**Gm**) is very rare along the inner shelf. Gravel and mud are not deposited in the ocean under the same hydrodynamic conditions, but may be found just beneath the seafloor in till deposited by glaciers more than 13,000 years ago beneath glacial ice.

Sandy Areas

Sandy seafloor (**S**) occupies only 8% of the inner shelf of the northwestern Gulf of Maine. The sandiest regions are offshore of southern Maine beaches such as Old Orchard and Ogunquit. In the mid coast region, a large sandy area "sand greater than gravel" (**Sg**) occurs off the Kennebec River mouth. This **Sg** area, consisting of many small rippled gravel patches that are intermingled with sand, has not changed appreciably in a decade, although large winter storms resuspend sand and gravel in water depths down to at least 55 m (180 ft). Many smaller bodies of sand are scattered elsewhere throughout the coast, occasionally around the 50 to 60 m (165 to 200 ft) depth, near the lowest stand of sea level since the Ice Age.

Sandy material is acoustically uniform and strongly contrasts with bordering areas of gravel and rock. Although many sediment samples from shallow water contain well-sorted ("clean") sand, areas mapped "sand" or sand with other materials frequently contain sediment in which the sand is mixed with mud, gravel and a variety of shell fragments.

"Sand greater than rock" (**Sr**) is a minor component of the seafloor that exists adjacent to small bedrock outcrops scattered across the mapped area. It is possible that more **Sr** areas exist, especially in the southern shelf, but few observations were made in that region. "Sand greater than mud" (**Sm**) is a very difficult unit to map because mixtures of mud and sand look similar on acoustic images. The only mapped areas of "sand greater than mud" are located in Saco Bay, where bottom samples confirmed the presence of both particle sizes. Similar occurrences of **Sm** may occur at the seaward margin of other beaches.

Muddy Areas

Muddy regions cover 39% of the seafloor and are the second most abundant surficial material. Mud is the dominant seabed material in all nearshore areas except for southern Maine and near the Canadian border. It is also the major deep-water surficial material in all locations except off the southern Maine coast.

Mud accumulates near areas where there is an available supply of fine-grained sediment and there are quieter hydrodynamic conditions, which favor the slow settling of small particles, or their entrapment by organisms. In nearshore regions, mud comes from eroding glacial bluffs and seasonally from rivers. In deep water, mud must be derived from winnowing and erosion of deposits in shallow water.

Muddy seafloors are featureless on acoustic records unless they have been disturbed or contain anomalous "hard" objects. Drag marks left by fishing gear are common in most sedimentary environments, but are most noticeable when carved into mud. Gas-escape pockmarks are generally hemispherical depressions that result from localized seabed disturbance. Where pockmarks occur in abundance, the seafloor is uneven. Thousands of pockmarks hundreds of meters (yards) in diameter and tens of meters (yards) deep make crater-like terrain in the muddy bottom in Belfast, Blue Hill, and Passamaquoddy Bays (**7,8**).

"Mud greater than rock" (**Mr**) occurs in some deepwater locations, but "mud greater than gravel" (**Mg**) is as rare as "gravel greater than mud" (**Gm**) because of the hydrodynamic differences between the sizes of materials. "Mud greater than sand" (**Ms**) occurs seaward of the sandy area of Saco Bay and is mapped on the basis of a large number of bottom samples that encountered this mixture in this region.

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ACKNOWLEDGMENTS

Funding for this compilation was provided by the Regional Marine Research Program of NOAA (Grant # NA46RM0451). We wish to thank Mr. Walter A. Anderson, former Director of the Maine Geological Survey, for more than ten years of unrelenting encouragement and support for our offshore research. In addition, we thank Dr. Robert E. Wall who directed the University of Maine Center for Marine Studies, which partly purchased the geophysical equipment and GIS used for this compilation. Most of the data collection was sponsored by the Maine-New Hampshire Sea Grant Program, the Continental Margins Program of the Minerals Management Service and Association of State Geologists, the National Science Foundation, the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Undersea Research Program, and the Maine Department of Marine Resources. We acknowledge many graduate students who assisted in the original collection and interpretation of much of the data, especially Dr. R. Craig Shipp. Finally, we acknowledge the able seamanship of Captain Michael Dunn, formerly of the Darling Marine Center, who participated in all bottom sampling and most geophysical expeditions.

10.1.3 Appendix A.3 – Offshore Wind Energy Geographic Information System Development and Reference Information

Appendix A.3 – OWEGIS Development and Reference Information

Offshore Wind Energy Geographic Information System (OWEGIS) layers were developed in reference to MMS' Proposed Rule 30 CFR Parts 250, 285, & 290 & the Multipurpose Marine Cadastre OCS Mapping Initiative.

Marine Mapping Cadastral Fact Sheet (Steve Kopach, Chief – MMS Mapping & Boundary Branch). Available at http://www.csc.noaa.gov/mbwg/htm/mmc_factsheet.doc. Last accessed May 2, 2009.

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Working Towards a Multipurpose Marine Cadastre (Stephen Kopach - MMS, James Fulmer – MMS, and David Stein – NOAA CSC), International Lands Management Conference Presentation, October 27, 2008, Application of Energy Policy Act of 2005, Section 388 (EPAct of 2005). Available at http://www.submergedlands2008.com/presentations/MMS-NOAA_session2ISLMC08.pdf. Last accessed May 2, 2009.

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Marine Boundary Working Group FY 07 Work Plan
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Reference layers and themes developed for OWEGIS from the above Agency efforts is illustrated on the following page.

Wind Energy Siting Considerations – Offshore Wind Energy GIS (OWEGIS) Data Layers

Physical Characteristics/Physical Environment ***Total: 113 layers***

- Wind Resource/Mean Annual Wind Speed (NREL/AWS Truewind, UMaine)
- Wind Resource/Mean Seasonal Wind Speed (DJF, MAM, JJA, SON – NREL/AWS Truewind, UMaine)
- Wave Resource/Mean Annual Wave Characteristics & Extreme Annual Wave Events (UMaine)
- Wave Resource/Mean Seasonal Wave Characteristics & Extreme Seasonal Wave Events (UMaine)
- Bathymetry
- Seabed morphology; Seabed surficial sediments
- Hurricanes; Hurricane tidal surges
- Topography (Islands, Coastal, Upland)

Infrastructure & Commercial Uses (Industrial Uses) ***Total: 73 layers***

- Coastal Restrictions/Marine Hazards - Military Zones
- Coastal Restrictions/Marine Hazards - Obstructions and Hazards
- Coastal Restrictions/Marine Hazards - Unexploded ordinances, spoil grounds, dumping grounds
- Marine Navigation, Navy & U.S.C.G. Issues – Radar locations
- Marine Navigation, Navy & U.S.C.G. Issues – Shipping Lanes, Traffic Separations
- Transportation (Airspace, Terrestrial, Coastal & Marine) - Airports
- Transportation (Airspace, Terrestrial, Coastal & Marine) – Roadways, Transportation Routes, Ports
- Utility & Development Infrastructure (Electrical, Pipelines)

Human Activity – Environmental/Ecological Impacts & Wildlife (Terrestrial, Coastal, Marine) ***Total: 144 layers***

- Dynamic Area Management Zones (Right Whales)
- Threatened/Endangered/Depleted Species
- Bald and Golden Eagles
- Essential Fish Habitats
- Terrestrial, coastal, and marine protected species
- Bird & bat migratory routes
- Marine mammal migratory routes

Human Activity – Coastal Economic & Extractive Resource Uses ***Total: 21 layers***

- Lobster Management Zones
- Shellfish Collection Regions
- Aquaculture Leases
- Worm Harvesting
- Groundfishing & Trawl Data

Human Activity – Cultural & Aesthetic Qualities ***Total: 47 layers***

- Native Resources
- Shipwrecks; Lighthouses
- National Parks; State Parks
- Maine's Finest Lakes & Scenic Rivers
- Maine Trails – Coastal Trails
- Windjammer Cruises
- Coastal Air Tours
- Landscapes, Seascapes, and Viewsheds
- Terrestrial, coastal, and marine archaeology
- Historic designations

***** As of 6/1/2009, OWEGIS contained over 443 distinct layers of information.***

Legal, Technical, and Permitting Boundaries ***Total: 45 layers***

- Private/State Boundary
- State/Federal Boundary
- 8 'g' Zone - Revenue Sharing Line
- Territorial Seas
- Contiguous Seas
- Economic Exclusive Zone
- Marine Sanctuaries

OWEGIS was created to collect, analyze, & display information to assist in planning, permitting, and offshore wind energy development in the Gulf of Maine. Items in gray indicate data in acquisition, data that can only be viewed for proprietary reasons, and/or data that have limited data sharing agreements.

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Aids and Hazards to Navigation (33 U.S.C. 62, 64, 66)
[U.S. Aids to Navigation System; Marking of Structures, Sunken Vessels, and other Obstructions; Private Aids
to Navigation]

American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996); Executive Order 13007, "Indian Sacred Sites" (May 24, 1996)

Atlantic Coast Fish Cooperative Management Act (16 U.S.C 71)

Bald and Golden Eagle Protection Act (16 U.S.C. 668 – 68d)

Clean Air Act, as amended (CAA) (42 U.S.C. 7401 *et seq.*)

Clean Boating Act of 2008 (S.2766)

Clean Water Act (CWA), Section 311, as amended (33 U.S.C. 1321); Executive Order 12777, "Implementation of Section 311 of the Federal Water Pollution Control Act of October 18, 1972, as amended, and the Oil Pollution Act of 1990"

Clean Water Act (CWA), 33 U.S.C. 1251, 1311

Clean Water Act (CWA), sections 301, 304, 306, 308, 402, 501, and 510, as amended (33 U.S.C. 1311, 1314, 1316, 1318, 1342, 1361, and 1370) and pursuant to the Pollution Prevention Act of 1990, 42 U.S.C. 13101 *et seq.*

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ICJ Rep 35.

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Estuary Protection Act (16 U.S.C. 1221 – 1226)

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Fish and Wildlife Coordination Act (16 U.S.C. 661)

High Seas and Inland Demarcation Lines, (33 U.S.C. 151)

Internal Revenue Code of 1986, (26 U.S.C. 45) – Production Tax Credit (PTC)

Internal Revenue Code, (26 U.S.C. 168) Modified Accelerated Cost Recovery System (MACRS)

Internal Revenue Code, (42 U.S.C. 13317 *et seq.*) Renewable Energy Production Incentive (REPI)

International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI Global Sulfur Caps

International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI SOx Emissions Control Area (SECA) for North America

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International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI; 2000 Tier I NOx standard

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Magnuson-Stevens Fishery Conservation and Management Act (also known as the Fishery Conservation and Management Act of 1976, as amended by the Sustainable Fisheries Act) (16 U.S.C. 1801 *et seq.*)

Marine compression-ignition (diesel) engine rule Compliance

Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1361-1407)

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Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 U.S.C. 4701

North Atlantic Salmon Fishing Act, (16 U.S.C. 56)

Ocean Dumping Act, 33 U.S.C. 1401

Ocean Thermal Energy Conversion Act, 42 U.S.C. 9101 (OTEC)

Oil Pollution Act of 1990, 33 U.S.C. 2701

Outer Continental Shelf (OCS) Lands Act (43 U.S.C. 1331 – 1337)

Ports and Waterways Safety Act, as amended (33 U.S.C. 1221 *et seq.*)

Prevention of Pollution from Ships, 33 U.S.C. 1902

Resource Conservation and Recovery Act, as amended by the Hazardous and Solid Waste Amendments of 1984
(42 U.S.C. 6901 *et seq.*)

Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. 401 *et seq.*)

Shore Protection from Municipal or Commercial Waste, 33 U.S.C. 2601

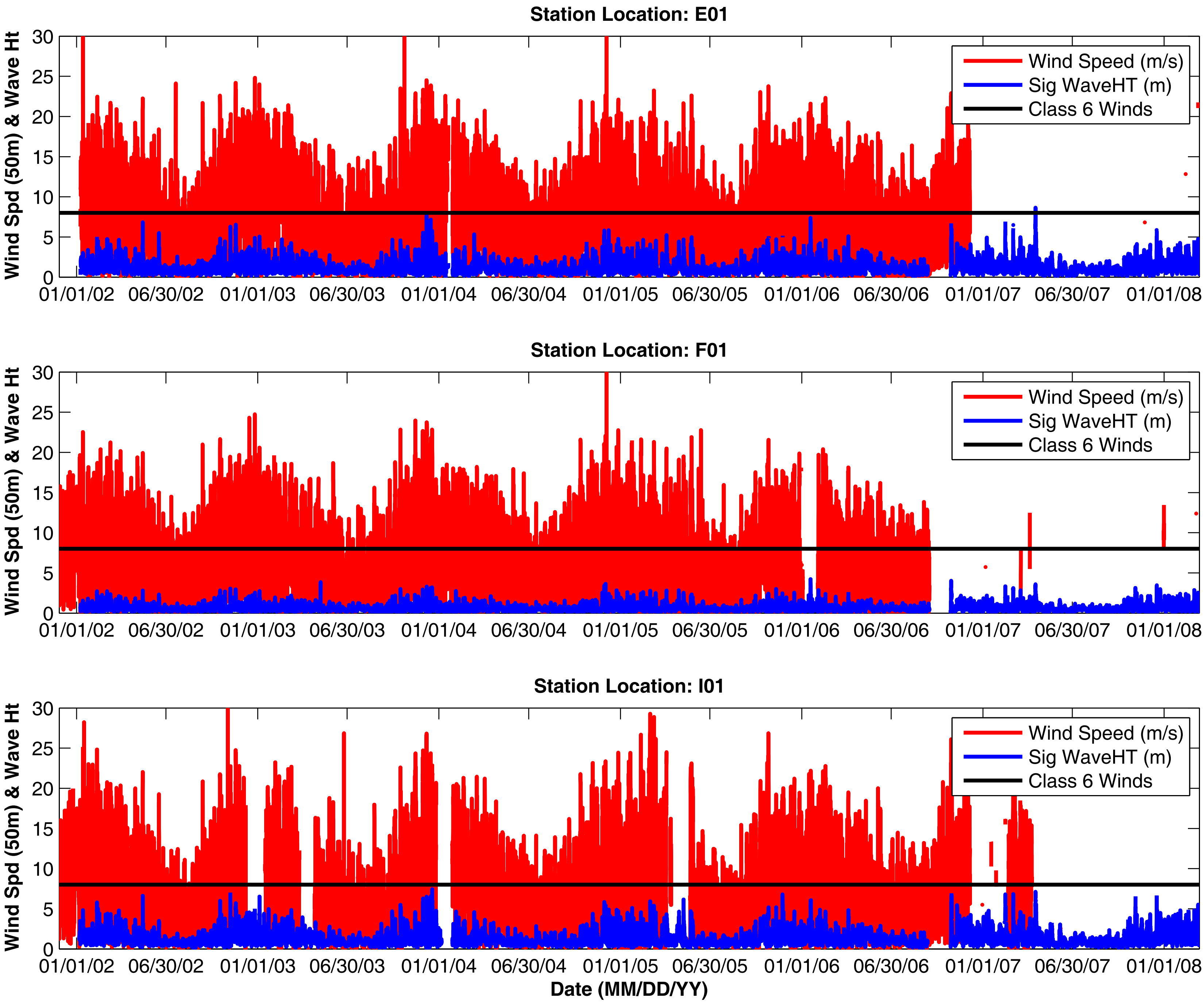
Submerged Lands Act, 43 U.S.C. 1301 (SLA)

The Investment Company Act of 1958 [established the Small Business Investment Company (SBIC)]

Water Resource Development Act of 1992 (33 U.S.C. 562)

10.2 APPENDIX B – IMPACT ASSESSMENT SUPPLEMENTAL INFORMATION

10.2.1 Appendix B.1 – Buoy Data Summary (Wind and Wave)



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Sig WaveHT (m)
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10
15
20
25
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06/30/03
01/01/04
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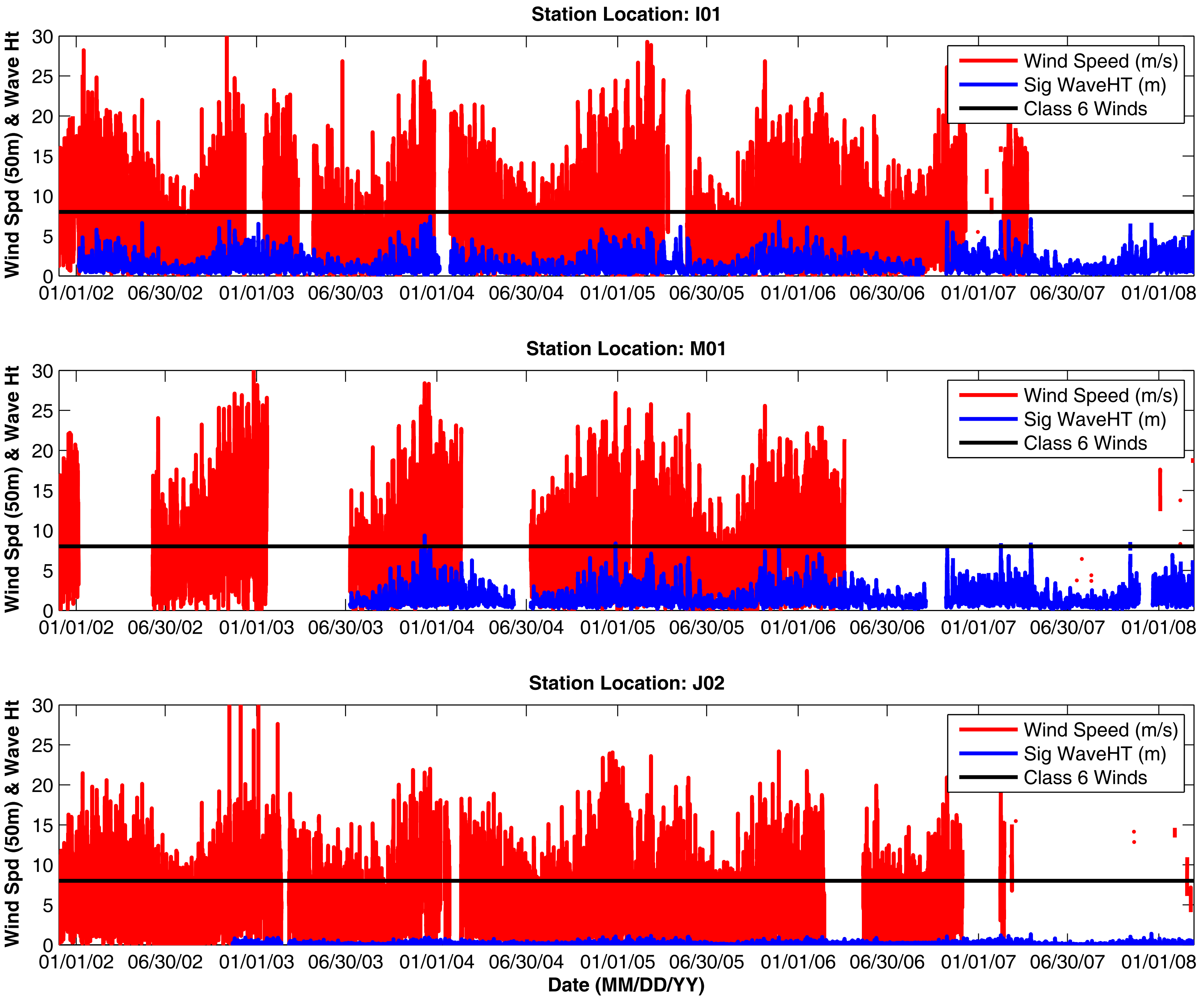
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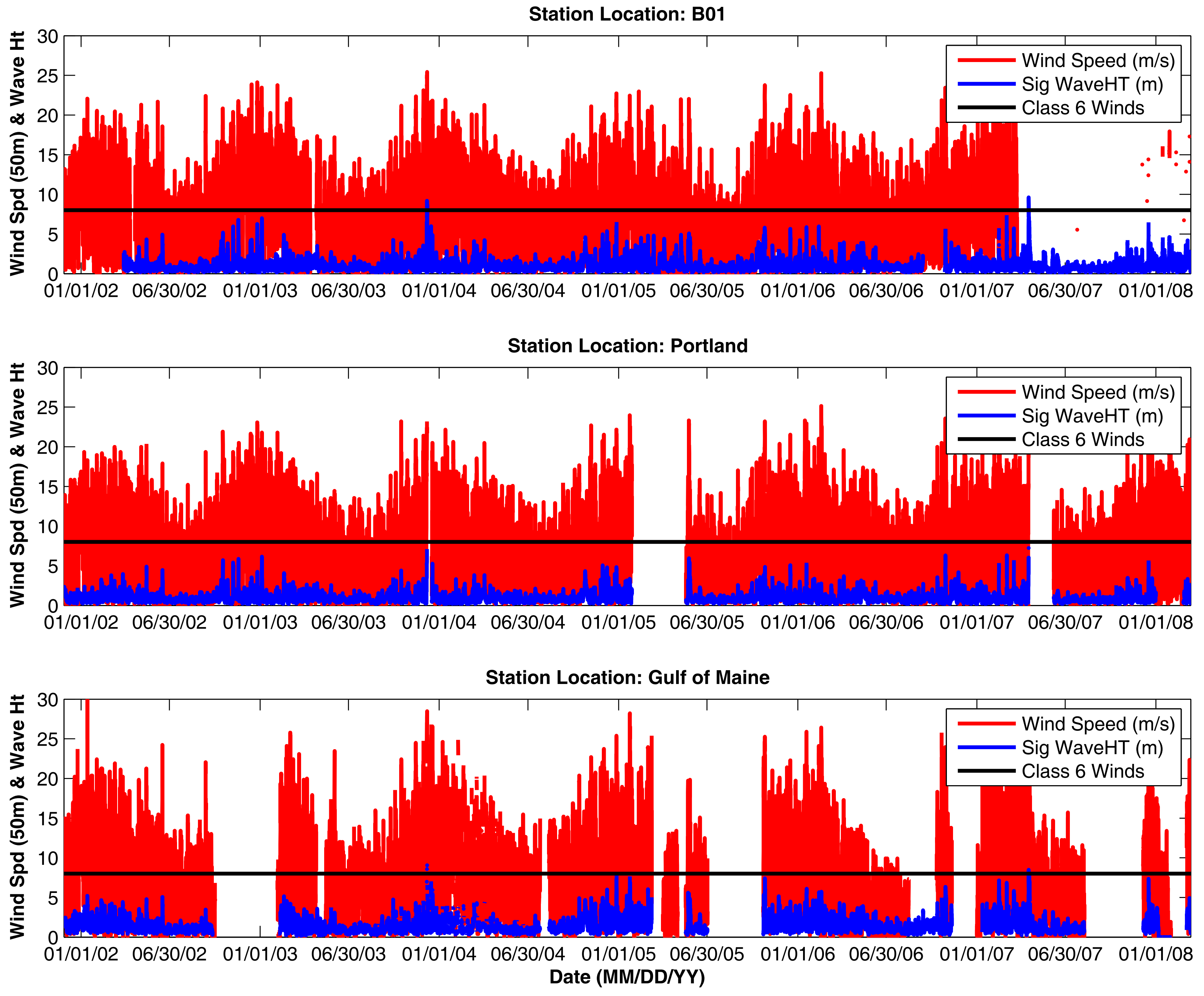
Wind Speed (m/s)
Sig WaveHT (m)
Class 6 Winds
Station Location: M01
Wind Spd (50m) & Wave Ht
Wind Speed (m/s)
Sig WaveHT (m)
Class 6 Winds
Station Location: J02
Wind Spd (50m) & Wave Ht
Wind Speed (m/s)
Sig WaveHT (m)
Class 6 Winds
Date (MM/DD/YY)



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Station Location: Gulf of Maine
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Sig WaveHT (m)
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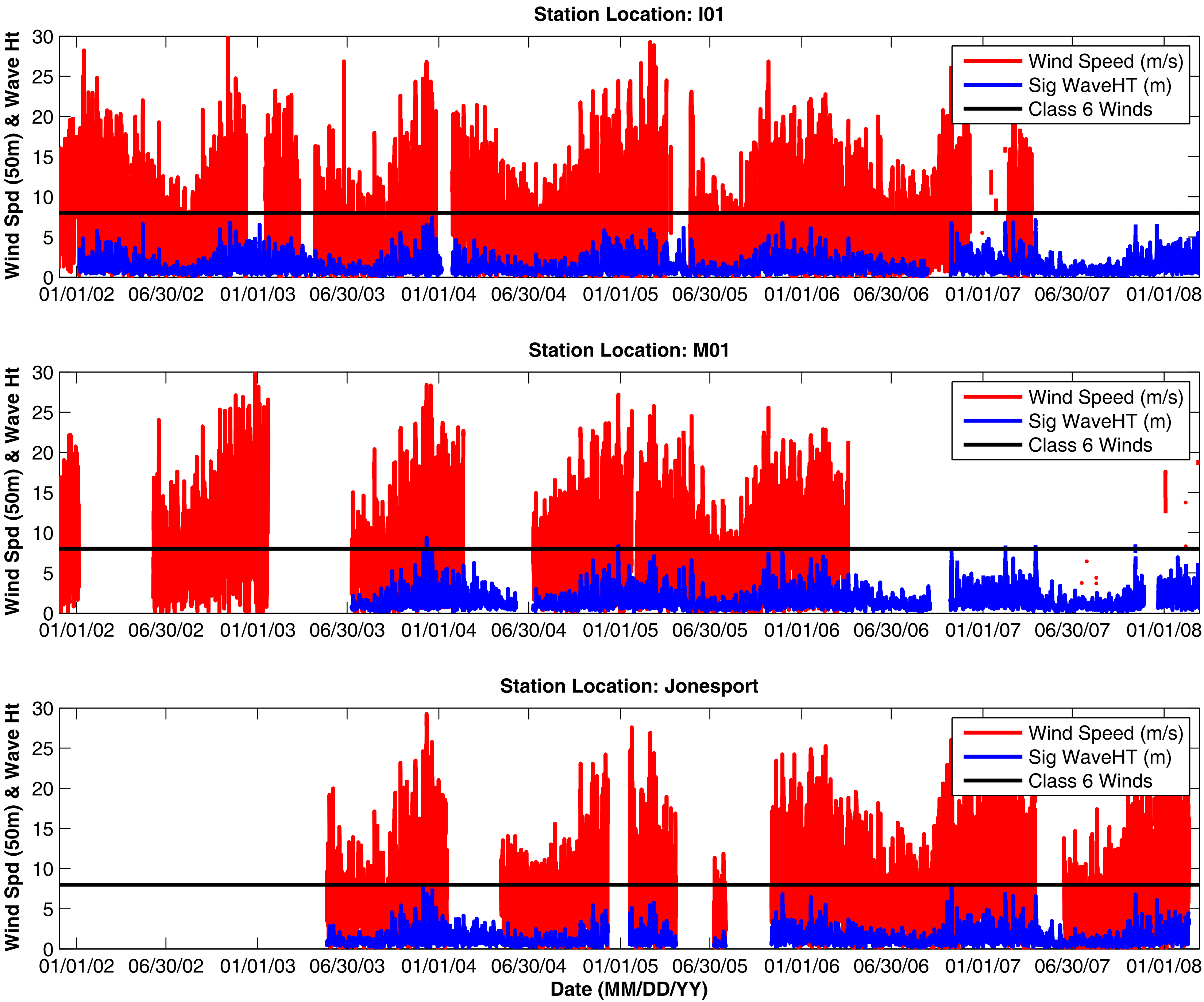
01/01/08
Date (MM/DD/YY)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Station Location: M01
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Wind Speed (m/s)
Sig WaveHT (m)
Class 6 Winds
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01/01/07
06/30/07
01/01/08
Date (MM/DD/YY)

10.2.2 Appendix B.2 – Important Bird Areas of Maine (Gallo et al., 2008)

IMPORTANT BIRD AREAS OF MAINE

An Analysis of Avian Diversity and Abundance

Compiled by:

Susan Gallo, Thomas P. Hodgman, and Judy Camuso

A Project Supported by the Maine Outdoor Heritage Fund

Important Bird Areas Of Maine

An Analysis of Avian Diversity and Abundance

February 7, 2008

Compiled by:

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(Present Address: Maine Department of Inland Fisheries and Wildlife, 358 Shaker Road, Gray, ME 04039)

Recommended citation:

Gallo, S., T. P. Hodgman, and J. Camuso, Compilers. 2008. Important Bird Areas Of Maine: an analysis of avian diversity and abundance. Maine Audubon, Falmouth, Maine. 94pp.

Cover Photo: Scarborough Marsh at sunrise, by W. G. Shriver

Table of Contents

Maine's landscape offers a variety of ecosystems, which provide habitat for a diverse array of wildlife. Maine birds have long been the focus of observation and study and their distribution and abundance has been well documented by ornithologists for over 100 years. The concept of an important bird area, a place where the abundance and/or diversity of birds is especially important for conservation or outreach, has been recognized for many years though never described as such. The Maine Dept. of Inland Fisheries and Wildlife (MDIFW), Audubon, The Nature Conservancy, the U.S. Fish and Wildlife Service, Acadia National Park, and numerous land trusts, as well as others, have, for decades, helped to conserve many areas important to birds and other wildlife and natural communities. Maine itself could be considered an important bird area. At one time, only one nesting island (Old Man Island off Cutler in Washington County) remained in the eastern U. S. for Common Eider, a species which numbers in the tens of thousands today. Also, the tremendous recovery of the Bald Eagle in the northeast could in part be founded in the population, which remained in eastern Maine despite ever-present threats of DDT elsewhere along the eastern seaboard.

History

In 2001, Maine Audubon, with the assistance of staff from MDIFW, set out to identify the most important areas for bird conservation in Maine. This project follows others throughout the U.S. that set forth similar objectives, each with a slightly different approach. We received a grant from the Maine Outdoor Heritage Fund during spring 2001 and MDIFW contracted with staff of Maine Audubon to provide project leadership. We used a slightly different approach from most other states in that our process used site-specific bird abundance data to make determinations of whether a site was indeed "important". We created a steering committee that we informed of the project and its status, and more importantly, a technical committee to advise us on establishing numeric criteria for assessing relative importance of each area.

What is an Important Bird Area?

An Important Bird Area (IBA) is a location that provides important habitat for one or more species of breeding, wintering, or migrating birds. IBAs generally support birds of conservation concern (including Threatened and Endangered Species), large concentrations of birds, or birds associated with unique or exceptional habitats. Furthermore, an IBA may be an area, which has historically been the location of a significant amount of avian research. In Maine, we typically identified "sites" which met certain numeric thresholds for abundance and diversity then assembled groups of these "sites" into "areas" (i.e., IBAs) based on their proximity to one another or thematically, typically based on the ecosystem within which they occur. Therefore, an IBA in Maine consists of one to several sites that support a high abundance (or diversity) relative to other sites supporting that species (or group of species).

Qualifying Criteria

A site qualifies for inclusion in an IBA if it meets at least one of the three primary criteria below. Two additional secondary criteria also are included that may strengthen the qualifications. *These* *criteria are not absolute and should be viewed as guidelines only.* Consideration of an IBA was based on how well its component sites met the criteria. Some sites met several criteria. Other factors, such as relative importance or a unique combination of characteristics, were considered when making final selections. A full description of the criteria used to evaluate sites is provided as an appendix.

Primary Criteria:

1. Sites for Threatened and Endangered Species

2. Sites for Species of Conservation Concern

3. Sites with Substantial Concentrations of Birds and/or High Species Diversity
   This criterion was applied to the following categories:

   A. Water Birds
   B. Seabirds
   C. Shorebirds
   D. Wadingbirds
   E. Raptors
   F. Migratory Land Birds
   G. Exceptional Abundance/Diversity

Secondary Criteria:

4. Sites for Species in Rare, Vulnerable, or Exemplary Habitat Types

5. Sites Important for Research/Monitoring

Data Use and Applicability Disclaimer

The Maine Important Bird Areas Project began in 2001, and by the time this document was prepared, significant time had elapsed. Consequently, some of the data may be slightly out of date. Furthermore, some IBAs may not currently support the same abundance and diversity as when evaluated for this project. It has been the philosophy of this project to evaluate qualifying data for a site, regardless of whether the site still supports equivalent numbers of birds. In essence, we believed that once a site qualified, it generally had the potential to support similar numbers of birds, given the habitat has not changed irreparably. We did not, however, consider data (often only available for seabird nesting islands) prior to the mid-1980s. Our analysis, therefore, examined diversity and abundance of birds in Maine for sites with available data from roughly 1985 to 2005.

Identification of a site or collection of sites as an IBA carries no legal standing and affords no special protection under Maine Law. The results of the Maine IBA project are not meant in any way to supplement or enhance the Maine Natural Resources Protection Act or other resource protection laws. The sites described in this document merely reflect an analysis of mostly public data to better facilitate public (and landowner) awareness, leading to improved conservation of resident bird populations, improved landscape-level habitat conservation, and possible community-scale economic benefits from increased birding opportunities.

Acknowledgements

The coordinators would like to thank all the Technical Committee members (Brad Allen, Louis Bevier, Lysle Brinker, Barry Burgason, David Evers, Norm Famous, Scott Hall, Ron Joseph, David Ladd, Don Mairs, Judy Markowsky, Jan Pierson, Bill Sheehan, and Peter Vickery) who attended meetings over the course of several years and exhibited extreme patience as they waited for each step in this lengthy process to be completed. We appreciate their time and effort spent writing and editing site descriptions, contributing ornithological data, and making the IBA process in Maine objective and unbiased. We especially thank Linda Welch from the Maine Coastal Islands National Wildlife Refuge, Kate O'Brien from Rachel Carson National Wildlife Refuge, Lindsay Tudor from MDIFW, and Bob Houston from U. S. Fish and Wildlife Service, Gulf of Maine Program for their help compiling data for use in our analysis and to Brad Allen for sharing his wealth of knowledge on Maine's coastal islands. Bruce Connery of Acadia National Park and Nancy Sferra of The Nature Conservancy provided helpful criticisms of earlier drafts of the site descriptions. Linda Alverson and Jody Despres provided input at an early stage of the project.

Maine Important Bird Areas

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Site and Area Descriptions

Batson River IBA **York County**

The Batson River IBA consists of sandy beaches and extensive saltmarshes, interspersed with tidal rivers and bays, scattered pockets of pitch pine forest, and rocky islands. This area stretches from the shoreline of Cape Porpoise, northwards through the saltmarshes of Marshall Point, to the sandy stretches of Goose Rocks Beach. Several small streams flow into the saltmarshes, but two larger tributaries, Batson River and Smith Brook, contribute the majority of the fresh water. Approximately 540 acres in this area are managed by Rachel Carson National Wildlife Refuge and remain undisturbed, while beachfronts host many seasonal and permanent residences. Cape Porpoise Harbor has a busy fishing pier and several small islands and is home to the Goat Island Light. Many of these islands and other parcels of land in the area are under permanent conservation protection by the Kennebunk Conservation Trust.

Batson River **Batson River IBA**
(including Smith Brook and adjacent marshes and bays)
Kennebunkport

Description - The Batson River and the smaller Smith Brook meet in a large saltmarsh and flow into Goosefare Bay. Smaller saltmarshes border both rivers and coalesce into a larger saltmarsh system as the flow nears the ocean. Pockets of pitch pine forest grade slowly into ribbons of thick maritime shrublands, switchgrass, and gradually into saltmarsh along the undisturbed sections of shoreline.

Bird Resources –American Black Ducks, Common Eiders, Buffleheads and Mallards are all common occurrences in winter and during migration. During migration, the mouth of the Batson River is often home to rafts of Red-breasted Mergansers. Pannes and pools, together with the saltmarsh north of Marshall Point Road, provide feeding habitat for numerous egrets, yellowlegs and Mallards. The beach at the north end of Marshall Point Road has had nesting Piping Plovers in the past. The uplands in the area are home to nesting grassland and shrubland birds, including Bobolinks and Eastern Towhees, both species of conservation concern in Maine. Portions of the marsh have high nesting concentrations of both species of sharp-tailed sparrows.

Conservation Issues - Invasive Phragmites is a problem in this portion of the coast and red fox predation on beach-nesting birds can be significant. As with other sites in coastal portions of southern Maine, bordering land uses and upland development are a constant threat to ecosystem health.

Ownership/Access – Ownership of the marshes and surrounding uplands is a mix of private, non-profit conservation and federal (Rachel Carson National Wildlife Refuge) holdings. Rachel Carson National Wildlife lands are generally closed to public entry in order to protect wildlife from undue disturbance. There are some public use trails and public uses that are permitted. Please consult the Refuge Manager for current regulations (207) 646-9226 or stop by the refuge headquarters and visitor center at 321 Port Road in Wells.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Snowy Egret	22 Breeding Adults[1], 1997	Breeding
Congregations: Wadingbirds	Glossy Ibis	7 Breeding Adults[1], 1997	Breeding
Congregations: Shorebirds	Semipalmated Plover	200 Adults[2], 1987	Fall Migration
T/E Species	Piping Plover	3 Fledglings[15], 1998	Breeding
T/E Species	Piping Plover	Present[15], 1998	Breeding
Congregations: Shorebirds	Lesser Yellowlegs	30 Adults[2], 1993	Fall Migration
Species at Risk	Willet	16 Breeding Adults[1], 1997	Breeding
Congregations: Shorebirds	Semipalmated Sandpiper	253 Adults[2], 1993	Fall Migration
Species at Risk	Short-billed Dowitcher	36 Adults[2], 1993	Fall Migration
T/E Species	Roseate Tern	6 Adults[16], 2004	Breeding
Species at Risk	Common Tern	133 Adults[16], 2004	Breeding
T/E Species	Least Tern	2 Adults[16], 2004	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	10 Breeding Adults[1], 1997	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	11 Breeding Adults[1], 1997	Breeding

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Sampson Cove — Batson River IBA

(including saltmarsh and Cape Porpoise Harbor)
Kennebunkport

Description – Sampson Cove is on the south side of Marshall Point and is surrounded by a narrow band of saltmarsh habitat with few pools and pannes. Upland areas include pockets of shrublands and pitch pine. Sampson Cove is a popular place for shorebirds at low tide and for Buffleheads in winter. The area off of Cape Porpoise is dotted with islands, many of which are under conservation ownership.

Bird Resources - Sampson Cove is a highlight of this IBA and hosts a great variety of bird life despite its small size. American Oystercatchers were spotted here for several weeks during the breeding season of 2004. Large flocks of peeps, mostly Semipalmated Plovers and Semipalmated Sandpipers, feed here at low tide. At higher tides, this site is visited by terns and is a traditional wintering area for large numbers of Buffleheads.

Conservation Issues - A little over half of the Sampson Cove area is under permanent conservation protection by Rachel Carson National Wildlife Refuge. However, other areas remain vulnerable to additional development. Disturbance by human activities such as kayaking is a threat, but at current levels is not believed to be significant.

Ownership/Access - Ownership of the marsh and surrounding uplands is a mix of private, non-profit conservation and federal (Rachel Carson National Wildlife Refuge) holdings. Lands managed by Rachel Carson National Wildlife Refuge are generally closed to public entry to protect wildlife from undue disturbance. There are some public use trails and public uses that could be permitted. Please consult the Refuge Manager for current regulations (207) 646-9226 or stop by the refuge headquarters and visitor center at 321 Port Road in Wells.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Snowy Egret	24 Adults[16], 2004	Breeding
Congregations: Shorebirds	Semipalmated Plover	100 Adults[16], 2004	Migration
Congregations: Shorebirds	American Oystercatcher	Present[16], 2004	Breeding
Congregations: Shorebirds	Semipalmated Sandpiper	100 Adults[16], 2004	Migration
Congregations: Shorebirds	Short-billed Dowitcher	38 Adults[16], 2004	Spring Migration
Congregations: Seabirds	Common Eider	50 Adults[16], 2004	Breeding
T/E Species	Roseate Tern	6 Adults[16], 2004	Breeding
Species at Risk	Common Tern	133 Adults[16], 2004	Breeding
T/E Species	Least Tern	2 Adults[16], 2004	Breeding

Great Pond — Cape Elizabeth IBA

Cape Elizabeth

Description - Great Pond is a shallow pond, averaging no more than five feet in depth. The approximately 130-acre pond and wetland complex is surrounded by woodlands.

Bird Resources - Despite its small size, this pond is important for two rare marshbirds: Least Bittern and Common Moorhen. This cattail marsh provides excellent habitat for these secretive birds, as well as for a variety of waterfowl during migration.

Conservation Issues - Half of the shoreline is undeveloped and owned by the Sprague Corporation. There are two neighborhoods of roughly 60 single-family homes located north of the pond.

Ownership/Access - Access is maintained by both the town of Cape Elizabeth and the Cape Elizabeth Land Trust. The pond is accessible by a sandy beach that is used as a boat launch. There is also a hiking trail to the pond from Route 77.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Least Bittern	Present[6], 2000	Breeding
Species at Risk	Northern Harrier	Present[6], 2000	Breeding
Congregations: Water Birds	Virginia Rail	Present[6], 2000	Breeding
Congregations: Water Birds	Sora	Present[6], 2000	Breeding
Species at Risk	Common Moorhen	Present[6], 2000	Breeding

Spurwink River — Cape Elizabeth IBA

Cape Elizabeth and Scarborough

Description - The Spurwink River is a relatively short (less than five miles) stretch of tidal river that forms much of the border between the towns of Cape Elizabeth and Scarborough. The river system includes a salt-hay salt marsh, an uncommon habitat type in southern Maine and home to several species of plants of special concern including Saltmarsh False-foxglove.

Bird Resources – The Spurwink River is a foraging site for a variety of wading birds, including Great Blue Herons, Great Egrets, Snowy Egrets and Glossy Ibises. The river and tidal flats are a key migration stopover for both shorebirds and a diverse array of waterfowl (including Mallards, American Black Ducks, Red-breasted Mergansers, Buffleheads, Common Goldeneyes) in the spring and fall, as well as a foraging area for Common and Least Terns that nest on nearby islands and beaches. In some winters, the uplands around the river attract Snowy Owls.

Conservation Issues – The east side of the Spurwink River and its associated uplands lie within Cape Elizabeth's Town Farm District, which is intended to recognize and protect the special nature of the area representing historic, cultural, scenic, natural, and open space qualities that should continue. Threat from major development is therefore limited, at least on the Cape Elizabeth side of the river. Development on the west side of the river has been sparse, though the number of new homes has increased in recent years.

Tidal water in the river is classified as "SA", the highest classification signifying the water is an outstanding natural resource that should be preserved because of its ecological importance. Biodiversity Research Institute tested mercury levels in marshbirds from the Spurwink River in 2004 and 2005, and found some of the lowest blood mercury concentrations among a dozen study sites in the northeast (Oksana Lane, Biodiversity Research Institute, unpublished data).

Ownership/Access – There is a boat launch on Route 77 though parking is limited. The river also may be accessed from the ocean, at its outlet at the north end of Higgins Beach (see Scarborough IBA description). The marsh and surrounding upland are a mix of private and federal (Rachel Carson National Wildlife Refuge) holdings. Specifically, the upper reaches of the river are owned and managed by the Rachel Carson Wildlife Refuge, where duck hunting is allowed in the fall.

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Wadingbirds	Snowy Egret	20 Breeding Adults[1], 1998	Breeding
Congregations: Wadingbirds	Glossy Ibis	33 Breeding Adults[1], 1998	Breeding
Species at Risk	Willet	25 Breeding Adults[1], 1998	Breeding
Species at Risk	Whimbrel	6 Adults[2], 1993	Fall Migration
Species at Risk	Nelson's Sharp-tailed Sparrow	24 Breeding Adults[1], 1998	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	14 Breeding Adults[1], 1998	Breeding

Casco Bay Islands IBA

Cumberland County

Casco Bay, like many coastal bays in Maine, consists of several drowned river outlets including the Stroudwater, Presumpscot, Royal, and Harraseeket Rivers. This IBA consists of a variety of islands both inside the sheltered portion of the bay and outer islands in more open ocean conditions. Broad expanses of mud flats and eelgrass meadows in the inner bay contribute to the richness of the waters surrounding these islands. Bird habitats provided by Casco Bay include wading bird rookeries on several of the larger islands, forested islands in the upper bay, nesting areas for gulls, cormorants, and eiders on the smaller islands and vegetated ledges, and tern colonies supported on two of the more remote islands. These islands also serve as migratory stopovers for a variety of passerines. Vegetative communities vary with island conditions from mixed hardwood-softwood forests on the sheltered islands to spruce-fir stands on more exposed forested islands to shrub/forb-dominated habitats on the most exposed islands.

Flag Island

Casco Bay Islands IBA

Harpswell

Description – This 26-acre island in northern Casco Bay is located east of Orrs Island and south of Cundy's Harbor. The island is primarily forested with a cleared area on the south side of the island.

Bird Resources – Flag Island is a traditional nesting site for a large colony of Great Blue Herons, though numbers have waned here in the last 10 years. This site also is home to the largest nesting colony of eiders in Casco Bay and one of the southernmost nesting sites in their range.

Conservation Issues – As for all the islands in this IBA, overboard discharge from boats in the harbor as well as the threat of an oil spill in or around the bay, are constant threats.

Ownership/Access – The site was placed in conservation ownership in 2001. The island is owned by the Maine Dept. of Inland Fisheries and Wildlife. Landing on Flag Island is prohibited during the nesting season (April 15 through July 31 each year).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Great Blue Heron	34 Breeding Pairs[11], 1992	Breeding
Congregations: Seabirds	Common Eider	626 Breeding Pairs[4], 1999	Breeding
Congregations: Seabirds	Herring Gull	150 Breeding Pairs[4], 1998	Breeding

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Jenny Island — Casco Bay Islands IBA
Harpswell

Description **–** This two-acre island in Casco Bay is located 1.5 miles south of Cundy's Harbor, about ½ mile from the closest point of land. Jenny Island is owned by the Maine Dept. of Inland Fisheries and Wildlife and is cooperatively managed with National Audubon's Seabird Restoration Program.

Bird Resources **–** The tern colony peaked in 1998 with nearly 1,200 pairs of terns, but was subsequently decimated by nocturnal avian (Great Horned Owl) and mammalian predators (Mink). In addition to the seabird nesting colony, the island is a migratory stopover for shorebirds, such as Whimbrel, Ruddy Turnstone, and Semipalmated Sandpipers. Purple Sandpipers winter on the shore of this island as well.

Conservation Issues **–** This island is in conservation ownership and is managed for nesting terns. National Audubon continues to manage predators to increase tern productivity. An oil spill should be considered the primary threat to this island.

Ownership/Access – Jenny Island is owned by the Maine Dept. of Inland Fisheries and Wildlife and managed as part of the Coast of Maine Wildlife Management Area. It is closed to public access during the seabird nesting season (April 15 – August 31).

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Species at Risk	Whimbrel	2 Adults[2], 1993	Migration
Species at Risk	Ruddy Turnstone	54 Adults[2], 1993	Migration
Congregations: Shorebirds	Semipalmated Sandpiper	148 Adults[2], 1993	Migration
Species at Risk	Short-billed Dowitcher	26 Adults[2], 1993	Migration
Species at Risk	Laughing Gull	5 Breeding Pairs[4], 2006	Breeding
T/E Species	Roseate Tern	15 Breeding Pairs[4], 2006	Breeding
Species at Risk	Common Tern	1167 Breeding Pairs[4], 1998*	Breeding

** The population has since declined to just under 650 pairs in 2006*

Mark Island — Casco Bay Islands IBA
Harpswell

Description – A small treeless island located about five miles south of Cundy's Harbor on the eastern edge of Casco Bay.

Bird Resources – This island has a mixed heronry with a large number of Great Blue Herons. It also hosts a sizable breeding population of Common Eiders. At one time, this island had one of the largest numbers of nesting Black-crowned Night Herons. The population of Snowy Egrets has declined slightly since the late 1990's.

Conservation Issues – Fortunately this site is in conservation ownership. Overboard discharge from boats as well as the threat of an oil spill, in or around the bay, are the greatest threats.

Ownership/Access – Mark Island is owned by the Maine Dept. of Inland Fisheries and Wildlife and is closed to public access during the seabird nesting season (April 15 through August 31 each year).

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Wadingbirds	Great Blue Heron	150 Breeding Pairs[11], 2006	Breeding
Congregations: Wadingbirds	Snowy Egret	49 Breeding Pairs[11], 1995	Breeding
Species at Risk	Black-crowned Night-Heron	12 Breeding Pairs[11], 1995	Breeding
Congregations: Seabirds	Common Eider	200 Breeding Pairs[4], 2006	Breeding

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Outer Green Island — Casco Bay Islands IBA

Portland

Description - This shrub and forb-dominated island is one of the most exposed islands in Casco Bay and is characterized by steep rocky bluffs and deep surrounding waters.

Bird Resources - In recent years, a breeding tern colony has been restored to the island through the efforts of National Audubon. With restoration, the breeding colony has swelled to nearly 1,000 nesting pairs of Common Terns. This island is also an important nesting island for Double-crested Cormorants, Common Eiders; over 92 species of migratory songbirds have been documented on this island in the past few years alone.

Conservation Issues – Given the remoteness of this island, it is especially valuable as a safe harbor for the terns, as other islands closer to the mainland have recently experienced predation by both birds and mammals. The greatest threat to this island probably would be an oil spill.

Ownership/Access – Outer Green Island is owned by the Maine Dept. of Inland Fisheries and Wildlife and landing on this seabird nesting island is prohibited during the nesting season (April 15 – July 31).

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Seabirds	Double-crested Cormorant	381 Breeding Pairs[4], 1994	Breeding

T/E Species	Roseate Tern	36 Breeding Pairs[20], 2005	Breeding
Species at Risk	Common Tern	971 Breeding Pairs[20], 2005	Breeding

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Upper Green Island — Casco Bay Islands IBA

Cumberland

Description – This small island is located about 1.5 miles northeast of Great Chebeague Island.

Bird Resources – Upper Green Island was, at one time, home to one of the largest colonies of Double-crested Cormorants in the state, with a high of 500 breeding pairs documented in the mid-1980s.

Conservation Issues – This site is in conservation ownership. Overboard discharge from boats as well as an oil spill, in or around the bay, are considered the primary threats.

Ownership/Access – Owned by the Maine Dept. of Inland Fisheries and Wildlife and part of the Coast of Maine Wildlife Management Area, the island is closed to the public to protect nesting colonial water birds from April 15 through July 31 each year.

Deer Isle IBA

Hancock County

Deer Isle is much more than a large coastal island. Comprised of two towns (Deer Isle and Stonington) the area is made up of dozens of smaller islands and ledges in East Penobscot Bay. Connected to the mainland by a bridge over Eggemoggin Reach, visitors traveling from the Blue Hill peninsula first arrive on Little Deer Isle, where excellent views of the reach are possible from Pumpkin Island Light at the northwest tip of Little Deer Isle. Deer Isle is connected to Little Deer Isle by a causeway, which at low tide, offers habitat for a variety of coastal birds. Many of the coves, such as Fish Creek, provide excellent habitat for wintering waterfowl. The islands and ledges south of Stonington are considered some of the most significant habitat for wintering Purple Sandpipers in Maine.

Hardhead Island

Deer Isle IBA

Deer Isle

Description - This important wildlife island lies to the west of Deer Isle in east Penobscot Bay. It is treeless, but supports a near-perfect mix of vegetation for seabirds, including terns. Cliffs and rock rubble dominate the perimeter of the island.

Bird Resources - This island supports one of the largest Double-crested Cormorant colonies in East Penobscot Bay (166 pairs in 1995). Hardhead Island is one of the most productive non-managed tern nesting islands in Maine (95 pairs in 2006). Bald Eagles often prey on Herring Gull chicks from this island.

Conservation Issues - Because Deer Isle islands are in LURC jurisdiction, this island is zoned P-FW (Protection-Fish and Wildlife). An oil spill is considered the greatest threat to this island.

Ownership/Access – This island has been owned and managed by the Maine Dept. of Inland Fisheries and Wildlife since at least 1973. Landing is prohibited on Hardhead Island between April 15 and July 31.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	166 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Common Eider	450 Breeding Pairs[4], 1981	Breeding
Congregations: Seabirds	Herring Gull	175 Breeding Pairs[4], 1996	Breeding
Species at Risk	Common Tern	95 Breeding Pairs[4], 2006	Breeding

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Scraggy Island — Deer Isle IBA
Stonington

Description – An 8.5-acre largely forested island located approximately three miles southwest of Stonington.

Bird Resources – Historically, the island had up to 200 nesting Common Eiders and 43 nesting pairs of Great Blue Herons. Heron numbers likely will decline as birds are displaced by the expanding Bald Eagle population. The island lies in the middle of a high quality wintering area for Purple Sandpipers with 400 birds documented here.

Conservation Issues - An easement ensures the conservation of the island, but off-shore threats include oil spills and other forms of pollution. Scraggy Island has been identified as a nationally significant seabird island and has been identified for potential acquisition by the Maine Coastal Islands National Wildlife Refuge provided there are willing sellers and federal funds available.

Ownership/Access – The island is privately owned, with a conservation easement held by Maine Coast Heritage Trust. There is no public access, consequently, viewing bird life here must be done from the water. The nearest public boat launch is in Stonington.

Scraggy Island Ledge — Deer Isle IBA
Isle au Haut

Description – The ledge is located approximately two miles south of Stonington.

Bird Resources – The ledge is an important winter roosting spot for as many as 600 Purple Sandpipers. Ospreys also nest on the ledge.

Conservation Issues – Threats include oil spills and other forms of pollution typical of coastal habitats.

Ownership/Access – The ledge is owned by the Maine Dept. of Inland Fisheries and Wildlife and managed under the Coast of Maine Wildlife Management Area. Public access to the ledge is prohibited from April 15 – July 31. During this period viewing birds must be from a boat only.

Shabby Island — Deer Isle IBA
Deer Isle

Description - This small (3.6-acre) seabird nesting island is located northeast of Stonington on the western edge of Jericho Bay. Low, dense vegetation is the dominant habitat type making it suitable for nesting seabirds and waterfowl.

Bird Resources - A diverse seabird nesting island with Common Eiders, Herring and Great Black-backed Gulls, Black Guillemots, and Double-crested Cormorants. This is a good site for nesting Common Eiders with 150 nests reported in 1984. Most significant is the large cormorant colony with an occasional Great Cormorant nesting within the boundaries of the primarily Double-crested Cormorant colony.

Conservation Issues – Because Deer Isle islands are in LURC jurisdiction, this island is zoned P-FW (Protection-Fish and Wildlife). Typical off-shore threats include oil spills and other forms of pollution.

Ownership/Access - Privately owned, but with easements held by both the Maine Dept. of Inland Fisheries and Wildlife and Acadia National Park. There is no public access. Viewing birds at this site must be strictly from the water. The nearest public boat launches are in Stonington, on Webb Cove, and on Whitmore Neck.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	312 Breeding Pairs[4], 1995	Breeding
Species at Risk	Purple Sandpiper	300 Adults and Juveniles[2], 2003	Winter
Congregations: Seabirds	Great Black-backed Gull	135 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Black Guillemot	14 Individuals[4], 1995	Breeding

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Shingle Island — Deer Isle IBA

Deer Isle

Description – A small (9.2-acre) island located about four miles off-shore and east of Stonington.

Bird Resources – This small island is a consistent wintering spot for Purple Sandpipers, with as many as 300 congregating at any one time.

Conservation Issues – Because Deer Isle islands are in LURC jurisdiction, this island is zoned P-FW (Protection-Fish and Wildlife). Typical off-shore threats include oil spills and other forms of pollution.

Ownership/Access – The island is privately owned with an easement held by Acadia National Park. There is no public access.

Duck Islands IBA

Hancock County

Comprised of two offshore islands that are largely wooded, this IBA is found approximately eight miles southeast of Mount Desert Island's Bass Harbor. These two remote islands host the largest Leach's Storm-petrel colonies in Maine, and in fact, on the east coast of the United States. In tandem, these protected islands provide significant nesting habitat for seabirds and Passerines, as well as significant stopover habitat for many migratory birds.

Great Duck Island

Duck Islands IBA

Frenchboro

Description – Great Duck Island is 220 acres in size and is located approximately eight miles southeast of Bass Harbor Head. Three major habitat types characterize the island's interior: perennial grass/raspberry meadow, spruce forest, and wetland. The perimeter of the island is dominated by rock out-croppings, and rock jumbles, with a couple of small cobble beaches. The island has a rich human history including a psychiatric clinic and a light station (constructed in 1890).

Bird Resources – Great Duck hosts the largest Leach's Storm-petrel colony along the east coast of the United States with historically over 5,000 breeding pairs. It also provides significant habitat for nesting Black Guillemots, Herring and Great Black-backed Gulls. A long-term productive Bald Eagle nest also can be found there. The upland and marsh habitat also may provide significant nesting and migratory stopover habitat for Passerines, raptors, shorebirds and waterfowl.

Conservation Issues – The College of The Atlantic maintains a field station on the island. One conservation concern unique to this site involves an introduced hare population (the origin and lineage of which can be debated) that can have significant impacts on the vegetation.

Ownership/Access - Great Duck Island is owned by The Nature Conservancy, the Maine Dept. of Inland Fisheries and Wildlife, and a private individual. The lighthouse, boathouse, and associated property are owned by the College of the Atlantic. Access to this island is restricted from February 15 through August 31. Access has not been granted to privately-owned portions of this island. Viewing the island's birdlife from the water is recommended.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	5,040 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Herring Gull	1,100 Breeding Pairs[4], 2004	Breeding
Congregations: Seabirds	Black Guillemot	749 Individuals[4], 1995	Breeding

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Little Duck Island — Duck Islands IBA

Frenchboro

Description – Little Duck Island is the closest of the Duck Islands to Mount Desert Island and is located a ½ mile north of Great Duck Island. The island is 90 acres in size and is characterized by overgrown fields, maritime spruce-fir forest, rock outcrops, and rock jumbles. Little Duck differs from many coastal islands because its remote nature deters immigration of terrestrial mammals that can decimate seabird colonies. The loose soil, protection of the forest, and proximity to the open ocean makes this island nearly ideal for nesting Leach's Storm-petrel.

Bird Resources – Little Duck represents the second largest Leach's Storm-petrel colony on the east coast of the United States, second in size only to Great Duck. It also provides nesting habitat for Black Guillemots among the rock jumbles; gulls and Double-crested Cormorants atop the many rock out-crops as well as in small trees; and Common Eiders under the cover of trees, shrubs, and ferns. Additionally, the island likely provides a vital stopover area for neotropical migrants.

Conservation Issues – If future public access should increase, trail networks should be established to protect petrel burrows from collapsing. Both of the Duck Islands face a constant threat from an oil spill.

Ownership/Access – One of the first islands to come into conservation ownership on the coast of Maine, Little Duck is owned primarily by National Audubon. Acadia National Park also holds a conservation easement on a portion of the island. Access has not been granted to privately-owned portions of this island and access to lands in conservation ownership is difficult. Viewing from the water is recommended.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	2,800 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Double-crested Cormorant	378 Breeding Pairs[4], 1995	Breeding
Species at Risk	Great Cormorant	Present[4], 1999	Breeding
Congregations: Seabirds	Common Eider	400 Breeding Pairs[4], 1977*	Breeding
Congregations: Seabirds	Black Guillemot	198 Individuals[4], 1995	Breeding

** No current estimate available.*

Brunswick Naval Air Station (including Mere Brook)
Brunswick

Description - This more than 1,400-acre property includes airfields, runways, towers, hangars and residential buildings. It has been managed as a Naval Air Base with permanent structures and landing strips since the early 1950s. Two areas within the base stand out as significant areas for birds. The southern portion of the base (Mere Brook and the surrounding wetlands) is characterized by high and low marsh habitats in an unusually large and unfragmented block. Because the area is on the Naval Air Station, the saltmarsh itself has very little human visitation or disturbance. A series of weapons bunkers and service roads are visible from the marsh in the uplands to the east. The second area within the base that is particularly valuable to birds is the northwestern portion that contains primarily grasslands (maintained in part by mowing for airstrips) as well as patches of pitch pine forest.

Bird Resources - Extensive airfields at this site are maintained as grassland habitat and are home to nesting Upland Sandpipers, Horned Larks, Bobolinks, Eastern Towhees, Eastern Meadowlarks, Grasshopper Sparrows, Field Sparrows and Vesper Sparrows. The site also has one of the highest concentrations of Savannah Sparrows recorded in the state. For its size, Mere Brook supports good numbers of both species of Sharp-tailed Sparrows. Herons, egrets, and numerous swallows forage here as well. Northern Goshawks have been observed at this site.

Conservation Issues - Contamination of ground water and soils from pesticides and fuel has been significantly reduced due to extensive clean-up efforts in the 1990s. Long-term monitoring is planned for the site. However, the base has been decommissioned and is due to close within the next ten years. Future ownership and management of this site is therefore unknown, but the likelihood of sustaining extensive grassland habitat is unlikely without extensive conservation efforts.

Ownership/Access - The site is owned by the Department of Defense. There is no public access without extensive security clearance.

Selected Ornithological Data

BNAS, Mere Brook

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Nelson's Sharp-tailed Sparrow	17 Breeding Adults[1], 1997	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	10 Breeding Adults[1], 1997	Breeding

BNAS, Grasslands

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Upland Sandpiper	10 Adults[21], 1985	Breeding
Species at Risk	Eastern Towhee	Present[8], 1998	Breeding
Species at Risk	Field Sparrow	Present[21], 1986	Breeding
Species at Risk	Vesper Sparrow	15 Adults[21], 1985	Breeding
Congregations: Migratory Landbirds	Savannah Sparrow	60 Adults[8], 1998	Breeding
T/E Species	Grasshopper Sparrow	15 Adults[8], 1997	Breeding
Species at Risk	Bobolink	Present[8], 1998	Breeding
Species at Risk	Eastern Meadowlark	7 Adults[8], 1997	Breeding

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Maquoit Bay
Freeport IBA

Brunswick

Description - A narrow coastal bay south of Brunswick and east of Freeport with exposed mudflats at low tide.

Bird Resources - This area supports the highest documented concentrations of wintering American Black Ducks and Canada Geese in the state. A variety of shorebirds use this site as a feeding area during migration. In the spring, Northern Shoveler, Blue-winged Teal and Green-winged Teal are among the many waterfowl species that feed and rest in the bay during migration. In addition, the marshes in the area support nesting Nelson's and Saltmarsh Sharp-tailed Sparrows, and Bobolinks nest in neighboring upland fields.

Conservation Issues - The land surrounding the bay is highly desirable and subject to high development pressure. The Trust for Public Land has been working to purchase conservation easements and/or property bordering the bay. Increased recreational use in the bay could influence staging and wintering birds. Oil spills in neighboring Casco Bay are an on-going threat and could be devastating to wintering waterfowl that use the area.

Ownership/Access – Lands surrounding Maquoit Bay are a high priority for both local and regional land trusts, and many areas have either been acquired or subject to conservation easements. Because access remains difficult, the area is best viewed from the water. A public boat launch is available at Wharton Point at the end of Maquoit Rd in Brunswick.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water birds	Canada Goose	800 Adults[22], 2001	Migration

Congregations: Water Birds	American Black Duck	800 Adults[22], 2001	Migration
Congregations: Shorebirds	Small Shorebirds	350 Adults[2], 1998	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	67 Adults[2], 1998	Fall Migration
Species at Risk	Willet	Present[2], 1998	Fall Migration
Species at Risk	Short-billed Dowitcher	21 Adults[2], 1998	Fall Migration
Congregations: Seabirds	Forster's Tern	12 Adults[22], 1990	Fall Migration
Species at Risk	Nelson's Sharp-tailed Sparrow	10 Breeding Adults[1], 1998	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	Present[1], 1998	Breeding
Species at Risk	Bobolink	16 Breeding Adults[1], 1998	Breeding

Harraseeket River — Freeport IBA

Freeport

Description - The Harraseeket River is a deep, but relatively short river, only about four miles long. The river was the site of boat building in the first half of the nineteenth century, with tall timbers for masts cut and transported here from adjacent forest lands. The site includes the length of the river, with major bird observation points at Winslow Park, Wildwood, and South Freeport Harbor.

Bird Resources - The Harraseeket River supports one of the highest documented concentrations of wintering Common Goldeneyes in Maine as well as several dozen wintering Barrow's Goldeneyes at any one time. The birds move throughout the river depending on the tide.

Conservation Issues - Part of the goldeneye wintering area is near, and actually in, a working harbor. The area is desirable for development, and there is pressure to develop the area for residential housing. The river and outlet are heavily used by recreational boaters and commercial fishermen. Increased boat traffic, moorings, and potential fuel spills could pose hazards for wintering birds.

Ownership/Access – With the exception of local parks and public landings, the surrounding properties are in private ownership.

Selected Ornithological Data

South Freeport Harbor

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water Birds	Common Goldeneye	100 Adults[3], 2000	Winter

Species at Risk	Barrow's Goldeneye	16 Adults[3], 2000	Winter

Wildwood

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water Birds	Common Goldeneye	190 Adults[3], 2000	Winter
Species at Risk	Barrow's Goldeneye	Present[3], 2000	Winter

Winslow Park

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water Birds	Common Goldeneye	375 Adults[3], 2000	Winter
Species at Risk	Barrow's Goldeneye	18 Adults[3], 2000	Winter

Fort Foster Gerrish Island IBA

Kittery

Description – Fort Foster was built in 1872 and remained active until 1949. A long pier extends off shore providing excellent views of Whaleback Lighthouse and Jerry's Point Lifesaving Station as well as the waters in between. On a clear day, the Isles of Shoals lighthouse is visible.

Bird Resources – Fort Foster is an excellent spot for migrating songbirds. As many as 90 species of birds have been recorded from this site. The pier offers a great platform for viewing water birds off shore (see Portsmouth Harbor description below).

Conservation Issues – This is a popular tourist attraction during the summer with thousands of visitors annually. Some disturbance is inevitable with that degree of human use. Other threats are believed minimal.

Ownership/Access **–** Fort Foster is owned by the Town of Kittery. The park is open May through Labor Day with an admission fee of $10 per vehicle, including all occupants. Information is available at (207) 439-0333 or (207) 439-2182. Access is via Pocahontas Road in Kittery Point.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Raptors	Raptors	12 Species[23], 1990-2002	Migration Winter
Species at Risk	Black-throated Blue Warbler	13 Adults[23], 1990-2002	Spring Migration
Species at Risk	Scarlet Tanager	6 Adults[23], 1990-2002	Spring Migration
Species at Risk	Eastern Towhee	4 Adults[23], 1990-2002	Spring Migration
Species at Risk	Bobolink	9 Adults[23], 1990-2002	Spring Migration
Species at Risk	Rusty Blackbird	31 Adults[23], 1990-2002	Fall Migration
Congregations: Migratory Landbirds	Migratory Landbirds	90 Species[23], 1990-2002	Spring Migration

Portsmouth Harbor — Gerrish Island IBA

(and mouth of the Piscataqua River)
Kittery

Description – Portsmouth Harbor and the mouth of the Piscataqua River are busy with boat traffic much of the year. The islands and ledges along the southern tip of Gerrish Island bring to mind Maine's island-studded coast to the north.

Bird Resources – This area is especially important for wintering water birds including Great Cormorants that have numbered over 350 at one time. Large numbers of Razorbills and Purple Sandpipers can be found here in winter as well.

Conservation Issues – The busy port of Portsmouth as well the Naval Base on nearby Seavey Island present hazards to bird life primarily from the potential of a petroleum spill into these waters.

Ownership/Access – This site can be viewed easily from the pier at Fort Foster (see previous site description for this IBA) as well as via the park road at Fort Foster.

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations	Water Birds	19 Species[23], 1990-2002	Migration Winter
Species at Risk	Great Cormorant	363 Adults[23], 1990-2002	Winter
Species at Risk	Purple Sandpiper	290 Adults[23], 1990-2002	Winter
T/E Species	Razorbill	55 Adults[23], 1990-2002	Winter

Greater Isle au Haut IBA — Knox and Hancock Counties

The Greater Isle au Haut IBA is located in outer Penobscot and Jericho Bays. This area consists of scattered islands and ledges located offshore from southern Vinalhaven and Deer Isle east to and including Isle au Haut, and to the islands just west of Swans Island. Some islands are dominated by spruce-fir forest communities, while others are vegetated by grasses, sedges, low shrubs, mosses and forbs. Numerous ledges can be found lying among these islands and are largely free of vegetation.

These islands provide an important migratory stopover during both spring and fall. Anecdotal reports list over 130 nesting species and a much larger number are known to migrate through this area. Although most visitors are limited by poor access to the islands and limited transportation and lodging facilities in the area, there are numerous opportunities to view many different songbirds, seabirds, and waterfowl throughout the year. Offshore waters provide a summer home to Common Eiders, gulls, and petrels that nest on the surrounding coastal islands. The area is very important to wintering Harlequin Ducks and Purple Sandpipers, and may be the core wintering area in eastern North America for both species. Large rafts of other ducks and seabirds use the area in the winter and Bald Eagles have become common here, as their populations have expanded in Maine.

Isle au Haut — Greater Isle au Haut IBA

Isle au Haut

Description – Isle au Haut is the largest island in this IBA spanning approximately 2,700 acres. The southern portion of the island is predominantly in federal ownership and includes a small tent-only campground and numerous hiking trails. The northern portion is largely privately owned with about 35 year-round residents swelling to over 200 residents during the summer. The bold rocky shoreline rings this island with numerous cobblestone coves and a few high cliffs on the most exposed headlands. The island is predominantly a mature maritime spruce-fir community.

Bird Resources – The complex shoreline provides abundant habitat for a diverse array of seabirds, shorebirds and ducks. This site is probably the most significant location for wintering Purple Sandpipers and Harlequin Ducks in eastern North America. The abundance of food resources and low disturbance make interior habitats favorable to eagles and landbirds as well.

Conservation Issues – Development in the northern portion of the island could threaten habitats and, in turn, some birds with increases in disturbance from recreation, land use, pets, etc. Another threat is the introduction of non-native species, both birds (e.g., game birds) and mammals (e.g., raccoons, furbearers, etc.). Although the potential for wildfire is a concern, disturbance to birds from a fire would be temporary. New habitats would quickly recover in burned areas, and would likely create a mosaic of plant communities. The potential for a hazardous spill or pollution from discharge of ballast is ever present.

Ownership/Access - Ownership is a complex of private and Federal property. Conserved lands here are owned and managed by Acadia National Park. Access to the island is by boat from Stonington.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Harlequin Duck	150 Adults[17 and 4], 2002	Winter
T/E Species	Bald Eagle	3 Breeding Pairs[17], 2002	Breeding
Species at Risk	Purple Sandpiper	300 Adults[17], 2002	Winter

Great Spoon Island — Greater Isle au Haut IBA

Isle au Haut

Description – Great Spoon is a treeless island lying east of Little Spoon Island and the southeastern tip of Isle au Haut's Eastern Ear. It has a long history of human uses including egg hunting, feather and down collecting, and sheep grazing.

Bird Resources – The complex rocky shoreline of the island provides a diversity of habitats for nesting Common Eiders, Double-crested Cormorants, Great Cormorants, and Leach's Storm-petrels. Good numbers of most seabirds and eiders have been recorded there. Great Spoon is one of only nine islands coast-wide with Great Cormorants and one of less than 20 islands with both Common and Arctic Terns. The area is known to be used by Harlequin Ducks throughout the winter and is suspected to be used by Purple Sandpipers. Bald Eagles are seen here regularly.

Conservation Issues – The rough shoreline, difficult access, and exposed location limit the threats common to other island IBAs. Protection at Great Spoon is enhanced by the recent acquisition of Little Spoon Island by the U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge. However, a hazardous spill or the on-going ballast discharge from the large number of cruise ships and Canadian-bound tankers that pass by the island potentially pose a more damaging threat with long-lasting effects.

Ownership/Access - The site is owned by the Maine Dept. of Inland Fisheries and Wildlife and managed as part of the Coast of Maine Wildlife Management Area. This seabird nesting island is closed to public use annually from April 15 to August 31.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	20 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Double-crested Cormorant	79 Breeding Pairs[4], 1995	Breeding
Species at Risk	Great Cormorant	35 Breeding Pairs[4], 1999	Breeding

Congregations: Seabirds	Common Eider	492 Breeding Pairs[4], 1992	Breeding
T/E Species	Harlequin Duck	102 Adults[3], 1998	Winter
Congregations: Seabirds	Herring Gull	420 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Great Black-backed Gull	314 Breeding Pairs[4], 1995	Breeding
Species at Risk	Common Tern	65 Breeding Pairs[4], 2003	Breeding
Congregations: Seabirds	Black Guillemot	450 Individuals[4], 1995	Breeding
T/E Species	Arctic Tern	Present[4], 2004	Breeding

Little Spoon Islands — Greater Isle au Haut IBA

Isle au Haut

Description – A treeless island lying east of the southeastern tip of the Isle au Haut, and west of Great Spoon Island. Smaller than Great Spoon, this island also has a long history of human uses including egg gathering, feather and down collecting, and sheep grazing.

Bird Resources – The complex rocky shoreline provides a diversity of habitats for nesting Common Eiders, Double-crested Cormorants, Great Cormorants, and gulls. The island supports one of the larger Black Guillemot breeding colonies in coastal Maine. It is unknown whether petrels use the island for nesting. The shoreline area is probably used by Purple Sandpipers, and is known to be used by Harlequin Ducks throughout the winter. The rich seabird population provides a stable food base for local Bald Eagles.

Conservation Issues – This island's conservation status is enhanced by its proximity to state-owned Great Spoon. The rough shoreline, difficult access, and exposed location may lessen the potential list of threats and their severity for this island. The site falls under a "forever wild" conservation easement. However, a hazardous spill or the on-going ballast discharge from the large number of cruise ships and Canadian-bound tankers that pass by the island potentially pose a more damaging threat with long-lasting effects.

Ownership/Access – The island was recently acquired by U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge and is closed to public access during the seabird nesting season (April 1 – August 31).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	194 Breeding Pairs[4], 1995	Breeding
Species at Risk	Great Cormorant	105 Breeding Pairs[4], 1991	Breeding
T/E Species	Harlequin Duck	86 Adults[30], 1996	Winter

Congregations: Seabirds	Great Black-backed Gull	177 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Black Guillemot	600 Individuals[4], 1995	Breeding

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John's Island — Greater Isle au Haut IBA

Swan Island

Description – The U. S. Fish and Wildlife Service acquired this 43-acre island in 1998. The island is primarily covered with low grasses and forbs with a few patches of woody shrubs. The perimeter of the island is granite ledge, ranging from gradual slopes to steep cliff.

Bird Resources – Both the sizes of the colonies and the diversity of species make John's Island unique. Nesting species include Common Eider, Great Black-backed and Herring Gulls, Black Guillemot, Double-crested Cormorant, and Great Cormorant. The island is also a harbor seal pupping area.

Conservation Issues – This island is difficult to access because of its rough shoreline and exposed location. This lessens the potential threats to the island. The potential for a hazardous spill or the problems associated with ballast discharge from the large number of cruise ships and Canadian-bound tankers that pass by the island all year pose a potentially serious threat.

Ownership/Access **-** The island has full conservation protection and is administered by the U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge. It is closed to public access during the seabird nesting season (April 1 – August 31).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	158 Breeding Pairs[4], 1995	Breeding
Species at Risk	Great Cormorant	20 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Common Eider	1,000 Breeding Pairs[4], 1996	Breeding
Congregations: Seabirds	Herring Gull	600 Breeding Pairs[4], 1986	Breeding
Congregations: Seabirds	Great Black-backed Gull	400 Breeding Pairs[4], 1986	Breeding
Congregations: Seabirds	Black Guillemot	450 Individuals[4], 1995	Breeding

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Heron Island — Greater Isle au Haut IBA

Swans Island

Description – Heron Island is treeless, primarily covered with herbaceous vegetation and patches of woody shrubs. The island is surrounded by granite boulders and ledges that range from gradually sloping to small steep cliffs.

Bird Resources – Common Eider, Great Black-backed and Herring Gulls, Black Guillemot, Double-crested Cormorant, Leach's Storm-petrel, and Great Cormorant all nest on the island. Harlequin Ducks use the near-shore habitats during the winter.

Conservation Issues – The rough shoreline, difficult access, and exposed location lessen the number of potential threats and reduce their severity. The potential for a hazardous spill or the problems associated with ballast discharge from the large number of cruise ships and Canadian-bound tankers that pass by the island all year poses a potentially serious threat. A full survey of nesting Leach's Storm-petrels has not been completed.

Ownership/Access - The island has full conservation protection and is administered by Acadia National Park. It is closed to public access during the seabird nesting season (April 1 – August 15).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Harlequin Duck	84 Adults[30], 1999	Winter
Congregations: Seabirds	Herring Gull	1,344 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Great Black-backed Gull	182 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Black Guillemot	193 Breeding Pairs[4], 1995	Breeding

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Spirit Ledge — Greater Isle au Haut IBA

Swans Island

Description - This site is located northeast of Isle au Haut near Boxam Cove on Marshall Island. This barren granite ledge is quite exposed to the southeast where there is little buffer from the open ocean.

Bird Resources – This ledge is not used by nesting birds, but instead is an important wintering area for Harlequin Ducks and Purple Sandpipers. Approximately 10,000 Common Eiders were observed in surrounding waters while molting during September 2005.

Conservation Issues - Oil spills and other overboard discharge pose the greatest threat to this site and surrounding waters. Its remote location and barren condition help to shield it from disturbance by recreationists.

Ownership/Access - The site is owned by the Maine Dept. of Inland Fisheries and Wildlife and managed as part of the Coast of Maine Wildlife Management Area. Spirit Ledge is closed to public use from April 15 to July 31, annually.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Common Eider	10,000 Adults, 2005	Winter
T/E Species	Harlequin Duck	88 Adults[3], 1991	Winter
Species at Risk	Purple Sandpiper	300 Adults and Juveniles[2], 1991	Winter

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The Cowpens/Whitehorse Island/ White and Green Ledges

Greater Isle au Haut IBA

Isle au Haut

Description - These sites are located east and northeast of Isle au Haut. Mostly barren granite ledges, these sites are exposed to the southeast with little protection from the open Atlantic.

Bird Resources – Greatest importance of these sites is providing wintering habitat for Harlequin Ducks and Purple Sandpipers. Large numbers of Common Eiders are found here as well. A large Double-crested Cormorant colony can be found at The Cowpen.

Conservation Issues - Oil spills and other overboard discharges pose the greatest threat to these sites and surrounding waters. Its remote location and barren condition shield it from disturbance by recreationists.

Ownership/Access - These sites are owned by the Maine Dept. of Inland Fisheries and Wildlife and managed as part of the Coast of Maine Wildlife Management Area. They are closed to public use from April 15 to July 31 each year.

Selected Ornithological Data

The Cow Pen (E)

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Harlequin Duck	80 Adults[30], 1998	Winter
Species at Risk	Purple Sandpiper	250 Adults and Juveniles[2], 1998	Winter
Species at Risk	Common Tern	96 Breeding Pairs[4], 2005	Breeding

Green Ledge

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Purple Sandpiper	275 Adults and Juveniles[2], 2003	Winter

White Horse Island

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Harlequin Duck	39 Adults[30], 1997	Winter

White Ledge

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Harlequin Duck	75 Adults[30], 1998	Winter
Species at Risk	Purple Sandpiper	200 Adults and Juveniles[2], 1989	Winter

Morgan Meadow Wildlife Management Area — Intervale Marshes IBA
Raymond

Description - Morgan Meadow Wildlife Management Area is a largely forested parcel bisected by Sucker Brook. A powerline corridor runs east-west through the area. Approximately 100 acres of this 1,100-acre management area are wetland. Predominant wetland types include emergent marsh and scrub-shrub. The uplands are characterized by largely mixed forest. The meadow itself probably results from an impoundment formed by a rock and earthen dam dating to the late 1800s. Remnants of an abandoned mill site are still present.

Bird Resources - For its size, Morgan Meadow has a diverse group of Maine's marshbirds including Green and Great Blue Heron, American Bittern, Sora and Virginia Rail. The surrounding uplands provide excellent habitat for forest birds, including many species of thrushes and warblers. Species recorded during surveys in 2000 included Nashville Warbler, Northern Waterthrush, and Wilson's Warbler.

Conservation Issues - This site was acquired by the Maine Dept. of Inland Fisheries and Wildlife in 1990. Few improvements have been made and there are minimal conservation concerns. Future acquisition of abutting parcels is desirable but will depend on availability of funds and opportunities. Sustainable harvest of timber will likely take place in the future.

Ownership/Access – This site is owned and managed by the Maine Dept. of Inland Fisheries and Wildlife. Access is restricted to foot traffic as the main road is gated. A small parking area is provided on the Egypt Road approximately 2.5 miles east of Route 85 (East Raymond).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Green Heron	Present[6], 2000	Breeding
Species at Risk	Northern Harrier	Present[6], 2000	Breeding
Congregations: Water Birds	Virginia Rail	8 Breeding Adults[6], 2000	Breeding
Congregations: Water Birds	Sora	Present[6], 2000	Breeding
Species at Risk	Black-billed Cuckoo	3 Breeding Adults[6], 2000	Breeding

Appledore/Smuttynose/Duck Islands Isle of Shoals IBA
Kittery

Description – These three islands are part of an archipelago on the Maine/New Hampshire border. The Isles were a favorite stop for fisherman prior to colonial times. Celia Thaxter, island poet, made the islands famous in her many writings. Appledore Island is home to Shoals Marine Laboratory which offers experiential education in an offshore setting. This is an important seabird island complex, in part because it abuts a long stretch of water with few islands to the south.

Bird Resources – Appledore supports Glossy Ibis, Black-crowned Night-herons, and gulls, as well as a sizeable colony of Snowy Egrets. Appledore has long been the site of an extensive songbird banding program. Duck Island is home to a large colony of Double-crested Cormorants. Smuttynose is best known for its Herring and Great Black-backed Gull colony.

Conservation Issues - Raccoon predation has been a problem. Disturbance is inevitable on Appledore with so many buildings and human inhabitants. However, staff of Shoals Marine Lab are sensitive to the needs of seabirds nesting on this island where they also live and work.

Ownership/Access – The U. S. Fish and Wildlife Service owns Duck Island and recently acquired an easement on Smuttynose. Appledore is owned by Cornell University. All are zoned Significant Wildlife Habitat under NRPA. For more information regarding Duck or Smuttynose, contact the Maine Coastal Island National Wildlife Refuge in Rockport, Maine. Visit www.sml.cornell.edu for information on Appledore Island. Smuttynose is closed to human activity during the seabird nesting season (April 1 – July 31). Duck Island is closed at all time due to unexploded ordinances on the island.

Selected Ornithological Data

Appledore Island/Boon Island Ledge

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Wadingbirds	Snowy Egret	125 Breeding Pairs[4], 1984	Breeding
Species at Risk	Black-crowned Night-heron	50 Breeding Pairs[4], 1989	Breeding
Congregations: Wadingbirds	Glossy Ibis	40 Individuals[4], 1995	Breeding
Congregations: Seabirds	Herring Gull	1083 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Great Black-backed Gull	841 Breeding Pairs[4], 1995	Breeding

Duck Island

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	1,388 Breeding Pairs[4], 2005	Breeding
Congregations: Seabirds	Great Black-backed Gull	301 Individuals[4], 1995	Breeding

Smuttynose Island

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Herring Gull	387 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Great Black-backed Gull	1,030 Breeding Pairs[4], 1995	Breeding

The Plains Kennebunk Plains IBA
Kennebunk

Description - The Plains is a large sandplain grassland in the town of Kennebunk. The site is composed of native grasses, forbs, and shrubs. The substrate is a thick bed of sand up to 100 feet deep. Grasses and other plants there are well-adapted to this xeric habitat.

Bird Resources - A distinctive group of grassland birds breed at this site. Upland Sandpipers, Grasshopper Sparrows, Vesper Sparrows, Savannah Sparrows, Eastern Meadowlarks, and Bobolinks all occur here. The forest edges support nesting Whip-poor-wills, Black-billed Cuckoos, and an assortment of warblers, and on occasion, local rarities such as Clay-colored Sparrow and Lark Bunting.

Conservation Issues - The site is in conservation ownership. The habitat is managed with periodic prescribed burning and mowing. The site is popular with birders and hikers, and it is important that naturalists and all visitors respect the regulations designed to protect nesting birds. Managing human use at this site is a constant struggle. Dumping trash and driving through The Plains during the nesting season is unfortunately far too common.

Ownership/Access – The Maine Dept. of Inland Fisheries and Wildlife owns over 1000 acres in the area with a conservation easement on an additional 200+ acres. The Nature Conservancy owns an abutting parcel of approximately 135 acres. Lands owned by the Maine Dept. of Inland Fisheries and Wildlife and The Nature Conservancy are cooperatively managed. There are two main access points, one approximately 3.5 miles west of I-95 on Route 99, and another via the McGuire Road about ½ mile east of the junction with Route 99. Travel throughout the plains is restricted during the nesting season and numerous signs describe suitable uses of this area.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Northern Harrier	Present[24]	Spring Migration
Species at Risk	Cooper's Hawk	Present[24]	Breeding
T/E Species	Upland Sandpiper	11 Males Only[18], 2003	Breeding
Species at Risk	Black-billed Cuckoo	Present[24]	Breeding
Species at Risk	Whip-poor-will	Present[24]	Breeding
Migratory Landbirds	Horned Lark	4 Males Only[18], 2002	Breeding
Species at Risk	Wood Thrush	Present[24]	Breeding
Species at Risk	Blue-winged Warbler	Present[7], 2000	Breeding

Species at Risk	Prairie Warbler	Present[7], 2000	Breeding
Species at Risk	Eastern Towhee	Present[7], 2000	Breeding
Species at Risk	Field Sparrow	Present[7], 2000	Breeding
Species at Risk	Vesper Sparrow	41 Males Only[18], 2002	Breeding
Migratory Landbirds	Savannah Sparrow	42 Males Only[18], 2001	Breeding
T/E Species	Grasshopper Sparrow	49 Males Only[18], 2001	Breeding
Species at Risk	Bobolink	30 Males Only[18], 2002	Breeding
Species at Risk	Eastern Meadowlark	27 Males Only[18], 2002	Breeding

Bates-Morse Mountain Conservation Area Lower Kennebec IBA
(Including Sprague and Morse River Saltmarshes)
Phippsburg

Description **–** The Bates-Morse Mountain Conservation Area is comprised of about 600 acres in Phippsburg extending from the Sprague River to the Morse River and to the upland edge of Seawall Beach. Habitats include the sandy Seawall Beach, one of the few remaining unaltered barrier dune systems in Maine, two extensive tidal marshes, and unique forested habitat (maritime spruce-fir forest and pitch pine woodlands).

Bird Resources **–** The mix of habitats and the undisturbed nature of the area provide a unique setting for breeding and migrating birds. The area offshore has concentrations of several hundred wintering American Black Ducks and Common Eiders. The mile-long beach is an annual nesting area for Piping Plovers, and also has been the site of a Least Tern colony in the past. During migration, it becomes a staging and feeding area for flocks of Sanderlings, Least and Semipalmated Sandpipers, Black-bellied and Semipalmated Plovers, and other shorebirds.

The dense woodlands dominated by spruce and fir, and the hardwood area dominated by oak, are populated by warblers, woodpeckers, and other songbirds. Hermit Thrushes and American Robins, for example, are often observed at the boundaries where the marsh and forest meet.

The two extensive saltmarshes support a variety of wading birds, including Great Blue Herons, Greater and Lesser Yellowlegs, Snowy and Great Egrets, and most recently Glossy Ibis. Both Nelson's and Saltmarsh Sharp-tailed Sparrows nest in the tall marsh grasses. Northern Harriers, Osprey, and Bald Eagles hunt the pools and channels. Various duck species breed in the extensive ditch system, as well as stop over during migration.

Conservation Issues **–** The beach is relatively undeveloped, with only two seasonal homes located above the sand dunes at the far northern end. A walk of slightly over one mile from the parking lot to the beach significantly reduces the number of people using the beach for recreation. Visitors number about 12,000 during the year.

Ownership/Access **–** The preserve is private property owned by the Bates-Morse Mountain Conservation Area Corporation, a non-profit corporation with members from the St. John Family, (which originally conserved the area), Bates College, and the general public. Much of Seawall Beach is owned by the Small Point Association. The Nature Conservancy holds conservation easements on the property and owns a small portion of both the Sprague River and Morse River saltmarshes. The Maine Department of Conservation (Bureau of Parks and Lands) owns a portion of the Morse River saltmarsh as part of Popham Beach State Park. Bates College manages the area for research and educational purposes. Public access is off of Route 216 and parking is limited to about 40 cars, with access suspended if the lot is full. Dogs are not allowed at any time of year.

Selected Ornithological Data

Morse River Marsh

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Piping Plover	8 Adults[2], 1993	Migration
Species at Risk	Willet	10 Adults[1, 2], 1997	Migration
Congregations: Shorebirds	Sanderling	100 Adults[2], 1993	Migration
Congregations: Shorebirds	Semipalmated Sandpiper	100 Adults[2], 1993	Migration
Congregations: Shorebirds	Least Sandpiper	100 Breeding Adults[1], 1997	Breeding
Species at Risk	Common Tern	16 Breeding Adults[1], 1997	Breeding
T/E Species	Arctic Tern	6 Breeding Adults[1], 1997	Breeding
T/E Species	Least Tern	3 Breeding Adults[1], 1997	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	22 Breeding Adults[1], 1997	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	7 Breeding Adults[1], 1997	Breeding

Seawall Beach

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Shorebirds (any/all sizes)	1,000 Adults[2], 1994	Fall Migration
T/E Species	Piping Plover	10 Breeding Pairs and 8 Fledglings[15], 2001	Breeding
Congregations: Shorebirds	Sanderling	275 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	175 Adults[2], 1994	Fall Migration
T/E Species	Least Tern	12 Breeding Pairs and 2 Fledglings[15], 1998	Breeding

Sprague River Marsh

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Great Egret	5 Breeding Adults[1], 1997	Breeding
Species at Risk	Black-crowned Night-Heron	Present[1], 1998	Breeding
Congregations: Shorebirds	Semipalmated Plover	25 Breeding Adults[1], 1998	Breeding
Species at Risk	Willet	6 Breeding Adults[1], 1998	Breeding
Species at Risk	Common Tern	26 Breeding Adults[1], 1998	Breeding
T/E Species	Least Tern	4 Breeding Adults[1], 1998	Breeding

Species at Risk	Nelson's Sharp-tailed Sparrow	18 Breeding Adults[1], 1998	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	6 Breeding Adults[1], 1998	Breeding

Popham Beach State Park — Lower Kennebec IBA
Phippsburg

Description – Bordered to the west by the Morse River and to the east by the Kennebec River, Popham Beach State Park encompasses over 500 acres of stunning sand beach, tidal saltmarsh, river estuary, and dune habitat. Surrounding uplands are dominated by pitch pine and heath shrub, with higher elevations characterized by oak/pine woodland and open ocean vistas. The site is named in honor of George Popham who together with 100 men attempted to build a settlement here in 1607. Fort Baldwin, less than two miles east on the Kennebec, was built in 1905 and is a favorite stop of summer visitors to the area.

Bird Resources – Important breeding species include Piping Plover and Least Tern in the sandy beach and dune areas. The marsh harbors good numbers of breeding Saltmarsh and Nelson's Sharp-tailed Sparrow and Willet. This is an important migratory stopover site for shorebirds, gulls, and terns, as well as waterfowl, including significant numbers of American Black Ducks. Migrant and wintering Ipswich Sparrows are reported from here annually. Purple Sandpipers use the rocky headlands. Sea ducks are numerous and easily observed here. Rough-legged Hawks use the marsh area in late fall and winter.

Conservation Issues – The site is visited by thousands of tourists, especially in summer. The number of visitors to this area presents substantial management issues that to date have been well managed. Although this site is protected, birds nesting along the beaches face serious pressure from predation and from dogs running off-leash. The park is adjacent to a major shipping channel and thus there are potential threats from spills or other hazards associated with shipping. Sampling of mercury in the blood of sharp-tailed sparrows indicated elevated levels.

Ownership/Access – The park is owned and managed by the Maine Bureau of Parks and Lands. Popham Beach State Park is accessed via Route 209 about 15 miles south of Bath.

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
T/E Species	Piping Plover	3 Fledgling and 2 Breeding Pairs[15], 1999	Breeding
Congregations: Shorebirds	Sanderling	120 Adults[2], 1982	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	150 Adults[2], 1994	Fall Migration
T/E Species	Least Tern	15 Breeding Pairs[15], 1997	Breeding

Reid State Park — Lower Kennebec IBA

Georgetown

Description – Much like Popham Beach just one peninsula away, Reid State Park is characterized by broad sandy beach, dunes, and coastal woodland. The tidal marsh of the Little River flanks the western border of the park. The mouth of Sheepscot Bay lies to the East. Here too, thousands of visitors come each summer to enjoy the sand, sun, and surf. Local businessman, Walter E. Reid, donated the property to the State of Maine in 1946, making it the first state-owned saltwater beach in Maine.

Bird Resources – As many birders will attest, this is a great spot to see Piping Plovers and Least Terns. The saltmarsh along the Little River and behind Mile Beach provide feeding habitat for Common and Least Terns, and numerous species of herons and egrets. Both Saltmarsh and Nelson's Sharp-tailed Sparrows nest here. Ledges offshore are favorite roosts for Great Cormorants in winter.

Conservation Issues – Similar to Popham, the site is in conservation ownership. The number of visitors to this area presents significant challenges to balancing conservation and public use. Despite its conservation status, beach-nesting birds are confronted with challenges from predation (fox and raccoon) and from dogs walking off-leash. As with other coastal sites, threats from oil spills and other hazardous cargo being spilled overboard is ever present.

Ownership/Access – Reid State Park is owned and managed by the Maine Bureau of Parks and Lands. The park is located at the end of the Sequinland Road in Georgetown about 15 miles south of Woolwich via Route 127.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Semipalmated Plover	250 Adults[2], 1994	Fall Migration
T/E Species	Piping Plover	7 Breeding Pairs and 19 Fledgling[15], 2003	Breeding
Species at Risk	Willet	17 Adults[2], 1997	Migration
Species at Risk	Ruddy Turnstone	8 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Sanderling	320 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	327 Adults[2], 1994	Fall Migration
T/E Species	Least Tern	35 Breeding Pairs[15], 1998	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	12 Breeding Adults[1], 1997	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	2 Breeding Adults[1], 1997	Breeding

Machias Bay IBA

Washington County

This region marks the easternmost edge of Maine's island-studded coastline. Further east, the coast is dominated by headlands flanking the Grand Manan Channel. This area is lightly developed, though oceanfront homes dot the coast, even here in the heart of Downeast Maine. Working harbors abound with activity, especially in the summer months. Tourism is evident, but significantly less than in coastal communities south of Mount Desert Island.

Machias Bay

Machias Bay IBA

Machiasport

Description – Machias Bay extends from the mouth of the Machias River at Machiasport to the Libby islands approximately three miles offshore. The eastern side of the bay is split by Sprague Neck, with the northeaster portion known as Holmes Bay. At low tide, significant tidal flats can be found. Numerous small islands and barren ledges provide habitat for seabirds and wintering waterfowl.

Bird Resources – Machias Bay is an especially important area for feeding and roosting shorebirds especially peeps. This area also supports large numbers of wintering Black Ducks.

Conservation Issues – Portions of Machias Bay are designated as Areas of Shorebird Management Concern that qualify as Significant Wildlife Habitat under Maine's Natural Resources Protection Act. This requires a permit for placement of permanent structures such as docks within the intertidal zone. Increasing coastal development is always a threat to sensitive species such as shorebirds. Though Washington County, in general, is not characterized by the rate of development that has been seen in southern and midcoast Maine, waterfront property is always at a premium. Threats from a coastal oil spill could have serious consequences for marine life in Machias Bay.

Ownership/Access – The bulk of the lands in this area are privately owned. The best viewing, therefore, is by water. Public boat launches are available in the village of Machiasport and in Bucks Harbor.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	870 Adults & Juveniles[2], 1991	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	250 Adults & Juveniles[2], 1991	Fall Migration
Species at Risk	Willet	Present[2], 1996	Fall Migration
Species at Risk	Whimbrel	80 Adults & Juveniles[2], 1996	Fall Migration
Species at Risk	Ruddy Turnstone	40 Adults[2], 1994	Fall Migration

Congregations: Shorebirds	Sanderling	200 Adults & Juveniles[2], 1996	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	1,800 Adults &Juveniles[2], 1991	Fall Migration
Species at Risk	Dunlin	6 Adults & Juveniles[2], 1994	Fall Migration
Species at Risk	Short-billed Dowitcher	11 Adults[2], 1994	Fall Migration

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Sprague Neck — Machias Bay IBA
Cutler

Description **–** Sprague Neck is a peninsula of land dividing Machias Bay to the west and south and Holmes Bay to the north and east. A gravel spit, approximately ½ mile long, is found on the north end of the neck. Extensive mudflats are found in nearby Holmes Bay.

Bird Resources **–** The neck and surrounding flats are extremely important for shorebird feeding and roosting.

Conservation Issues **–** Nearby Holmes Bay is designated as an Area of Shorebird Management Concern that qualifies as Significant Wildlife Habitat under Maine's Natural Resources Protection Act. A permit is required for placement of permanent structures such as docks within the intertidal zone. Coastal development along the shore of Holmes Bay could be a problem at some point in the future. Threats from a coastal oil spill could have serious consequences for shorebirds and the marine invertebrates on which they depend. Disturbance associated with clamming and worming can be a problem when large numbers of persons use the area. Also, use of airboats to access the flats for clamming can be disturbing to shorebirds.

Ownership/Access **–** Sprague Neck is currently owned by the U. S. Dept. of the Navy, as the Naval Computer and Telecommunications Station - Cutler. Although the area includes an ecological reserve and a watchable wildlife site, access is difficult and best made in writing well in advance of visiting the area. Birds feeding and roosting in the area can be viewed from the water and boat launches in Machiasport and Bucks Harbor facilitate access to locations throughout Machias Bay.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Black-bellied Plover	250 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	224 Adults[2], 1991	Fall Migration
T/E Species	Piping Plover	Present[2], 1994	Fall Migration
Species at Risk	Whimbrel	24 Adults and Juveniles[2], 1991	Fall Migration
Species at Risk	Ruddy Turnstone	10 Adults[2], 1994	Fall Migration

Congregations: Shorebirds	Semipalmated Sandpiper	2000 Adults and Juveniles[2], 1994	Fall Migration
Congregations: Shorebirds	Western Sandpiper	Present[2], 1991	Fall Migration
Congregations: Shorebirds	Least Sandpiper	150 Adults[2], 1996	Fall Migration
Species at Risk	Dunlin	7 Adults and Juveniles[2], 1994	Fall Migration
Species at Risk	Short-billed Dowitcher	400 Adults and Juveniles[2], 1991	Fall Migration

Old Man Island — Machias Bay IBA

Cutler

Description – Old Man Island lies just beyond the mouth of Little Machias Bay, about four miles southwest of Cutler. This important wildlife island is small and treeless.

Bird Resources – This is an extremely important seabird island at the edge of the "Bold Coast". This site is especially well known for its large colony of Razorbills with 160 pairs present in 1999. Numerous other seabirds nest here as well, including Double-crested Cormorants, Common Eiders, Black Guillemots, Leach's Storm-petrels, and gulls. Of note, in 1907, this island supported the only two remaining pairs of eiders nesting on the entire coast of Maine.

Conservation Issues – This island was one of the first to come into conservation ownership by a government agency in coastal Maine. It is zoned Significant Wildlife Habitat under Maine's Natural Resources Protection Act.

Ownership/Access – The island is owned by U. S. Fish and Wildlife Service and managed as part of the Maine Coastal Islands National Wildlife Refuge. Access to this seabird nesting island is restricted from April 1 through August 31.

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Species at Risk	Leach's Storm-petrel	400 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Double-crested Cormorant	306 Breeding Pairs[4], 1991	Breeding
T/E Species	Razorbill	160 Individuals[4], 1999	Breeding
Congregations: Seabirds	Black Guillemot	125 Individuals[4], 1999	Breeding

Libby Islands — Machias Bay IBA

Machiasport

Description – Big and little Libby Islands are mostly treeless and lie in outer Machias Bay.

Bird Resources – At one time, over 1500 Common Eiders nested on these islands. They are also especially important Herring Gull and Great Black-backed Gull nesting sites. Large numbers of Leach's Storm-petrels are believed to nest here as well. Furthermore, the shoreline is especially good habitat for Black Guillemots. There has been a large population of resident Canada Geese nesting here in recent years.

Conservation Issues – An active aquaculture site is adjacent to these islands. It is not clear whether there is any effect on nesting or feeding seabirds. These islands are zoned as Significant Wildlife Habitat under Maine's Natural Resources Protection Act.

Ownership/Access – Big Libby Island is owned by the Maine Dept. of Inland Fisheries and Wildlife, and managed as part of the Coast of Maine Wildlife Management Area. It was purchased with funds from the first state duck stamp print in 1984. The U. S. Fish and Wildlife Service assumed ownership of Little Libby Island when it took responsibility for the lighthouse there. Landing at either of the Libby Islands is restricted from April 1 through August 31.

Selected Ornithological Data

Big Libby Island

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	Present[4], 1994	Breeding
Congregations: Seabirds	Common Eider	450 Breeding Pairs[4], 1994	Breeding
Congregations: Seabirds	Herring Gull	2,160 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Great Black-backed Gull	1,400 Breeding Pairs[4], 1991	Breeding
Congregations: Seabirds	Black Guillemot	101 Individuals[4], 2001	Breeding

Milbridge to Addison IBA **Washington County**

The many bays, coves, and flats between Milbridge and Addison are widely recognized as an area of continental significance for shorebird conservation. The fertile waters and sheltered shores allow migrant shorebirds the opportunity to stopover and put on fat stores before a long flight to wintering grounds in the southern hemisphere. This area in western Washington County is crowned by four small towns: Milbridge, Cherryfield, Harrington, and Addison. These villages are not widely considered tourist destinations, but rather hubs of local commerce. As such, the coast here is largely undisturbed. The area supports a local fishing community, where clamming is especially important. In addition to the thousands of shorebirds that can be found here, the area is also well known for Bald Eagles and wintering Black Ducks. Nelson's Sharp-tailed Sparrows breed in the saltmarshes at the head of the many rivers in this area.

Narraguagus River & Bay/Back Bay **Milbridge to Addison IBA**

Milbridge

Description **–**The landscape of the Milbridge area is dominated by the Narraguagus River. This river drains an extensive area of western Washington and eastern Hancock Counties. Back Bay is an expansive mudflat at low tide with surrounding components of eelgrass beds and emergent saltmarsh. At high tide there is an exposed ledge in the center of the bay where shorebirds, including large numbers of Short-billed Dowitchers, roost. Bald Eagles are commonly seen throughout the area.

Bird Resources **–** The area supports productive feeding flats for thousands of migrating shorebirds from July through September. The mouth of the Narraguagus River, together with Back Bay, are important sites for wintering Black Ducks.

Conservation Issues **–** Although several camps and permanent residences surround the bay, human disturbance is minimal due to the expansive mudflat area. The flats here are designated as an Area of Shorebird Management Concern that qualifies as Significant Wildlife Habitat under Maine's Natural Resources Protection Act. As such, a permit is required prior to placement of permanent structures such as docks within the intertidal zone.

Ownership/Access **–** Surrounding lands are mostly privately owned though the Maine Dept. of Inland Fisheries and Wildlife does own a small parcel in Milbridge with frontage on both the Narraguagus River and Route 1A. Parking is extremely limited. A public boat launch is available at the mouth of the Narraguagus River and on Rays Point Road which provide the best opportunity for viewing this area from the water. Portions of Back Bay may be viewed from Rays Point Road itself.

Selected Ornithological Data

Narraguagus River

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Least Sandpiper	100 Adults[2], 1996	Migration
Species at Risk	Short-billed Dowitcher	300 Adults[2], 1996	Fall Migration

Narraguagus River Marshes

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Bald Eagle	Present[1], 1999	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	18 Breeding Adults[1], 1999	Breeding

Smith Cove

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	1000 Adults[2], 1999	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	274 Adults[2], 1999	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	1282 Adults[2], 1999	Fall Migration

Dyer Cove

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	700 Adults and Juveniles[2], 1996	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	200 Adults[2], 1999	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	3000 Adults[2], 1989	Fall Migration
Species at Risk	Short-billed Dowitcher	30 Adults[2], 1999	Fall Migration

Pigeon Hill Bay

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	660 Adults and Juveniles[2], 1996	Fall Migration
Congregations: Shorebirds	Black-bellied Plover	110 Adults and Juveniles[2], 1989	Fall Migration
Congregations: Shorebirds	Yellowlegs Spp.	100 Adults[2], 1996	Fall Migration
Species at Risk	Willet	Present[2], 1996	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	326 Adults[2], 1999	Fall Migration
Species at Risk	Short-billed Dowitcher	300 Adults[2], 1996	Fall Migration

Congregations: Shorebirds	Dowitcher Spp.	370 Adults[2], 1989	Migration

Back Bay

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	4,000 Adults[2], 1996	Fall Migration
Congregations: Shorebirds	Greater Yellowlegs	200 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Yellowlegs Spp.	500 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Lesser Yellowlegs	125 Adults[2], 1994	Fall Migration
Species at Risk	Ruddy Turnstone	50 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	1,000 Adults[2], 1999	Fall Migration
Species at Risk	Short-billed Dowitcher	300 Adults[2], 1999	Fall Migration

Mill River/Flat Bay/Blasket Point — Milbridge-Addison IBA

Milbridge and Harrington

Description – Mill River is a meandering tidal river with extensive saltwater marsh and pannes on both banks and on adjacent Cole Creek. Mill River empties into Flat Bay, which together with Blasket Point, has substantial mudflats at low tide. The flats are easily viewed from Oak Point.

Bird Resources – The mudflats in this area are extremely productive, feeding thousands of shorebirds, primarily Semipalmated Sandpipers, but also Least Sandpipers, Black-bellied Plovers, Semipalmated Plovers, Lesser and Greater Yellowlegs, and Short-billed Dowitchers. The Mill River offers salt pannes for feeding and roosting shorebirds at high tide when the flats are unavailable. This area also hosts wintering Bonaparte's gulls and an abundance of waterfowl.

Conservation Issues – This site is designated as an Area of Shorebird Management Concern by the Maine Dept. of Inland Fisheries and Wildlife and qualifies as Significant Wildlife Habitat under Maine's Natural Resources Protection Act. This requires permit review regarding placement of permanent structures within the intertidal zone or saltwater marsh. Upland and marsh habitat on Mill Point have been acquired recently by the Maine Dept. of Inland Fisheries and Wildlife. Although surrounding upland areas are presently undeveloped, the potential for future developments and associated human disturbances is a concern.

Ownership/Access - Surrounding lands are mostly privately owned though the Maine Dept. of Inland Fisheries and Wildlife does own a parcel in Mill River as well as a conservation easement nearby. Public boat launches are available on Rays Point Road in Milbridge and Ripley Neck in Harrington. These provide the best opportunities for viewing this area from the water. Only limited views of Flat Bay can be made from Rays Point Road. A primitive boat launch at Oak Point provides decent views of Flat Bay and an opportunity to launch as well.

Selected Ornithological Data

Mill River

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	500 Adults[2], 1999	Fall Migration
Congregations: Shorebirds	Black-bellied Plover	160 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	300 Adults[2], 1999	Fall Migration
Species at Risk	Whimbrel	Present[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	4,300 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	White-rumped Sandpiper	100 Adults[2], 1994	Fall Migration
Species at Risk	Short-billed Dowitcher	200 Adults[2], 1994	Fall Migration

Flat Bay

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Shorebirds (any/all sizes)	3,000 Adults[2], 1989	Migration
Congregations: Shorebirds	Small Shorebirds	2,000 Adults[2], 1996	Fall Migration
Congregations: Shorebirds	Black-bellied Plover	250 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Greater Yellowlegs	200 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Lesser Yellowlegs	125 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	600 Adults[2], 1994	Fall Migration
Species at Risk	Short-billed Dowitcher	200 Adults[2], 1996	Migration

Blasket Point

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	2,000 Adults[2], 1996	Fall Migration
Congregations: Shorebirds	Greater Yellowlegs	100 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Lesser Yellowlegs	150 Adults[2], 1994	Fall Migration
Species at Risk	Whimbrel	3 Adults[2], 1994	Fall Migration
Species at Risk	Ruddy Turnstone	20 Adults[2], 1994	Fall Migration

Congregations: Shorebirds	Semipalmated Sandpiper	1,000 Adults[2], 1994	Fall Migration
Species at Risk	Short-billed Dowitcher	100 Adults[2], 1994	Fall Migration

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Harrington River and Pleasant River — Milbridge to Addison IBA

Harrington, Addison

***Description* –** The numerous bays and coves and their low tide flats are key to the abundance of shorebirds in this area. The Harrington and Pleasant Rivers divided by the peninsula leading to Ripley Neck are the major landforms of this area.

***Bird Resources* –** This site supports the highest documented concentration of Semipalmated Sandpipers in Maine. The area also supports a large number of wintering Black Ducks and Common Eiders.

***Conservation Issues* –** This area is designated as an Area of Shorebird Management Concern that qualifies as Significant Wildlife Habitat under Maine's Natural Resources Protection Act. This requires a permit prior to placement of permanent structures within the intertidal zone or saltwater marsh. Surrounding upland areas are largely undeveloped, yet, the potential for future housing developments and associated human disturbances is a concern. An oil spill here or at any of the sites in this IBA could be devastating for migrating shorebirds.

***Ownership/Access* –**Surrounding lands are in private ownership, although the Maine Dept. of Inland Fisheries and Wildlife owns a portion of the saltmarsh in the Pleasant River. Access to the estuary is best provided by public boat launches in Addison, Upper Wass Cove, Carrying Place Cove, the west shore of Ripley Neck, and near Mill Creek in Harrington. This site is best viewed from the water.

Selected Ornithological Data

Pleasant River

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Black-bellied Plover	100 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Lesser Yellowlegs	29 Adults[2], 1999	Fall Migration
Species at Risk	Ruddy Turnstone	60 Adults[2], 1999	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	10,000 Adults[2], 2002	Fall Migration
Species at Risk	Short-billed Dowitcher	287 Adults[2], 1996	Fall Migration

Pleasant River Marshes

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Bald Eagle	Present[1], 1999	Breeding

Congregations: Shorebirds	Lesser Yellowlegs	68 Breeding Adults[1], 1999	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	15 Breeding Adults[1], 1999	Breeding

East Carrying Place Cove

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Shorebirds (any/all sizes)	5,000 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Small Shorebirds	4,000 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	100 Adults[2], 1993	Fall Migration
Species at Risk	Whimbrel	Present[2], 1995	Fall Migration
Species at Risk	Ruddy Turnstone	Present[2], 1995	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	800 Adults[2], 1993	Fall Migration
Species at Risk	Dunlin	Present[2], 1998	Fall Migration

Harrington River

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Bald Eagle	Present[1], 1999	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	11 Breeding Adults[1], 1999	Breeding
Species at Risk	Short-billed Dowitcher	500 Adults[2], 1999	Fall Migration

Mash Harbor

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	450 Adults[2], 1998	Fall Migration
Congregations: Shorebirds	Black-bellied Plover	146 Adults[2], 1999	Fall Migration
Species at Risk	Ruddy Turnstone	60 Adults[2], 1998	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	600 Adults[2], 1999	Fall Migration
Species at Risk	Short-billed Dowitcher	296 Adults[2], 1999	Fall Migration

Wass Coves

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water Birds	Common Goldeneye	178 Adults[3], 1999	Winter
Species at Risk	Barrow's Goldeneye	3 Adults[3], 1999	Winter

Congregations: Shorebirds	Shorebirds (any/all sizes)	1,000 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	300 Adults and Juveniles[2], 1998	Fall Migration
Species at Risk	Whimbrel	Present[2], 1996	Fall Migration
Species at Risk	Ruddy Turnstone	2 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	2,000 Adults[2], 2001	Migration
Congregations: Shorebirds	Least Sandpiper	100 Adults[2], 1999	Fall Migration
Species at Risk	Dunlin	6 Adults and Juveniles[2], 1989	Fall Migration
Species at Risk	Short-billed Dowitcher	35 Adults[2], 1999	Fall Migration

West Carrying Place

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Shorebirds (any/all sizes)	3,000 Adults[2], 1989	Migration
Congregations: Shorebirds	Semipalmated Plover	300 Adults and Juveniles[2], 1998	Fall Migration
Congregations: Shorebirds	Greater Yellowlegs	50 Adults[2], 1994	Fall Migration
Species at Risk	Ruddy Turnstone	Present[2], 1999	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	2250 Adults[2], 1989	Migration
Congregations: Shorebirds	Least Sandpiper	100 Adults[2], 1999	Fall Migration
Species at Risk	Dunlin	Present[2], 1999	Fall Migration
Species at Risk	Short-billed Dowitcher	56 Adults[2], 2001	Fall Migration
Congregations: Shorebirds	Dowitcher Spp.	680 Adults[2], 1989	Migration

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West River/Indian River — Milbridge-Addison IBA

Addison/Jonesport

Description – The Indian River flows south through Addison to Whoa Bay. Here the river separates around Crowley Island forming the West River on the west side of Crowley Island and continues as the Indian River on the east side of the island. Both rivers provide productive mud flats for foraging shorebirds.

Bird Resources – Mudflats surrounding Crowley Island provide hundreds of migratory shorebirds with a large feeding area during their fall migration. At one time, thousands of Semipalmated Sandpipers, as well as large numbers of Black–bellied Plovers and Short-billed

Dowitchers have been documented at this site. In recent years, the number of Semipalmated Sandpipers here has waned. Smaller numbers of Lesser Yellowlegs, Greater Yellowlegs, Red Knots, Sanderlings, and White-rumped Sandpipers also use this area. Large boulders at the north end of Crowley Island provide roosting opportunities for Black-bellied Plovers. Wintering Black Ducks are common on both rivers as well.

Conservation Issues – This area is designated as an Area of Shorebird Management Concern that qualifies as Significant Wildlife Habitat under Maine's Natural Resources Protection Act. This requires a permit prior to placement of permanent structures within the intertidal zone. Collaboration between the Pleasant River Wildlife Foundation and Maine Coast Heritage Trust have resulted in the conservation of 293 acres and three miles of shoreline on Crowley Island.

Ownership/Access – A combination of private and conserved lands occurs in the area mostly on Crowley Island where the Maine Dept. of Inland Fisheries and Wildlife and others hold conservation easements. Boat access would be the most efficient means of visiting this area. Boat launches in South Addison and Joneport facilitate birding this area from the water.

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Shorebirds	Shorebirds (any/all sizes)	2,255 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Small Shorebirds	1,290 Adults & Juveniles[2], 1991	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	150 Adults[2], 1989	Fall Migration
Species at Risk	Whimbrel	17 Adults[2], 1999	Fall Migration
Species at Risk	Ruddy Turnstone	Present[2], 1996	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	100 Adults[2], 1989	Fall Migration
Species at Risk	Short-billed Dowitcher	210 Adults[2], 1991	Fall Migration
Congregations: Shorebirds	Dowitcher Spp.	102 Adults[2], 1989	Fall Migration

Mount Desert IBA — Hancock County

The Mount Desert region abounds with natural beauty including coastal mountains, cliffs and Maine's only fjord. Numerous lakes and freshwater ponds dot the landscape, while the surrounding coastal waters in Frenchman and Blue Hill Bays have numerous islands and ledges. Mount Desert Island (MDI) is home to Acadia National Park, which is one of the most heavily visited parks in America. Because of the tremendous natural features and resources in this region, the area has long been a center of commercial activity and tourism. Four municipalities are found on MDI, with Bar Harbor being the most well known and a favorite tourist destination. Mount Desert Island was first explored over 400 years ago and experienced European colonization beginning more than 300 years ago. The island and bays have experienced numerous habitat changes stemming from the expansion and resource use/extraction of first the Europeans and later American colonists. These uses included fishing, granite quarrying, timber harvesting, grazing, and down and egg collecting from numerous species of birds. In extreme cases, entire islands were deforested, marshes were cut for hay, islands were heavily grazed, bird colonies were raided for eggs or down, and in the process, a few species were extirpated or their populations greatly diminished. A large wildfire occurred in 1947 on the northeastern and eastern portions of MDI. This remains evident by the younger hardwood forest communities found in the burned area and stands in stark contrast to the mature coniferous or mixed coniferous forests that dominate the remainder of the island. However, MDI and the numerous islands in the surrounding bays remain an important migratory stopover in both spring and fall with more than 200 species of birds documented as nesting in the area. The MDI region offers numerous opportunities to view all types of birds throughout the year. A few of the region's outer islands comprise the greatest concentration of nesting Common Eiders as well as being important for cormorants, other seabirds, ducks, shorebirds, and colonial birds. A number of the islands surrounding and including MDI are important to the ongoing recovery and stability of Maine's Bald Eagle population and have been for more than 25 years. The island also was one of the initial recovery sites for the Peregrine Falcon and has one of the most reliable and most easily observed Peregrine Falcon eyries in the state.

Mount Desert Narrows — Mount Desert IBA

Bar Harbor, Trenton, Lamoine

Description **–** Separating Mount Desert Island from the mainland, Mount Desert Narrows (together with Eastern Bay) is a thin strip of saltwater extending from roughly Haynes Point in Trenton in the west to Lamoine Beach in the east. The narrows includes several small islands, coves, and ledges, as well as a small saltmarsh. Thompson Island serves as the gateway to Acadia National Park and endures thousands of visitors annually. The Jordan River, a small estuary, empties into the sea here.

Bird Resources **–** This is an excellent spot for viewing congregations of coastal birds including over 2000 Common Eiders, hundreds of Great Black-backed and Herring Gulls, groups of ducks numbering in the hundreds during all seasons, but especially winter. For many years, this area was known for its wintering population of scaup; one of just a few places to support this species on the entire Maine coast. The narrows supports feeding and roosting habitat for numerous species of shorebirds during fall migration, and three known bald eagle nesting territories are found here.

Conservation Issues – This site is vulnerable to the same host of threats as other coastal habitats. Overharvesting of prey species, an oil spill, and direct disturbance from commercial fishing as well as disturbance and pollution from shoreline development are chief concerns in this area. Also, disturbance from intense summer recreational use must be considered.

Ownership/Access – Lands surrounding the Mount Desert Narrows include numerous types of owners. Private commercial and residential developments make up the majority of the owners here. Acadia National Park owns Thompson Island and an adjacent parcel on Mount Desert Island. The Maine Bureau of Parks and Lands operates Lamoine State Park just to the east of the narrows. Some of the best views of the narrows can be made from Thompson Island where there is ample space for parking and picnicking as well as rest room facilities. Two boat launches, one at the Trenton Boat Yard and another at Lamoine State Park, facilitate exploring the narrows from the water without trespassing on private property. A third, more primitive, boat launch can be found on Hadley Point at the north end of Mount Desert Island.

Selected Ornithological Data

Jordan River

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Water Birds	Common Goldeneye	122 Adults[3], 1999	Winter
Species at Risk	Barrow's Goldeneye	6 Adults[3], 1999	Winter
Species at Risk	Nelson's Sharp-tailed Sparrow	9 Breeding Adults[1], 1999	Breeding

Mount Desert Narrows

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Water Birds	American Black Duck	200 Adults and Juveniles[9], 2002	Winter
Congregations: Seabirds	Common Eider	2,500 Adults and Juveniles[9], 2002	Winter

Raccoon Cove

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Shorebirds	Semipalmated Plover	80 Adults and Juveniles[2], 1999	Fall Migration
Species at Risk	Ruddy Turnstone	Present[2], 1989	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	392 Adults and Juveniles[2], 1999	Fall Migration
Congregations: Shorebirds	Western Sandpiper	Present[2], 1999	Migration
Congregations: Shorebirds	Least Sandpiper	400 Adults[2], 1989	Fall Migration

Bass Harbor Marsh — Mount Desert IBA

Tremont/Southwest Harbor

Description – Near the coastal village of Bass Harbor on the southern coastline of Mount Desert Island lies one of its two major tidal marshes. This large saltmarsh contrasts strongly with the surrounding mature coniferous woodland.

Bird Resources – The area is a well-known breeding location for American Black Ducks and Nelson's Sharp-tailed Sparrows. The site has been surveyed extensively, by both amateur birders and professional biologists, and is also the site of several research studies by Acadia National Park. Such surveys have yielded breeding records of rare species including Least Bittern. Open water during fall and winter along the tidal creeks of this marsh often support numerous waterfowl.

Conservation Issues – Although the immediate shoreline of the marsh is in conservation ownership, adjacent lands on most sides of this thin shoreline buffer remain unprotected. These private lands are currently used for housing, extractive and construction industries, and small businesses. Local zoning does not limit further development on these private lands and thereby poses an additional threat to the marsh and lower reaches of the tidal creeks. Buffering from the current and potential private land uses should be a short-term goal, with the long-term goal to conserve these lands to protect water quality, shoreline habitats, and other resource values. Easy access makes Bass Harbor Marsh a great place for ecological outreach for the numerous seasonal visitors to the area. The addition of a small parking area and kiosk would safely accommodate these users.

Ownership/Access – Bass Harbor Marsh is primarily owned by the National Park Service and managed as part of Acadia National Park. Access is easiest from Route 102 just east of the intersection of Routes 102 and 102A. Parking is limited along the roadside.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Least Bittern	3 Adults and Juveniles[17], 2001	Breeding
Species at Risk	Northern Harrier	2 Breeding Adults[1], 1999	Breeding
Species at Risk	American Woodcock	Present	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	9 Males Only[17], 2001	Breeding

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Egg Rock — Mount Desert IBA

Winter Harbor

Description – Found near the mouth of Frenchman Bay, Egg Rock is a barren, 12-acre island with a lighthouse dating to 1875.

Bird Resources – Best known for its large colony of Herring Gulls, this island also supports breeding Great Black-backed Gulls and Common Eiders. In winter, this site has a significant concentration of Purple Sandpipers.

Conservation Issues – Human activities have continued to increase in and around the island because of its proximity to Bar Harbor. These activities range from personal watercraft to tour operators to large cruise ships. Human disturbance linked to the recreational use of small watercraft is a constant threat. Potentially more damaging and of a longer-term nature are the threats (i.e., hazardous spill, overboard discharges, and direct disturbance) associated with the increasing number of cruise ships visiting Frenchman Bay, the multiple daily tours provided by commercial operators during the non-winter months, and the continuing high volume of recreational and commercial fishing boats.

Ownership/Access - The site is currently owned by the U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge, which took ownership from the U. S. Coast Guard in 1999. The island is closed to public access during the seabird nesting season (April 1 – July 31).

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Species at Risk	Purple Sandpiper	290 Adults and Juveniles[2], 1989	Winter
Congregations: Seabirds	Common Eider	600 Adults and Juveniles[9], 2002	Winter

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Ship/Trumpet Islands and Barge Ledges — Mount Desert IBA
Tremont

Description – Ship Island (11 acres), Trumpet Island (3 acres) and nearby East and West Barge Ledges (1 acre combined) lie in the heart of Blue Hill Bay. These small treeless islands have been sites for seabird restoration efforts over the past decade.

Bird Resources – Site of a Common Tern restoration project, Ship Island once supported Common Eiders and Herring Gulls. Eiders and gulls largely avoided the site while conservation interns were present on the island. The smaller Trumpet Island and East and West Barge Ledges provide nesting habitat for Double-crested Cormorants, Great Black-backed Gulls, and Herring Gulls.

Conservation Issues – Ship Island is fully in conservation ownership. Despite this fact, efforts to restore terns have failed because of predation. The high count for nesting Common Terns was 558 pairs in 1999. At present, tern restoration efforts at this site have been discontinued. Human disturbance linked to the recreational use of small watercraft is a known and possibly growing threat, and could limit natural colonization or use by terns or other birds.

Ownership/Access - The site is currently owned by the U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge. The islands are closed to public access during the seabird nesting season (April 1 – July 31).

Selected Ornithological Data

Ship Island

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	166 Breeding Pairs[31], 2003	Breeding
Congregations: Seabirds	Common Eider	850 Breeding Pairs[31], 1999	Breeding
Congregations: Shorebirds	American Oystercatcher	Present[31], 2003	Breeding
Species at Risk	Purple Sandpiper	300 Adults and Juveniles[2 and 5], 1989	Winter
Congregations: Seabirds	Herring Gull	345 Breeding Pairs[31], 1989	Breeding
Congregations: Seabirds	Great Black-backed Gull	343 Breeding Pairs[31], 1989	Breeding
Species at Risk	Common Tern	558 Breeding Pairs[4], 1999*	Breeding

** ≤ 3 pairs since 2004*

Trumpet Island

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	487 Breeding Pairs[4], 1992	Breeding
Congregations: Seabirds	Common Eider	620 Breeding Pairs[4], 2003	Breeding

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The Thrumcap — Mount Desert IBA

Bar Harbor

Description – This granite “dome” island lies just over two miles southeast of Bar Harbor in Frenchman Bay. This island was once forested, but trees have long since died probably as a result of the guano from nesting birds.

Bird Resources – The Thrumcap supports one of the states most significant colonies of Double-crested Cormorants, with a high of 430 pairs documented in 1994. Common Eiders, Herring and Great Black-backed Gulls, and Black Guillemots also nest there. The island is equally important during the winter months to most of these species as well as to wintering flocks of Purple Sandpipers

Conservation Issues – The island is fully in conservation ownership. The most obvious threat is likely from human disturbance, although the steep shoreline makes landing on this island tricky and consequently restricts easy access from recreationists. Potentially more damaging and of a longer-term nature are the threats (i.e., hazardous spill, overboard discharges, and direct disturbance) associated with the increasing number of cruise ships visiting Frenchman Bay, the multiple daily tours provided by commercial operators during the non-winter months, and the continuing high volume of recreational and commercial fishing boats.

Ownership/Access – The island is owned by Acadia National Park, but is managed as part of the Coast of Maine Wildlife Management Area. Therefore, the island is closed to public access during the seabird nesting season (April 15 – July 31).

Muscongus Bay IBA Knox and Lincoln County

Muscongus Bay, located in mid-coast Maine, has a rich fishing history and has long supported significant numbers of breeding and non-breeding water birds on and around the many islands and ledges. The first seabird restoration projects were initiated here in the 1970's on Eastern Egg Rock and Old Hump Ledge. The bay is bordered to the west by the Pemaquid Peninsula, to the south by Monhegan Island (an internationally famous migrant trap) and to the east by the fishing villages of Port Clyde and Friendship. The surrounding coastal waters support rich fisheries and tourism.

Hog Island (Todd Wildlife Sanctuary) Muscongus Bay IBA
Bremen

Description – Hog Island is a 330-acre forested island (predominantly maritime spruce-fir forest) with significant populations of breeding songbirds. The island is a wildlife sanctuary and the north end of the island has a rich human history, including a long-running Audubon camp for adults and youth.

Bird Resources – The area is a well-known breeding location for warblers (i.e. Blackburnian, Magnolia, Northern Parula, Black-throated Green, and Yellow-rumped). Swainson's Thrush, kinglets and Winter Wren also are notable breeders. Several raptors breed on the island including Bald Eagle, Osprey, Merlin and Sharp-shinned Hawk. The island is a haven for up to 500 Purple Sandpipers in winter. Both amateur birders and professional biologists, attending the Audubon camp, have extensively surveyed bird populations at this site.

Conservation Issues – This wildlife sanctuary has no known conservation issues that would threaten the bird populations at this site.

Ownership/Access – The island is owned by National Audubon and access is limited. Camp programs managed by Maine Audubon run throughout the summer for both adults and kids, with topics focusing on birds and conservation science. Call 781-2330 for more information.

Wreck Island Muscongus Bay IBA
Bristol

Description – Wreck Island is located in a transitional zone and is one of the last large undeveloped forested islands in the outer portions of Muscongus Bay. The forest here is a mixture of deciduous and coniferous species.

Bird Resources – This island supports nesting Bald Eagles, Osprey and a significant mixed heron rookery including nesting Great Blue Herons and Black-crowned Night-herons. Snowy Egrets also have been observed courting on the island. Several species of seabirds also nest on the island including Herring and Great Black-backed Gulls as well as Common Eider.

Conservation Issues – The primary conservation issue for Wreck Island is disturbance from recreational boating traffic including sea kayaks. Threat of an oil spill here is of concern.

Ownership/Access – Owned by the State of Maine, the Dept. of Inland Fisheries and Wildlife has management authority for Wreck Island as part of the Coast of Maine Wildlife Management Area. This island is closed to visitation from February 15 – August 31, annually.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Great Blue Heron	150 Breeding Pairs[11], 1995	Breeding
Species at Risk	Black-crowned Night-Heron	30 Breeding Pairs[11], 1977	Breeding
Congregations: Seabirds	Common Eider	450 Breeding Pairs[4], 1995	Breeding
Congregations: Shorebirds	Small Shorebirds	159 Adults and Juveniles[2], 1989	Fall Migration
Congregations: Shorebirds	Black-bellied Plover	Present[2], 1989	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	221 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Greater Yellowlegs	Present[2], 1989	Fall Migration
Congregations: Shorebirds	Spotted Sandpiper	Present[2], 1989	Migration
Species at Risk	Ruddy Turnstone	Present[2], 1989	Fall Migration
Congregations: Shorebirds	Sanderling	126 Adults and Juveniles[2], 1989	Fall Migration

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Franklin Island — Muscongus Bay IBA

Friendship

Description – Franklin Island is a 12-acre island with small stands of red spruce and abundant open habitat dominated by raspberry, grasses, and forbs. The third lighthouse in Maine was constructed on the island in 1808.

Bird Resources – Franklin Island once supported the largest nesting population of Common Eiders in Maine. Unfortunately, avian cholera virtually eliminated the population in the 1980s. Common Eiders still breed here (over 300 pairs in 2003) together with Herring and Great Black-backed Gulls, Leach's Storm-petrels, Black Guillemots and Ospreys. In winter, this site provides foraging and roosting habitat for Purple Sandpipers.

Conservation Issues – Human disturbance and mammalian predation are the greatest threat to this site. Risks from oil spill and other discharge from boats are constant threats as well.

Ownership/Access - The site is owned by the U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge, which took ownership from the U. S. Coast Guard in 1973. The island is closed to public access during the seabird nesting season (April 1 – July 31).

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Species at Risk	Leach's Storm-petrel	12 Breeding Pairs[4], 1977	Breeding
Species at Risk	Black-crowned Night-Heron	4 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Common Eider	1,300 Breeding Pairs[4], 1983*	Breeding
Species at Risk	Purple Sandpiper	290 Adults and Juveniles[2], 1996	Wintering
Congregations: Seabirds	Herring Gull	74 Breeding Pairs[4], 2003	Breeding
Congregations: Seabirds	Great Black-backed Gull	74 Breeding Pairs[4], 2003	Breeding

** The latest estimate was 336 pairs in 2003.*

Eastern Egg Rock — Muscongus Bay IBA

St. George

Description – Eastern Egg Rock is a seven-acre treeless island located in outer Muscongus Bay. This site was host to the first seabird restoration program in Maine, with a focused effort to reintroduce breeding Atlantic Puffins. Building on that success, Arctic, Common, and Roseate Terns have been restored here as well.

Bird Resources – The island supports state and regionally significant populations of nesting Arctic and Common Terns as well as the largest colony of federally Endangered Roseate Terns in the Gulf of Maine. It is also home to nesting Atlantic Puffins, Black Guillemots, Laughing Gulls (the largest colony in the state), Common Eider and Leach's Storm-petrel. Razorbills have been prospecting in recent years and it is hoped they too will eventually breed. The island also supports significant numbers of migratory and wintering shorebirds including Ruddy Turnstones and Purple Sandpipers, as well as a notable Passerine migration in the spring.

Conservation Issues – Human disturbance is limited, but may be a concern. During summer, this island is frequently visited by large numbers of private boats and commercial tours hoping to view puffins. Foraging locations for breeding seabirds are not known so hazardous spills off-site could potentially devastate the bird life of the island. Predation and displacement of nesting Roseate Terns by Laughing Gulls are also significant conservation issues.

Ownership/Access – The island is owned by the Maine Dept. of Inland Fisheries and Wildlife and managed intensively by National Audubon. This seabird nesting island is closed to landing during the nesting season (April 15 through August 31).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	113 Breeding Pairs[4], 1996	Breeding
Congregations: Seabirds	Common Eider	369 Breeding Pairs[4], 2004	Breeding
Species at Risk	Willet	Present, Adult[2], 1994	Migration
Species at Risk	Whimbrel	Present, Adult[2], 1994	Migration
Species at Risk	Ruddy Turnstone	450 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Red Knot	53 Adults[2], 1993	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	81 Adults[2], 1993	Fall Migration
Species at Risk	Purple Sandpiper	300 Adults and Juveniles[2], 1989	Fall Migration
Species at Risk	Short-billed Dowitcher	10 Adults[2], 1993	Fall Migration
Species at Risk	Laughing Gull	1,638 Breeding Pairs[4], 2005	Breeding
T/E Species	Roseate Tern	165 Breeding Pairs[4], 2000	Breeding
Species at Risk	Common Tern	1,514 Breeding Pairs[4], 2001	Breeding
T/E Species	Arctic Tern	94 Breeding Pairs[4], 1997	Breeding
T/E Species	Atlantic Puffin	80 Breeding Pairs[4], 2006	Breeding

Outer Penobscot Bay IBA **Knox County**

The islands that make up the Outer Penobscot Bay IBA are each unique and starkly beautiful. Together they are essential for successful seabird conservation on the coast of Maine. These islands, largely unforested, lie at the edge of the open Atlantic and consequently are often harsh, inhospitable places. All three of the islands have active seabird restoration programs and are occupied by conservation interns each breeding season.

Matinicus Rock **Outer Penobscot Bay IBA**

Criehaven Township

Description – This treeless island marks the outermost boundary of Penobscot Bay. The site has had the longest conservation presence of any island in the state with National Audubon providing stewardship since the 1960s.

Bird Resources – This site is truly special for many Alcids, with Atlantic Puffins, Razorbills and Black Guillemots all nesting here in large numbers. In recent years, Common Murres and even a Manx Shearwater, have been prospecting here. This site is especially important for Arctic Tern, Laughing Gull, and Leach's Storm-petrel. In total, eight species of seabirds nest here.

Conservation Issues – Despite seabird conservation interns living on the island and posted closure during the nesting season (see below), the public still attempts to land on the island every year. Such landings can have disastrous consequences on tern productivity. The threat of an oil spill here is ever present.

Ownership/Access – The island is owned by the U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge. The island is closed to the public during the Seabird nesting season (April 1 to August 31).

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Species at Risk	Leach's Storm-petrel	706 Breeding Pairs[4], 1994	Breeding
Species at Risk	Laughing Gull	842 Breeding Pairs[4], 2006	Breeding
Species at Risk	Common Tern	292 Breeding Pairs[4], 2006	Breeding
T/E Species	Arctic Tern	1,161 Breeding Pairs[4], 1991	Breeding
T/E Species	Razorbill	291 Breeding Pairs[4], 2006	Breeding
Congregations: Seabirds	Black Guillemot	600 Breeding Pairs[4], 1995	Breeding
T/E Species	Atlantic Puffin	309 Breeding Pairs[4], 2006	Breeding

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Metinic Island — Outer Penobscot Bay IBA

Matinicus Island Plantation

Description – At 300 acres, this is the largest of the islands in the Outer Penobscot Bay IBA. The middle section of the island is forested, while the two ends of the island are covered with mixed grass, raspberry, and shrubs. A flock of 120 sheep graze the entire island during some portion of the year. A small seasonal community maintains several homes on the island.

Bird Resources – This site supports eight nesting species including all three coastal tern species. Several hundred pairs of Common Eiders nest on the island, while several thousand molting eiders gather around the island in late summer. Bald Eagles recently began nesting in the interior portion of the island. Forests on the island are believed to provide important stopover habitat for migrating songbirds especially warblers.

Conservation Issues – The Refuge initiated a tern restoration project on Metinic Island in 1998, and the colony grew to 750 pairs by 2004. Sheep grazing may be adversely affecting nesting habitat for Common Eiders. The Refuge uses seasonal sheep grazing to maintain nesting habitat for the terns. The sheep are excluded from the tern nesting area each spring. Biological technicians monitor the tern colony throughout the nesting season.

Ownership/Access – The U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge, owns the northern half of this island. The Refuge-owned portion of the island is closed to public access during the seabird nesting season (Feb 15 – August 31)

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	50 Breeding Pairs[4], 1994	Breeding
Congregations: Seabirds	Common Eider	401 Breeding Pairs[4], 1991	Breeding
Congregations: Seabirds	Herring Gull	322 Breeding Pairs[4], 1995	Breeding
Species at Risk	Common Tern	342 Breeding Pairs[4], 2004	Breeding
T/E Species	Arctic Tern	426 Breeding Pairs[4], 2004	Breeding
Congregations: Seabirds	Black Guillemot	363 Individuals[4], 1995	Breeding
T/E Species	Roseate Tern	3 Breeding Pairs[4], 2003	Breeding

Seal Island — Outer Penobscot Bay IBA

Criehaven Township

Description – This large treeless island was once used for bombing practice by the U. S. Military. Today, the island is best known as a national wildlife refuge with an abundance of seabirds.

Bird Resources – As a breeding area, this site is truly special with a diverse mix of nesting terns, Black Guillemots, and Atlantic Puffins. Seal Island also supports one of the largest colonies of Great Cormorants in the state.

Conservation Issues – The key threat to this site would be an oil spill during the breeding season. Ecotourism, based out of Bar Harbor, has increased in recent years though no known negative effects have been documented.

Ownership/Access – The island is owned by the U. S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge. The island is closed to the public during the seabird nesting season (April 1 to August 31).

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Species at Risk	Leach's Storm-petrel	724 Breeding Pairs[4], 1994	Breeding
Species at Risk	Great Cormorant	29 Breeding Pairs[4], 2004	Breeding
Congregations: Seabirds	Common Eider	333 Breeding Pairs[4], 1997	Breeding
Congregations: Seabirds	Great Black-backed Gull	221 Breeding Pairs[4], 1995	Breeding
T/E Species	Roseate Tern	Present[4], 2006	Breeding
Species at Risk	Common Tern	1,726 Breeding Pairs[4], 2006	Breeding
T/E Species	Arctic Tern	1,167 Breeding Pairs[4], 2004	Breeding
T/E Species	Razorbill	4 Breeding Pair[4], 2006	Breeding
Congregations: Seabirds	Black Guillemot	1,955 Individuals[4], 1995	Breeding
T/E Species	Atlantic Puffin	335 Breeding Pairs[4], 2006	Breeding

Petit Manan IBA — Washington County

The Petit Manan region provides a tremendous diversity of habitat, from long narrow peninsulas jutting into the ocean to countless coastal islands that provide habitat for nesting and migratory species. Bald Eagles nest on many of the forested islands in this area and forage among the nearby seabird islands and in adjacent waters. Common Eiders, Great Black-blacked and Herring Gulls, and Double-crested Cormorants all nest on a variety of treeless islands. Petit Manan Island is home to one of the largest tern colonies in Maine, and one of only four islands in Maine that supports nesting Atlantic Puffins. Razorbills began nesting on Petit Manan in 2004 and their numbers, together with Common Murres, has continued to increase in the region. The jagged shoreline on the mainland and the numerous islands provide extensive intertidal ledges and mudflats that support a variety of migratory and wintering shorebirds and waterfowl. Often overlooked, Cranberry Impoundment on Petit Manan Point supports more than 5,000 ducks at one time, including Black Ducks, Mallards, Pintail and teal, and is protected by Maine Coastal Islands National Wildlife Refuge.

Green Island — Petit Manan IBA

Steuben

Description – The Maine Dept. of Inland Fisheries and Wildlife owns this 10-acre island that is attached to Petit Manan Island by a bar at low tide. The island is located two miles south of Petit Manan Point in Steuben. A mixture of grasses, *Rugosa* rose, *Angelica*, and stinging nettle are the dominant vegetation here.

Bird Resources – Great Black-backed Gull, Herring Gull, and Black Guillemot all nest on Green Island. This island is also one of four islands in Maine where American Oystercatchers nest. In 2001, over 1000 Common Eiders nested there. During the late summer months, the waters surrounding Petit Manan and Green Island support between 5,000 and 7,000 molting Common Eiders. During fall migration, the island supports a variety of shorebirds, with one of the largest concentrations of Ruddy Turnstones recorded in the state. Purple Sandpipers winter on the adjacent ledges.

Conservation Issues – Although the site is in conservation ownership and closed to the public during the nesting season, human disturbance during the nesting season remains a concern. Predation by Bald Eagles and gulls may significantly limit eider production at the colony. Biologists are currently conducting a survival and recruitment study on eiders here.

Ownership/Access – The island is owned by the Maine Dept. of Inland Fisheries and Wildlife and managed as part of the Coast of Maine Wildlife Management Area. It is closed to public access during the seabird nesting season (April 15 – August 31).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Common Eider	1,086 Breeding Pairs[4], 1998	Breeding

Congregations: Shorebirds	Small Shorebirds	1,440 Adults and Juveniles[2], 1989	Fall Migration
Congregations: Shorebirds	American Oystercatcher	Present[2], 2005	Fall Migration
Species at Risk	Ruddy Turnstone	650 Adults[2], 1989	Fall Migration
Congregations: Shorebirds	Red Knot	Present[2], 1989	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	289 Adults[2], 1989	Migration
Congregations: Shorebirds	Least Sandpiper	195 Adults[2], 1999	Fall Migration
Species at Risk	Purple Sandpiper	200 Adults[2], 1993	Winter
Species at Risk	Dunlin	Present[2], 1989	Fall Migration
Species at Risk	Short-billed Dowitcher	54 Adults[2], 1989	Migration
Congregations: Shorebirds	Dowitcher Spp.	343 Adults[2], 1989	Migration

Petit Manan Island — Petit Manan IBA

Steuben

Description – Mixed grasses (especially Canada blue joint) and raspberry dominate the vegetation of this 10-acre island. The island is owned by the U. S. Fish and Wildlife Service, and has several structures (e.g., lighthouse keepers house and 123 foot tower) on the National Historic Register.

Bird Resources – Petit Manan Island hosts the second largest tern colony in Maine. In recent years, over 2,000 pairs of Common, Arctic, and Roseate Terns have nested on the island. In addition, Atlantic Puffins, Razorbills, Black Guillemots, Laughing Gulls, Common Eiders, and Leach's Storm-petrels also nest on Petit Manan Island. The intertidal ledges surrounding the island are used extensively by migratory shorebirds and wintering Purple Sandpipers. During the late summer months, the waters surrounding Petit Manan and Green Island support between 5,000 and 7,000 molting Common Eiders.

Conservation Issues – Biological technicians are stationed on the island from May through August to monitor the colony and prevent public access. Habitat degradation from an oil spill is a constant threat.

Ownership/Access – The island is owned by the U. S. Fish and Wildlife Service (Maine Coastal Islands National Wildlife Refuge) and is closed to public access during the seabird nesting season (April 1 –August 31).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	75 Breeding Pairs[4], 2004	Breeding
Species at Risk	Laughing Gull	1,208 Breeding Pairs[4], 2006	Breeding
T/E Species	Roseate Tern	31 Breeding Pairs[4], 2003	Breeding
Species at Risk	Common Tern	1,602 Breeding Pairs[4], 2006	Breeding
T/E Species	Arctic Tern	911 Breeding Pairs[4], 2004	Breeding
T/E Species	Atlantic Puffin	66 Breeding Pairs[4], 2006	Breeding
T/E Species	Razorbill	Present[4], 2006	Breeding
Species at Risk	Purple Sandpiper	400 Adults and Juveniles[2], 1989	Winter
Congregations: Seabirds	Common Eider	157 Breeding Pairs[4], 2003	Breeding
Congregations: Seabirds	Black Guillemot	150 Breeding Pairs[31], 2004	Breeding

Jordan's Delight — Petit Manan IBA
Milbridge

Description – The vegetation on this 27-acre island is predominately mixed grasses, raspberry, and *Angelica* with several pockets of spruce trees. Large granite cliffs dominate the western shore of the island.

Bird Resources – Common Eiders, Great Black-backed and Herring Gulls, Leach's Storm-petrels, Black Guillemots, and Double-crested Cormorants nest on Jordan's Delight. Throughout the winter months, Purple Sandpipers and Harlequin Ducks forage on and around the intertidal ledges surrounding the island. During migration, Peregrine Falcons frequently perch on the cliffs, waiting for passing songbirds to cross the open water.

Conservation Issues – Maine Coastal Islands National Wildlife Refuge recently acquired majority ownership of this island. A large home that had been constructed within the seabird colony has been removed. Human disturbance during the nesting season has been a problem. Oil spills and other forms of overboard discharge further threaten this island.

Ownership/Access – Most (90% of the island) is in conservation ownership with Maine Coastal Islands National Wildlife Refuge. The remaining land is privately owned with a conservation easement. The island is closed to public access during the seabird nesting season (April 1 – August 31).

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Species at Risk	Leach's Storm-petrel	200 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Common Eider	450 Breeding Pairs[4], 1989	Breeding
Congregations: Seabirds	Black Guillemot	234 Individuals[4], 1995	Breeding
Congregations: Seabirds	Great Black-backed Gull	1400 Individuals[4], 1989	Breeding
Congregations: Seabirds	Double-crested Cormorant	200 Breeding Pairs[4], 1989	Breeding
Congregations: Seabirds	Herring Gull	600 Individuals[4], 1989	Breeding

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Over Point — Petit Manan IBA

Steuben

Description – Over Point is located on the western shore of Petit Manan Point in Steuben. Shorebirds utilize two distinct areas: a long narrow tidal cove and a tidal lagoon surrounded by a cobble bar.

Bird Resources – This site provides stopover and foraging habitat for a variety of shorebirds during the fall migration, including as many as 1,200 Semipalmated Plovers, which is one of the highest concentrations of this species in the state. Shorebirds using this area are counted annually as part of the PRISM shorebird monitoring program.

Conservation Issues – A portion of the area was recently placed under conservation easement with Great Auk Land Trust, however some public use still occurs.

Ownership/Access – Ownership is a mix of conservation (Great Auk Land Trust) and private interests. There is no public access at this time. Portions of the area could be viewed from the water. A boat launch in Pinkham Bay facilitates exploring this area by boat without trespassing on private property.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Small Shorebirds	500 Adults[2], 1996	Fall Migration
Congregations: Shorebirds	Black-bellied Plover	150 Adults[2], 1989	Spring Migration
Congregations: Shorebirds	Semipalmated Plover	1,200 Adults[2], 1988	Fall Migration
T/E Species	Piping Plover	Present[2], 1988	Migration
Species at Risk	Willet	14 Adults[2], 1989	Spring Migration

Species at Risk	Whimbrel	7 Adults[2], 1988	Fall Migration
Species at Risk	Ruddy Turnstone	50 Adults[2], 1988	Spring Migration
Congregations: Shorebirds	Red Knot	38 Adults[2], 1988	Spring Migration
Congregations: Shorebirds	Semipalmated Sandpiper	800 Adults[2], 1988	Migration
Congregations: Shorebirds	Least Sandpiper	150 Adults[2], 1996	Migration
Species at Risk	Dunlin	100 Adults and Juveniles[2], 1987	Fall Migration
Species at Risk	Short-billed Dowitcher	300 Adults[2], 1988	Migration

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Trafton Island — Petit Manan IBA

Harrington

Description – Trafton Island is a small island in outermost Narraguagus Bay. Only one mile offshore, this island is largely forested with several small coves on its perimeter. A recent microburst storm leveled some of the forest there.

Bird Resources – The island has a long established heronry. In 1995, 80 nesting Great Blue Herons could be found here. The island has not been formally surveyed in the interim though numbers of nests are believed to be similar or slightly less. A Bald Eagle nest is located near the center of the island.

Conservation Issues – Concerns are few with the exception of those generally facing coastal habitats: oil spill, overboard discharge, pollution. Heronries in Maine are somewhat ephemeral, so a decline at this site would be consistent with observations at many other island heronries.

Ownership/Access – The Maine Department of Inland Fisheries and Wildlife holds only a conservation easement on this property. There is no public access.

Scarborough IBA — York and Cumberland Counties

The Scarborough IBA is comprised of several different habitats: the marsh proper, the beaches surrounding the marsh, the outlet of the Scarborough River, and two coastal islands. As the state's largest contiguous saltmarsh, Scarborough Marsh supports a variety of flora and fauna with its large expanse of salt meadow communities and numerous salt pannes. Located behind a heavily developed beach system, Scarborough Marsh is crossed by U. S. Route 1, two railroad lines (one active and one abandoned and converted to a recreational trail), and U. S. Route 9. In addition, smaller roads cross several tidal tributaries of the marsh. All of these affect the hydrology of the area. The marsh and surrounding beaches are located in some of the most heavily-developed and fastest-growing communities in southern Maine. However, the rich waters and marine life in this area support a number of breeding colonial wading and seabirds on the off-shore islands. The marsh, mud flats, and salt pannes function as essential migratory stopover sites for many species of shorebirds. This area also supports one of the few remaining commercial soft shell clam industries in southern Cumberland County. Additionally, the Scarborough River continues to serve as an active harbor for commercial fishermen. Unlike smaller saltmarsh systems in southern Maine, Scarborough Marsh is interspersed with fingers of forested uplands, creating a unique juxtaposition of habitat types.

Adjacent to Old Orchard Beach and home to miles of sandy beaches, Scarborough has long been a tourist destination and is visited by thousands of people each year. The marsh provides a unique opportunity for birders, and the general public to observe much of its wildlife. The newly dedicated section of the Eastern Trail has enhanced public access, offering people walking and biking opportunities through the center of the marsh. Maine Audubon provides an interpretive center on the edge of the marsh on Pine Point Road, offering both the experienced and casual birder the latest information on rare sightings and locations to find various species.

Scarborough Marsh Wildlife Management Area — Scarborough IBA
Scarborough

Description – The core of the marsh includes both high and low marsh communities extending from U. S. Route 1 south to the harbor at Pine Point. The total size is approximately 3,000 acres making it Maine's largest contiguous saltmarsh. It is fed by three major tributaries: the Scarborough, Nonesuch, and Libby Rivers. Two partially impounded tidal areas, Dunstan's Landing and areas behind what is commonly referred to as the Pelreco Building, provide a hydrological regime different than other portions of the marsh, and thus attract large seasonal concentrations of waterfowl and wading birds including: Blue and Green-winged Teal, Ring-necked Duck, American Black Duck, American Wigeon, Gadwall, Northern Shoveler, and Northern Pintail, among others. At low tide, extensive mudflats become available along the Scarborough River.

Bird Resources – The marsh supports breeding habitat for both Nelson's and Saltmarsh Sharp-tailed Sparrows, probably the most significant breeding site for these species in Maine. Nelson's/Saltmarsh hybrids may be seen here as well. Least Bitterns have been recorded breeding in the freshwater wetlands surrounding the marsh. Many species of wading birds can be seen feeding in the large salt panne complexes (especially at the outlet of the Libby River, south of the Eastern Road and along U.S. Route 1). Among this network of tidal creeks and pannes, wading birds including Glossy Ibises, American Oystercatchers, Great Blue and Little Blue Herons, Snowy and Great Egrets can be seen feeding. This site also provides feeding habitat for many species of migrating shorebirds including: Whimbrels, Short and Long-billed Dowitchers, Dunlin, Least and Semipalmated Sandpipers, and Red-necked Phalaropes.

Conservation Issues – Human impact has long been an issue at Scarborough Marsh. The U. S. Fish and Wildlife Service is currently working with the U. S. D. A. Natural Resources Conservation Service and other partners to restore tidal flow and control the spread of invasive species in the northern reaches of the marsh. Some of this work results from mitigation efforts following the Julie N oil spill in 1996. In addition, some effort has been put forth to plug ditches that were dug to facilitate the harvest of salt hay. Recent research on Sharp-tailed Sparrows at this site revealed that this species accumulates high levels of mercury from the marsh. Whether the levels affect reproductive success is unclear, but it suggests that human activities around the marsh is significant and may be affecting the ecology of the marsh.

Ownership/Access – The Maine Department of Inland Fisheries and Wildlife owns and manages the area. Maine Audubon maintains an education center there where canoes can be rented for exploring tidal creeks. The easiest foot access is via Pine Point Road (Route 9) where it meets the Eastern Trail, approximately 1.5 miles south of U. S. Route 1. Parking is provided in a small gravel lot; dogs must remain on leash.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water Birds	Water Birds	500 Adults[27]	Migration
Congregations: Wadingbirds	Great Egret	Present[1], 1997	Breeding
Congregations: Wadingbirds	Snowy Egret	62 Breeding Adults[1], 1997	Breeding
Congregations: Wadingbirds	Little Blue Heron	11 Breeding Adults[6], 2000	Breeding
Congregations: Wadingbirds	Tricolored Heron	Present[1], 1998	Breeding
Species at Risk	Black-crowned Night-Heron	Present[1], 1997	Breeding
Congregations: Wadingbirds	Glossy Ibis	33 Breeding Adults[1], 1997	Breeding
Congregations: Water Birds	King Rail	Present[6], 1998	Breeding
Species at Risk	Common Moorhen	Present[27]	Breeding
Congregations: Shorebirds	Small Shorebirds	1,000 Adults[27]	Migration
Congregations: Shorebirds	Black-bellied Plover	124 Adults[2], 1993	Fall Migration
T/E Species	Piping Plover	3 Breeding Pairs and 8 Fledglings[15], 2000	Breeding

Species at Risk	Willet	75 Breeding Adults[1], 1997	Breeding
Congregations: Shorebirds	Spotted Sandpiper	32 Breeding Adults[6], 1998	Breeding
Congregations: Shorebirds	Least Sandpiper	288 Breeding Adults[1], 1997	Breeding
Species at Risk	Short-billed Dowitcher	36 Adults[2], 1993	Migration
T/E Species	Roseate Tern	Present[27]	Breeding
Species at Risk	Common Tern	26 Breeding Adults[1], 1998	Breeding
T/E Species	Arctic Tern	Present[1], 1997	Breeding
T/E Species	Least Tern	Present[1], 1998	Breeding
Species at Risk	Black-billed Cuckoo	Present[27]	Breeding
Species at Risk	Blue-winged Warbler	Present[1], 1998	Breeding
Species at Risk	Chestnut-sided Warbler	Present[1], 1998	Breeding
Species at Risk	Louisiana Waterthrush	Present[27]	Breeding
Species at Risk	Eastern Towhee	Present[27]	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	63 Breeding Adults[1], 1997	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	37 Breeding Adults[6], 1997	Breeding

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Western Beach — Scarborough IBA

Scarborough

Description – Western Beach is a wide, sandy beach about 2500 feet long with a minimal back dune system.

Bird Resources – The beach has become a regular nesting area for Piping Plovers.

Conservation Issues – The beach has accreted in recent years following the dredging of the Scarborough River. Potential habitat for beach-nesting birds has been improved. Dogs off leash (despite signs and ordinances restricting dogs) continue to be a management issue, though efforts to enforce leash laws are in effect. Crow predation also has been a problem for birds nesting on this beach.

Ownership/Access – Western Beach is adjacent to Ferry Beach, which has a paved parking lot for approximately 100 cars. No parking is permitted on Ferry Road. Fees are charged for residents, non-residents, parking, and boat launching. A combination seasonal pass for Ferry Beach and Pine Point beaches is available to Scarborough residents.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Semipalmated Plover	191 Adults[2], 1993	Fall Migration
T/E Species	Piping Plover	3 Breeding Pairs[15], 1998	Breeding
Species at Risk	Willet	9 Adults[2], 1999	Migration
Species at Risk	Whimbrel	Present[2], 1999	Migration
Species at Risk	Ruddy Turnstone	32 Adults[2], 1993	Fall Migration
Species at Risk	Short-billed Dowitcher	31 Adults[2], 1999	Migration

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Pine Point Beach — Scarborough IBA

Scarborough

Description – Pine Point Beach is just over three acres in size, and has 7,000 feet of sandy ocean frontage. A sensitive sand dune system borders the beach, along with substantial summer home development on either side.

Bird Resources – The beach is a regular nesting area for Piping Plovers with a high of four breeding pairs in 2002. The beach is a key feeding area for shorebirds in the spring and fall, with more than 2,000 birds and more than six species using the beach at one time.

Conservation Issues – Crowds of beach-goers and dogs off leash are the primary challenges to the success of nesting Piping Plovers each year. Changes in beach composition following seasonal storms also affect the suitability of the site from year to year.

Ownership/Access – The beach is owned by the Town of Scarborough, and there is parking in a paved lot for a fee.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Piping Plover	4 Breeding Pairs[15], 2002	Breeding
Species at Risk	Willet	15 Adults[2], 1993	Fall Migration
Species at Risk	Whimbrel	23 Adults[2], 1993	Fall Migration
Congregations: Shorebirds	Hudsonian Godwit	13 Adults[2], 1993	Fall Migration
Species at Risk	Ruddy Turnstone	Present[2], 1999	Fall Migration
Congregations: Shorebirds	Sanderling	850 Adults and Juveniles[2], 1993	Fall Migration

Congregations: Shorebirds	Semipalmated Sandpiper	2300 Adults and Juveniles[2], 1993	Fall Migration
Congregations: Shorebirds	Least Sandpiper	87 Adults[2], 1993	Fall Migration
Species at Risk	Dunlin	Present[2], 1993	Fall Migration
Species at Risk	Short-billed Dowitcher	75 Adults and Juveniles[2], 1993	Fall Migration

Higgins Beach — Scarborough IBA

Scarborough

Description – Higgins Beach is a wide sandy beach, approximately 1,000 feet long at the outlet of the Spurwink River. There is a dense neighborhood of about 400 small-to medium-sized homes, many of which are closed up in the winter, abutting the length of the beach.

Bird Resources – The beach is a regular nesting area for Piping Plovers with a high of five breeding pairs and ten fledglings in 2003. Least Terns also nest in regular, but relatively small numbers, with a high of 38 pairs nesting in 2003.

Conservation Issues – The beach is primarily in private ownership. The public may access the beach, but parking limits the number of visitors from outside of the residential area. The beach is heavily used all summer by people and dogs. Restrictions on dogs during the nesting season have helped reduce disturbance to nesting Piping Plovers, but is difficult to enforce. Continued outreach to dog owners in the neighborhood is needed to keep this major disturbance off the beach. In the past, the sensitive nesting areas at the northern end of the beach have been prime sites for gatherings of local teens. Though this activity has decreased in recent years, continued monitoring and education is essential. The town of Scarborough has designated the Piping Plover as its town bird.

Ownership/Access – The beach is primarily in private ownership though there is public access along several points to the beach. Parking is not allowed on the street and is limited to a small pay lot about ½ mile from the beach itself.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Semipalmated Plover	195 Adults[2], 1993	Fall Migration
T/E Species	Piping Plover	5 Breeding Pairs and 10 Fledglings[15], 2003	Breeding
Congregations: Shorebirds	Semipalmated Sandpiper	114 Adults[2], 1993	Fall Migration
T/E Species	Least Tern	38 Breeding Pairs and 53 Fledglings[15], 2003	Breeding

Stratton Island — Scarborough IBA

Old Orchard Beach

Description – Stratton Island is a truly special place. This small island hosts not only a significant tern colony, but a diverse heronry as well. The island's center is dominated by tall shrubs within which the herons nest. The shoreline is a combination of sandy beach and rock outcrop. Small grassy openings also occur on the island as does a small brackish marsh.

Bird Resources – Stratton Island is an important breeding site for numerous Endangered and Threatened birds. Chief among these is the occurrence of over 120 Roseate Terns and nearly 1900 pairs of Common Terns. However, Stratton is better known for its nesting wading birds. At one time, as many as seven species of wading birds nested here, including Cattle, Snowy, and Great Egrets; Little Blue and Tricolored Herons; Black-crowned Night-herons and Glossy Ibis. This island also supports nesting Double-crested Cormorants and Common Eiders.

Conservation Issues – Despite conservation ownership, the island's bird population faces many threats. Each breeding season, seabird interns reside on the island to monitor tern populations and prevent disturbance from boaters and kayakers wishing to land on the island. Predation threats abound as well, especially from resident Black-crowned Night-herons. As with any island, the threat from oil spill or other discharge is ever present.

Ownership/Access – The island is owned by National Audubon. Public access is not allowed during the seabird breeding season.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	209 Breeding Pairs[4], 1999	Breeding
Congregations: Wadingbirds	Great Egret	15 Breeding Pairs[4], 2005	Breeding
Congregations: Wadingbirds	Snowy Egret	163 Breeding Pairs[4], 1999	Breeding
Congregations: Wadingbirds	Little Blue Heron	24 Individuals[4], 1996	Breeding
Congregations: Wadingbirds	Tricolored Heron	Present[11], 1995	Breeding
Congregations: Wadingbirds	Cattle Egret	Present[11], 1994*	Breeding
Species at Risk	Black-crowned Night-Heron	100 Breeding Pairs[11], 1980	Breeding
Congregations: Wadingbirds	Glossy Ibis	163 Breeding Pairs[4], 1996	Breeding
Congregations: Seabirds	Common Eider	1247 Breeding Pairs[4], 2004	Breeding
Congregations: Shorebirds	Small Shorebirds	581 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Plover	132 Adults[2], 1994	Fall Migration

Congregations: Shorebirds	American Oystercatcher	Present[2], 1996	Breeding
Species at Risk	Willet	55 Adults[2], 1993	Migration
Species at Risk	Whimbrel	38 Adults[2], 1994	Migration
Species at Risk	Ruddy Turnstone	251 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	500 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Stilt Sandpiper	Present[2], 1994	Fall Migration
Species at Risk	Short-billed Dowitcher	103 Adults[2], 1994	Fall Migration
T/E Species	Roseate Tern	127 Breeding Pairs[4], 2001	Breeding
Species at Risk	Common Tern	1881 Breeding Pairs[4], 2001	Breeding
T/E Species	Arctic Tern	12 Breeding Pairs[4], 1999	Breeding

** No records since 1994.*

Thomaston IBA — Knox County

Marblehead Island — Thomaston IBA
Matinicus Island Plantation

Description **–** This island is a small, treeless, granite dome in southern Penobscot Bay.

Bird Resources **–** This site was once a significant nesting site for Double-crested Cormorants with over 300 nesting pairs in the mid-1980s. The most recent estimate in 1999 revealed a decline to only 70 nests. This also is the northernmost nesting location for Snowy Egrets. However, the most recent breeding record for Snowy Egret was in 1995 and the site has not been surveyed since 1999.

Conservation Issues **–** Typical of other islands in this area, threats from an oil spill and other forms of pollution are the greatest concern. Steep rock faces surrounding much of the island serve as a deterrent to visitors landing at this site.

Ownership/Access **–** Owned by the State of Maine, the Maine Dept. of Inland Fisheries and Wildlife has management authority for Marblehead Island as part of the Coast of Maine Wildlife Management Area. This island is closed to visitation from April 15 to July 31 each year.

Weskeag Marsh — Thomaston IBA
(Waldo Tyler WMA and Weskeag River)
South Thomaston

Description – This is a tidal river with extensive saltmarsh in the upper portion. Because of tidal restriction at Buttermilk Lane, the marsh above this road is more brackish, lacking large expanses of *Spartina* that characterize much of the saltmarsh. This site is best known for its abundance of pannes and overall surface complexity. The land surrounding the marsh is largely undeveloped despite its close proximity to Thomaston and Rockland. A large cement factory is located within a mile of the site. The marsh is largely surrounded by forest, but agricultural fields border the marsh on portions of its eastern periphery. Extensive tidal flats are found in the lower portion of the river.

Bird Resources – The marsh supports significant numbers of migratory shorebirds, waterfowl, wading birds, and breeding wetland species. The northernmost known breeding site for Saltmarsh Sharp-tailed Sparrow occurs here along with an abundance of Nelson's Sharp-tailed Sparrow. The marsh is an important area for observation of shorebirds (part of PRISM shorebird monitoring network) and is especially good habitat within the state for Stilt, Western, and Baird's Sandpipers and Long-billed Dowitcher. Merlin, Peregrine Falcon, and Northern Harrier occur regularly here, with Peregrines frequently seen chasing shorebirds from the many pannes during late summer. The marsh has a history of attracting rare species including Garganey, Eurasian Wigeon, and Ruff.

Conservation Issues – The Thomaston flats are susceptible to commercial uses (e.g., clamming and worming, industrial development from adjacent boat yard). It is unlikely the cement factory has any environmental influences on the site, given its long history in the area and the continued abundant bird life at the site. Effort to plug ditches (originally constructed to facilitate draining then harvest of salt hay) was initiated in the late 1990's. Disturbance is generally not a problem at this site, though occasional rare birds attract large numbers of birders from across New England. An effort is underway to provide improved viewing opportunities from the adjacent uplands.

Ownership/Access - Weskeag Marsh is fully in conservation ownership, with some of the surrounding upland on the east side protected as well. An easement is being negotiated for further protection near the northern end of the marsh. Access can be found along Buttermilk Lane about 1.5 miles south of U.S. Route 1 in Thomaston. This area is open for public use throughout the year.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	American Bittern	Present[6], 1998	Breeding
Species at Risk	Northern Harrier	Present[6], 1998	Breeding
Congregations: Shorebirds	Small Shorebirds	455 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Black-bellied Plover	210 Adults[2], 1994	Fall Migration
Congregations: Shorebirds	Greater Yellowlegs	65 Adults[2], 1994	Fall Migration
Species at Risk	Willet	Present[1], 1998	Breeding
Congregations: Shorebirds	Marbled Godwit	Present[2], 1996	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	600 Adults[2], 1996	Fall Migration
Congregations: Shorebirds	Least Sandpiper	187 Breeding Adults[1], 1998	Breeding
Species at Risk	Short-billed Dowitcher	330 Adults[2], 1994	Fall Migration
Species at Risk	Nelson's Sharp-tailed Sparrow	29 Breeding Adults[1], 1998	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	8 Breeding Adults[1], 1998	Breeding
Species at Risk	Bobolink	Present[1], 1998	Breeding

Upper Penobscot Bay IBA **Waldo and Hancock Counties**

Where the Penobscot River meets the sea, Upper Penobscot Bay IBA extends from the tidal marshes near Winterport southward to Lincolnville on the west shore and Cape Rosier to the east. This is a working portion of the bay with numerous harbors supporting the lobster fishery and other shipping trades. A variety of sites contribute to this area's importance for bird conservation including state-owned marshes, working waterfronts, and small islands.

Belfast Harbor **Upper Penobscot Bay IBA**

Belfast

Description – On the east side of Penobscot Bay, Belfast Harbor marks the mouth of the Passagassawakeag ("Passy") River. The City of Belfast lies on the southwest shore with some commercial, but mostly residential development on the northeast shore. The harbor has a growing number of recreational boats anchored here during the summer. The closing and removal of the poultry processing facility has changed the face of the waterfront.

Bird Resources – The most significant avian resource here is the annual wintering population of Barrow's Goldeneye. Numerous other species of waterfowl can be found in the estuary year round. The harbor still supports over 2,000 wintering gulls, perhaps more during summer, and is a favorite spot to search for wintering Iceland and Glaucous Gulls.

Conservation Issues – Renovating the Belfast waterfront has been underway for many years and with that perhaps an increase in moorings will follow. Potential for overboard discharge and spilled fuel could degrade the habitat here if the number of moorings expands to very high densities.

Ownership/Access – The surrounding lands are a combination of private commercial and residential with some municipal holdings on the waterfront. There are three public ways of viewing the harbor from land. First is the footbridge which spans the river just seaward from U.S. Route 1. Second, the public pier (beside the Weathervane Restaurant) affords a good view of the main harbor, and third, the waterfront park and boathouse allow great views of the outer harbor. All three access points can be found by taking High Street from U. S. Route 1 to Pierce St. then following along the waterfront.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water Birds	Common Goldeneye	28 Adults[3], 2000	Winter
Species at Risk	Barrow's Goldeneye	15 Adults[3], 2000	Winter

Flat Island — Upper Penobscot Bay IBA

Isleboro

Description – This treeless island lies to the west of Isleboro and east of Northport. This site is an important seabird nesting island in the upper portion of Penobscot Bay.

Bird Resources – For many years, Flat Island has been an important nesting area for Double-crested Cormorants. Herring Gulls, Common Eiders, and Great Black-backed Gulls nest there as well. The abundance of gulls in recent years is generally lower than numbers observed during the mid 1980s.

Conservation Issues – Easy access and close proximity to public boat landings contribute to a constant threat of disturbance, especially to the cormorants nesting there. A small beach on the southeastern side of the island further complicates issues of disturbance during the nesting season.

Ownership/Access – The island is owned by the Maine Dept. of Inland Fisheries and Wildlife and is easily accessible by small boat from several launches including Lincolnville Beach, Bayside, and the ferry terminal on Isleboro. However, this seabird nesting island is closed to human access during the seabird nesting season, April 15 through July 31. During the restricted period, viewing must be from the water only.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Seabirds	Double-crested Cormorant	237 Breeding Pairs[4], 1995	Breeding
Congregations: Seabirds	Common Eider	500 Breeding Pairs[4], 1981	Breeding
Congregations: Seabirds	Herring Gull	1,350 Individuals[4], 1986	Breeding
Congregations: Seabirds	Great Black-backed Gull	600 Individuals[4], 1987	Breeding
Species at Risk	Common Tern	Present[4], 2001	Breeding

Howard Mendall Wildlife Management Area — Upper Penobscot Bay IBA

Frankfort and Prospect

Description – Named for research biologist, educator, and consummate naturalist, Howard L. Mendall, this is one of the few significant saltmarsh habitats in all of Penobscot Bay. Mendall Marsh, as it is often referred to, is formed by the confluence of the north and south branches of Marsh Stream and the Penobscot River. The marsh at one time was an important terminal for shipping granite quarried from nearby mountains. Today, the marsh is dominated by sedges and other grasses and is a popular spot for waterfowl hunting. U. S. Route 1A follows the western edge of the marsh.

Bird Resources – The expansive patches of saltmarsh sedge provide excellent habitat for a large breeding population of Nelson's Sharp-tailed Sparrows. American Black Ducks are found here in good numbers during the nonbreeding season.

Conservation Issues – Despite having a conservation owner, this site is easily accessible and public dumping (e.g., domestic trash, construction debris, white goods, etc.) is an annoyance to managers. U. S. Route 1A is a constant presence through noise, roadside trash, and introduction of invasive species. Purple Loosestrife is present in a few locations and non-native Phragmites occurs in sections along Route 1A. Contaminants in the Penobscot River (mercury, dioxins, heavy metals) are undoubtedly present in the marsh as well, but the level to which local bird life is affected is yet unknown.

Ownership/Access – The marsh is owned and managed by the Maine Dept. of Inland Fisheries and Wildlife and is accessible year round from U. S. Route 1A, about one mile south of Frankfort. A boat launch and an old granite pier provide fine views of the marsh.

Selected Ornithological Data

Criteria	**Common Name**	**Maximum #, Unit, Year**	**Season**
Congregations: Wadingbirds	American Bittern	Present[6], 1998	Breeding
Congregations: Wadingbirds	Great Blue Heron	Present[6], 1998	Breeding
Congregations: Wadingbirds	Snowy Egret	Present[1], 1999*	Breeding
Migratory Landbirds	Turkey Vulture	7 Breeding Adults[1], 1998	Breeding
Congregations: Water Birds	American Black Duck	Present[6], 1998	Breeding
Congregations: Water Birds	Virginia Rail	Present[6], 1998	Breeding
Migratory Landbirds	Bank Swallow	22 Breeding Adults[1], 1999	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	35 Breeding Adults[1], 1999	Breeding
Species at Risk	Bobolink	Present[1], 1999	Breeding

** Seen foraging and roosting (not nesting)*

Sandy Point Wildlife Management Area — Upper Penobscot Bay IBA
Stockton Springs

Description – This 540-acre property is composed primarily of freshwater wetland that drains into the nearby Penobscot River at Sandy Point. The wetland is characterized by dense stands of cattail. A floating mat of vegetation creates a mosaic of habitat with high interspersion of water and vegetation. There are some forested uplands as well.

Bird Resources – This site has supported Least Bitterns for many years and provides habitat for large numbers of Marsh Wrens. Ring-necked Ducks breed here each year at some of the highest densities recorded in Maine.

Conservation Issues – Few threats face this site. Although development and gravel mining along the Muskrat Road could at some time influence the site, this is not anticipated. Portions of the floating mat within the marsh frequently break free and can block the spillway. Under certain conditions, this could lead to a rapid rise in water level.

Ownership/Access – The area is owned and managed by the Maine Dept. of Inland Fisheries and Wildlife. Access is provided from the Muskrat Road in Stockton Springs approximately ¼ mile north of its intersection with U. S. Route 1. The area can be scanned from the dike, although it is best viewed from canoe or kayak. There are no hiking trails in the uplands.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Water Birds	American Black Duck	Present[13], 2002	Breeding
Congregations: Water Birds	American Bittern	5 Adults, 1995	Breeding
Congregations: Water Birds	Ring-necked Duck	33 Breeding Adults[13], 2002	Breeding
T/E Species	Least Bittern	Present, 2005	Breeding

Penobscot River near Bucksport/Fort Knox — Upper Penobscot Bay IBA

Bucksport and Prospect

Description – This portion of the river is a mix of both undeveloped riverfront mostly on the western shore and urban/industrial waterfront on the eastern shore. The city of Bucksport and a large paper mill are obvious features in this portion of the bay.

Bird Resources – Open water portions of the river are important for wintering waterfowl. Some of the largest single congregations of Barrow's Goldeneye in Maine have been recorded here, including 70 adults in the winter of 1980. Peregrine Falcons historically nested on the west support tower of the former Waldo/Hancock Suspension Bridge. Ospreys are commonly seen in this area and several nests can be found on the abandoned pier at Sandy Point Beach.

Conservation Issues – Threats associated with wastewater discharge from the mill and from the City of Bucksport are the greatest concerns. However, the area does not appear to be under the same threats of development as other similar waterfronts. An oil spill, either in the bay or upriver, is a constant threat.

Ownership/Access - Best views of the river are from Fort Knox historic site in Prospect, and from the waterfront park in downtown Bucksport. A boat launch on Verona Island facilitates exploring this area from the water.

Wells IBA

York County

The Wells and Ogunquit regions are home to miles of sandy beaches, hundreds of acres of wide-open saltmarshes and over 16 rivers and streams flowing to the sea. The surrounding uplands generally consist of pockets of undisturbed dune/grassland systems, back barrier beaches, and rocky shores all in the midst of intense coastal development. Forests generally consist of white pine and oak, with remnant patches of pitch pine forest, pitch pine bogs, and maritime shrublands. Saltmarsh, beaches, and shrublands comprise some of the most biologically significant features of this area. The Wells/Ogunquit marshes make up the second largest saltmarsh complex in the State of Maine. The region supports a diverse bird community, in addition to rare and declining plant and animal species.

Crescent Surf Beach

Wells IBA

Kennebunk

Description – This site consists of beach front and dune systems along the northeast shore of the outlet of the Little River in Kennebunk. Most of it is privately owned, though some is U. S. Fish and Wildlife Service property. The site is characterized by a high-energy beach, that is often overwashed providing excellent Piping Plover and Least Tern habitat.

Bird Resources – In most years, the site hosts the largest breeding colony of the state-Endangered Least Tern. Multiple pairs of Piping Plovers nest here as well and generally have had good success. The site provides important shorebird roosts during fall migration. It is an important staging area for Roseate and Common Terns, and provides an alternate roost site for Roseate Terns when they fail on their breeding grounds.

Conservation Issues - Avian and mammalian predation, as well as human disturbance, are the key threats. However, upstream land uses and additional development adjacent to this site also are believed to be important. The location of the Least Tern nesting colony is under conservation easement.

Ownership/Access – Ownership at this site is a mix of private and federal (Rachel Carson National Wildlife Refuge) holdings. There is no public access to this site. Interested parties could launch a boat at Wells Harbor or in the Mousam River in Kennebunk and view this site from the water without trespassing on private property.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Shorebirds	Semipalmated Plover	590 Adults, 2005	Fall Migration
T/E Species	Piping Plover	8 Breeding Pairs[15], 2005	Breeding
Species at Risk	Willet	Present[2], 1993	Fall Migration
Species at Risk	Whimbrel	8 Adults[2], 1988	Migration

Species at Risk	Ruddy Turnstone	Present[2], 1993	Fall Migration
Congregations: Shorebirds	Sanderling	200 Adults, 2005	Fall Migration
Congregations: Shorebirds	Semipalmated Sandpiper	106 Adults[2], 1988	Fall Migration
Species at Risk	Short-billed Dowitcher	90 Adults[2], 1988	Migration
T/E Species	Least Tern	102 Breeding Pairs and 57 Fledglings[15], 2003	Breeding
T/E Species	Roseate Tern	10 Adults[16], 2005	Fall Migration

Laudholm Beach — Wells IBA
Wells

Description – This site consists of a beachfront and dune system along the southwest shore of the Little River outlet, across the river from Crescent Surf Beach. Beaches and dunes south of the immediate area are intensively developed for summer and seasonal residences.

Bird Resources – The site generally hosts a small Least Tern colony as well as nesting Piping Plovers. The site is an especially important shorebird roost during fall migration. Piping Plovers congregate here in large flocks as well, mainly during late summer, prior to migration.

Conservation Issues – As with Crescent Surf Beach, predation and public use, especially dogs off leash, are significant threats to productivity at this site. Dogs are not allowed on Laudholm Beach, but enforcement of regulations has been difficult.

Ownership/Access – This site is owned by the State of Maine, Bureau of Parks and Lands and managed cooperatively with the Wells National Estuarine Research Reserve. Parking is provided at the Wells Reserve where a walking path of approximately ½ mile facilitates accessing the beach without trespassing. For more information and access questions, call the Wells Reserve at (207) 646-1555.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
T/E Species	Piping Plover	5 Breeding Pairs and 15 Fledglings[15], 2002	Breeding
T/E Species	Least Tern	37 Breeding Pairs and 17 Fledglings[15], 2000	Breeding

Marginal Way — Wells IBA
Ogunquit

Description - Nestled in the busy tourist town of Ogunquit, Marginal Way is a paved foot path, stretching 1.25 miles from Perkins Cove to Ogunquit Beach. The path was given to the Town of

Ogunquit in 1923 and has been enjoyed by residents and visitors ever since. The path hugs the rocky sections of the shoreline, offering visitors expansive views of the ocean on one side, and maritime shrubs and impressive homes on the other.

Bird Resources – Marginal Way is especially well known as a viewing area for wintering populations of up to 50 Harlequin Ducks (2000, Maine Bird Notes). Peregrine Falcons, Purple Sandpipers, Common Eider, and occasionally a King Eider, can be seen from here in winter as well.

Conservation Issues - The majority of birds use the adjacent habitat in the winter, when the tourist crowd thins and the wave action provides feeding opportunities. Possible erosion of the path could be a concern, however, this area generally accommodates both heavy public use and excellent bird foraging habitat along the rocky shore. As with other coastal sites in this IBA, threat of oil spill or other overboard discharge remain a concern.

Ownership/Access – Marginal Way is owned and maintained by the Town of Ogunquit. Parking is provided at both ends: on Cottage Street in Perkins Cove and on Shore Road in Ogunquit.

Mousam River

Wells IBA

Kennebunk

Description – The Mousam River in the town of Kennebunk originates at Mousam Lake near Shapleigh and flows through the city of Sanford. The river eventually enters the sea at Parsons Beach just southwest of Kennebunkport village. Saltmarsh habitat borders the river for nearly 2 miles inland from its terminus. The river is a popular spot for sport fisherman, especially at its end.

Bird Resources – This area has not been adequately surveyed for the diverse array of birds that occur here. However, yellowlegs, egrets and various sandpipers use the saltmarsh pannes and pools along the river. High marsh portions of the estuary support Saltmarsh Sharp-tailed Sparrows. The cut banks of the meandering Mousam provide nesting opportunities for Belted Kingfishers and Northern Rough-winged Swallows. Least Terns feed at the mouth of the river. In the winter, the outlet provides habitat for numerous loons.

Conservation Issues – Water quality and human disturbance are the primary concerns at this site.

Ownership/Access – Ownership at this site is characterized by a complex of private, non-profit, and federal (Rachel Carson National Wildlife Refuge) properties. Rachel Carson National Wildlife Refuge lands are generally closed to public entry to protect wildlife from undue disturbance. However, there is a public trail system here that parallels the Mousam River. This trail network includes a viewing platform and offers good opportunities to bird this area. Please consult the Refuge Manager for directions and current regulations (207) 646-9226 or stop by the headquarters and visitor center at 321 Port Road in Wells.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Great Egret	Present[1], 1997	Breeding
Species at Risk	Willet	8 Breeding Adults[1], 1997	Breeding
Species at Risk	Laughing Gull	Present[1], 1997	Breeding
Species at Risk	Common Tern	57 Breeding Adults[1], 1997	Breeding
T/E Species	Arctic Tern	12 Breeding Adults[1], 1997	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	Present[1], 1997	Breeding

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Rachel Carson/Webhannet/Wells Bay Saltmarshes — Wells IBA

Ogunquit and Wells

Description – This is the second largest saltmarsh complex in the state. It has been designated by the Maine Natural Areas Program as an "exemplary natural community" and supports a large array of rare plants and animals. The marsh system has numerous tidal creeks, pools, and pannes and a mixture of high and low marsh habitats. The marsh system is extensive, and is crossed by several roads.

Bird Resources – A complete assessment of the birds using the saltmarsh is exceedingly difficult. The topography of the marsh, specifically its deep tidal creeks, ensures that counts from the road underestimate a large number of birds. Tidal cycles also influence survey counts. However, there are several areas where a great diversity of avian life can be viewed. The marsh has large numbers of sharp-tailed sparrows, egrets, herons, Willets, and shorebirds. It also supports a colony of marsh-nesting Common Terns. Wintering Black Ducks and Canada Geese use the marshes extensively and Northern Harriers are common during migration. Rarities (recently American Avocets) are frequently reported here.

Conservation Issues – Over 500 units of seasonal housing were built on U.S. Route 1 in Wells in 2005 alone. These large developments and increasing impervious surface will likely increase the freshwater and pollutant discharge to the marsh. An increase in commercial kayaking tours has brought people into areas of the marsh that were largely inaccessible before. Sea level rise and tidal restrictions also threaten the health of the marsh. Saltmarsh Sharp-tailed Sparrows sampled from this area had elevated blood mercury levels. Some areas of the marsh have human alterations (roads, ditches, berms, etc.) that have changed the hydrology. Both native genotype and non-native genotype *Phragmites* are documented in the system. The non-native *Phragmites* may threaten the health of the ecosystem. Resident Canada Geese appear to be increasing and could degrade the quality of habitat if numbers become excessive. An updated comprehensive bird survey of this area is needed.

Ownership/Access – Much of the saltmarsh habitat is owned and managed by the U. S. Fish and Wildlife Service (Rachel Carson National Wildlife Refuge). Ownership of the surrounding uplands is a mixture of mostly private, but some federal properties. Refuge lands are generally closed to public entry to protect wildlife from undue disturbance. There are many roads that cross this area and birding from the side of the road can be quite good. Please consult the Refuge Manager for current regulations at (207) 646-9226 or stop by the refuge headquarters and visitor center at 321 Port Road in Wells.

Selected Ornithological Data

Criteria	Common Name	Maximum #, Unit, Year	Season
Congregations: Wadingbirds	Great Blue Heron	38 Breeding Adults[1], 1997	Breeding
Congregations: Wadingbirds	Great Egret	Present[1], 1997	Breeding
Congregations: Wadingbirds	Snowy Egret	55 Breeding Adults[1], 1997	Breeding
Congregations: Wadingbirds	Tricolored Heron	Present[1], 1997	Breeding
Congregations: Wadingbirds	Glossy Ibis	16 Breeding Adults[6], 1998	Breeding
Congregations: Water Birds	Green-winged Teal	Present[1], 1997	Breeding
Congregations: Water Birds	Virginia Rail	Present[6], 1998	Breeding
Congregations: Shorebirds	Semipalmated Plover	250 Adults[16], 2004	Fall Migration
Congregations: Shorebirds	Greater Yellowlegs	40 Adults[16], 2004	Fall Migration
Congregations: Shorebirds	Lesser Yellowlegs	27 Adults[16], 2004	Fall Migration
Species at Risk	Willet	66 Breeding Adults[1], 1997	Breeding
Congregations: Shorebirds	Semipalmated Sandpiper	208 Adults[16], 2004	Fall Migration
Congregations: Shorebirds	Least Sandpiper	90 Adults[16], 2004	Fall Migration
Congregations: Shorebirds	Dunlin	40 Adults[16], 2004	Fall Migration
Species at Risk	Short-billed Dowitcher	Present[16], 2004	Fall Migration
T/E Species	Least Tern	12 Breeding Adults[16], 2004	Breeding
Congregations: Seabirds	Bonaparte's Gull	65 Adults[16], 2004	Fall Migration
Congregations: Seabirds	Ring-billed Gull	69 Breeding Adults[1], 1997	Breeding
Species at Risk	Common Tern	35 Breeding Adults[1], 1997	Breeding
T/E Species	Arctic Tern	24 Breeding Adults[1], 1997	Breeding
Migratory Landbirds	Purple Martin	7 Breeding Adults[1], 1997	Breeding

Migratory Landbirds	Tree Swallow	274 Breeding Adults[1], 1997	Breeding
Migratory Landbirds	Northern Rough-winged Swallow	19 Breeding Adults[1], 1997	Breeding
Migratory Landbirds	Bank Swallow	36 Breeding Adults[1], 1997	Breeding
Species at Risk	Nelson's Sharp-tailed Sparrow	12 Breeding Adults[1], 1997	Breeding
Species at Risk	Saltmarsh Sharp-tailed Sparrow	25 Breeding Adults[1], 1997	Breeding

Sources of Data

1. MDIFW Saltmarsh Surveys
2. MDIFW Shorebird Surveys
3. MDIFW Barrow's Goldeneye Surveys
4. MDIFW Seabird Surveys
5. MDIFW Purple Sandpiper Surveys
6. MDIFW Marshbird Surveys
7. MDIFW Shrubland Surveys
8. MDIFW Airfield Database
9. MDIFW Mid-winter Inventory
10. MDIFW Grassland Surveys
11. MDIFW Wading bird Surveys
12. MDIFW Penjajawoc Survey
13. MDIFW Brood Counts
14. MDIFW Ecoregional Surveys
15. Maine Audubon Data
16. Rachel Carson National Wildlife Refuge, Sampson Cove Surveys
17. Acadia National Park, B. Connery,
18. The Nature Conservancy, Annual Report 2003
19. Maine Bird Notes
20. S. Hall, National Audubon
21. P. Vickery, field notes
22. A. Cadot, field notes
23. D. Tucker, B. Coulton, Field Notes
24. D. Tucker, York Co. Audubon Records
25. J. Markowsky, field notes
26. P. Moynihan, field notes
27. L. Woodard and R. Duddy, field notes
28. Steve Mirick, field notes
29. Tingley 2000
30. Mittelhauser 2002
31. Maine Coastal Islands National Wildlife Refuge Surveys

Appendix

Qualifying Criteria

Primary Criteria:

1. Sites for Threatened and Endangered Species

Sites that regularly support breeding or non-breeding birds listed as Endangered or Threatened at either the state or federal level. The site should have regular and/or recent records for species (within the past 10 years). There is no minimum number to meet the criteria but ideally sites should include at least 1% of the state population (if known) in a season, or be the 3-5 sites in the state with the highest regularly occurring numbers. The list of species includes:

Harlequin Duck	Upland Sandpiper	Razorbill
Bald Eagle	Roseate Tern	Atlantic Puffin
Golden Eagle	Arctic Tern	Sedge Wren
Peregrine Falcon	Least Tern	American Pipit (breeding)
Piping Plover	Black Tern	Grasshopper Sparrow

2. Sites with Species of Conservation Concern ("At Risk")

Sites that regularly support substantial numbers of breeding or non-breeding species that are of conservation concern due to vulnerable and/or declining populations either locally, regionally, or globally. These include all species on the Maine Department of Inland Fisheries and Wildlife's special concern list, regular breeders or migrants ranked by Partners in Flight as Category IA (High Continental Priority/Regional Responsibility), priority species as identified by the National Shorebird Conservation Plan, and additional species that in the expert opinion of the Technical Committee warrant conservation concern. The site should have regular and/or recent records for species (within the past 20 years). There is no minimum number to meet the criteria, but ideally sites will have at least 25 breeding pairs, 5% or more of the state population (if known), or be one of the 2-3 sites in the state with the highest regularly occurring numbers. Sites may also be considered under this criterion if they include a substantial mix of these species. The list of species will be revised and updated as priority and special concern species change over time. The list of species includes:

Leach's Storm-Petrel	American Woodcock	Black-throated Blue Warbler
Great Cormorant	Red-necked Phalarope	Blackburnian Warbler
Black-crowned Night-Heron	Laughing Gull	Prairie Warbler
Least Bittern	Common Tern	Bay-breasted Warbler
Barrow's Goldeneye	Black-billed Cuckoo	Louisiana Waterthrush
Northern Harrier	Eastern Screech-owl	Canada Warbler
Cooper's Hawk	Long-eared Owl	Scarlet Tanager
Northern Goshawk	Short-eared Owl	Eastern Towhee
Red-shouldered Hawk	Whip-poor-will	Field Sparrow
Yellow Rail	Three-toed Woodpecker	Vesper Sparrow

Common Moorhen	Olive-sided Flycatcher	Nelson's Sharp-tailed Sparrow
American Coot	Loggerhead Shrike (migrants)	Saltmarsh Sharp-tailed Sparrow
Willet	Yellow-throated Vireo	Bobolink
Whimbrel	Bicknell's Thrush	Eastern Meadowlark
Ruddy Turnstone	Wood Thrush	Rusty Blackbird
Purple Sandpiper	Blue-winged Warbler	Orchard Oriole
Dunlin	Chestnut-sided Warbler	Baltimore Oriole
Short-billed Dowitcher	Cape May Warbler	

3. Sites with Substantial Concentrations of Birds and/or High Species Diversity

Sites that regularly support high concentrations of one or more species in the breeding or non-breeding season or during migration. The site should have regular and/or recent records for species (within the past 20 years). The guidelines below suggest thresholds for minimum numbers, but should not be viewed as absolute. Numerical estimates should be based on a short period of time, e.g. one-time counts such as daily surveys, not cumulative totals over a season (with the exception of raptors, see below). Exotic and feral species are not included.

A. Water Birds**:** The site regularly supports at least 100 water birds (at one time) if inland or at least 500 water birds (at one time) if coastal, during some part of the year. (For IBA purposes, "water birds" include non-colonial breeders that may migrate or winter in large groups, including loons, grebes, geese, dabbling/diving ducks).

B. Seabirds**:** The site regularly supports at least 1,000 gulls, 200 terns, or 200 Alcids, pelagics and/or in-shore seabirds (at one time) during some part of the year. Pelagic sites are the actual location being used by seabirds, not the point of land from which an observer counts seabirds. Smaller concentrations of less common gulls such as Laughing or Bonaparte's will be considered. Human-made food sources for gulls such as landfills, sewage outflows, etc. will not be considered. (For IBA purposes, "seabirds" are colonial breeders as well as those wintering or migrating at sea in large concentrations, including cormorants, eiders, Alcids, gulls, terns, storm-petrels, and other pelagic birds (e.g., shearwaters, jaegers, gannets)).

C. Shorebirds**:** The site regularly supports at least 100 small shorebirds ("peeps") and/or 40 medium/large shorebirds (at one time) if inland, or at least 1,000 "peeps" and/or 100 medium/large shorebirds (at one time) if coastal, during some part of the year. (Mainly non-breeders that migrate through the state in large numbers, including plovers, sandpipers, snipe, woodcock, phalaropes).

D. Wadingbirds**:** The site regularly supports 60 breeding pairs or 50 foraging wading birds (at one time). (Mainly colonial nesters and/or those that congregate for feeding or staging, including herons, egrets and ibises).

E. Raptors**:** The site is a regular seasonal migration corridor or "bottleneck" for at least 1,000 individuals over the course of the season.

***F. Migratory Land Birds*:** The site is an important and regular stopover or seasonal concentration site for migratory landbirds (e.g., warblers, other non-passerine migrants, etc.), supports exceptionally high densities of breeding species as shown from point counts or other surveys, and/or represents a "migrant trap" relative to surrounding sites. Strong consideration will be given to sites with consistently high overall species diversity.

***G. Exceptional Abundance/Diversity*:** The site is recognized within Maine as having an exceptional concentration and/or diversity of bird life which is clearly outstanding relative to other sites, though may not meet the thresholds described above. Includes sites that do not necessarily harbor large numbers of birds but provide important habitat for many more species, unique species assemblages, or more individuals than most other sites.

Secondary Criteria:

4. Sites for Species in Rare, Vulnerable, or Exemplary Habitat Types:

Sites that support species assemblages dependent on rare or unique habitat types or natural communities within the state, or sites that are exceptional, high-quality, representative examples (e.g., large and intact) of other habitat types or natural communities and contain associated species assemblages.

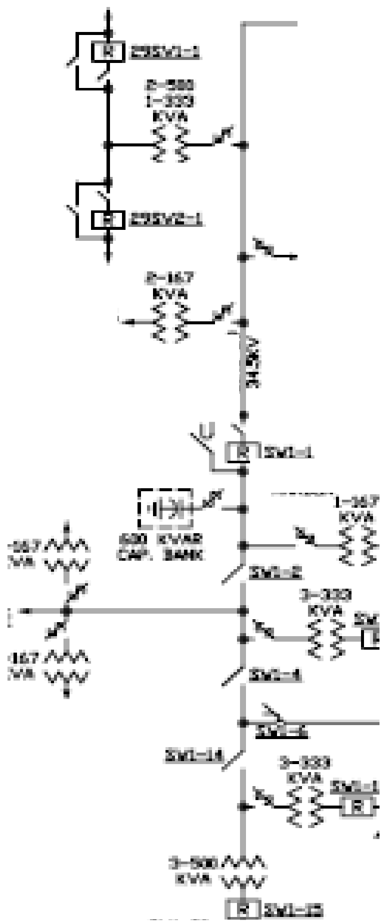
5. Sites Important for Research/Monitoring:

Sites that are important for long-term avian research and/or monitoring projects that contribute substantially to ornithology and bird conservation.

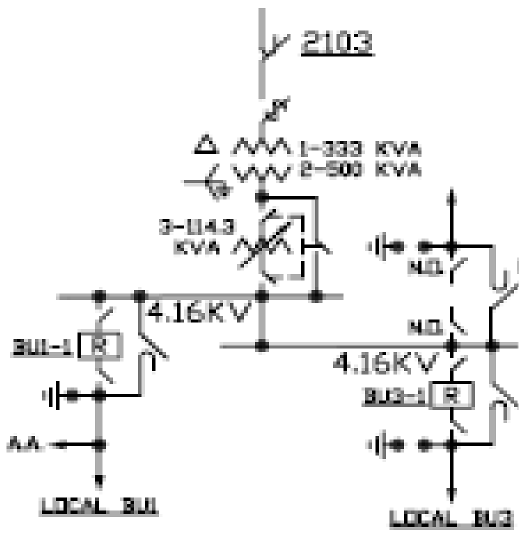
10.3 APPENDIX C – SUBSTATION DIAGRAMS

10.3.1 Appendix C.1 – Substation Diagrams

BHE-Hancock-6 Substation



BHE-Washington-1 Substation



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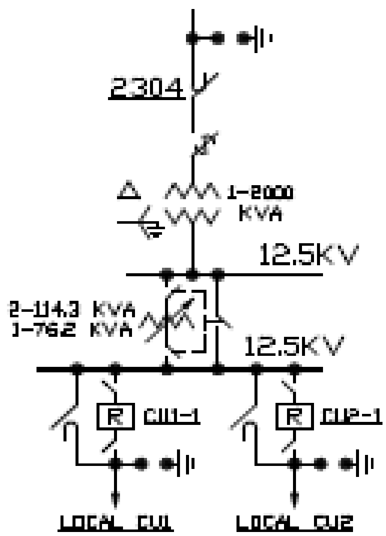
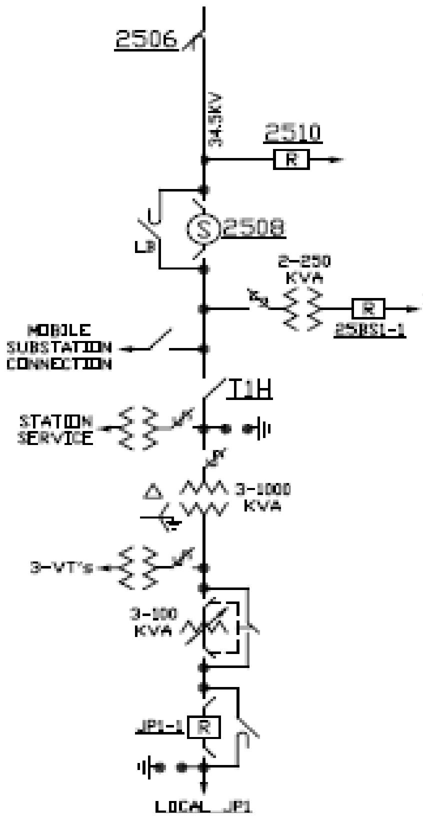
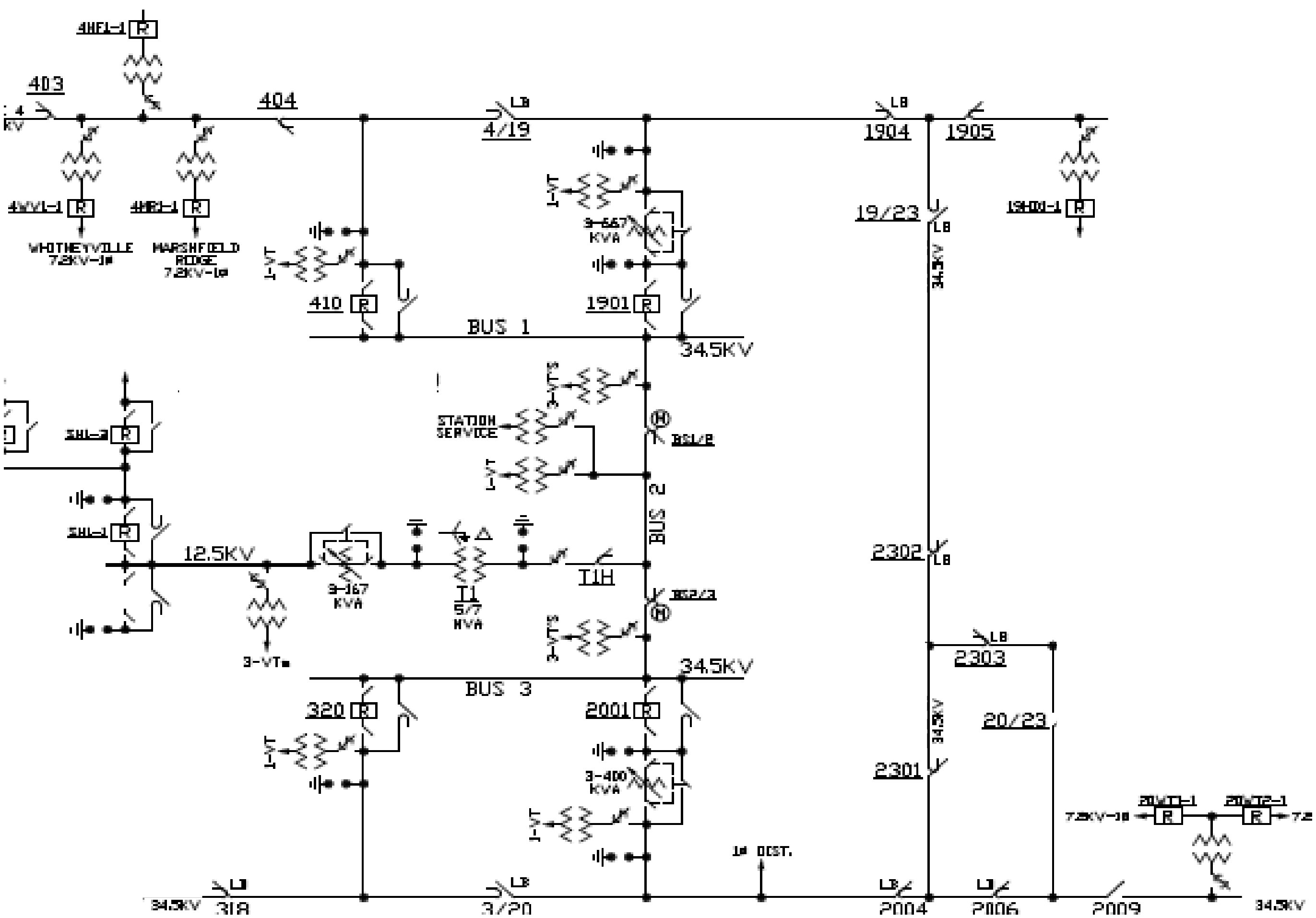


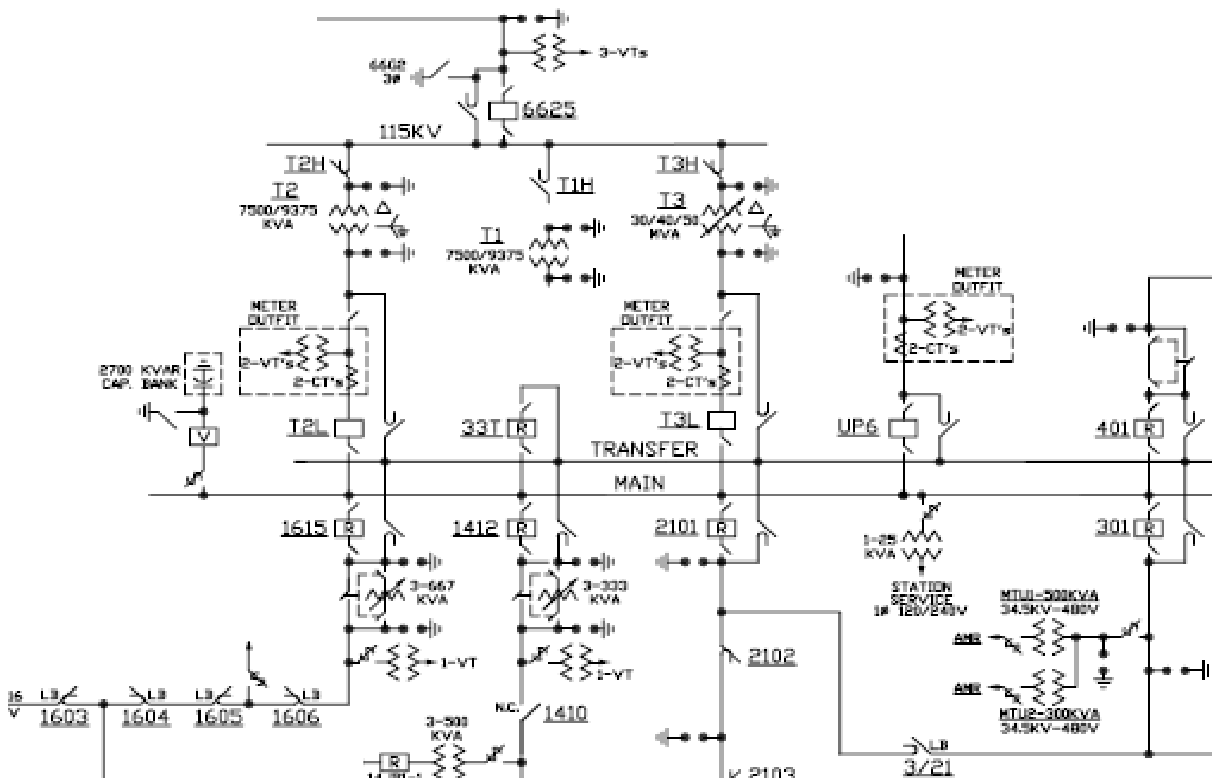
BHE-Washington-4 Substation



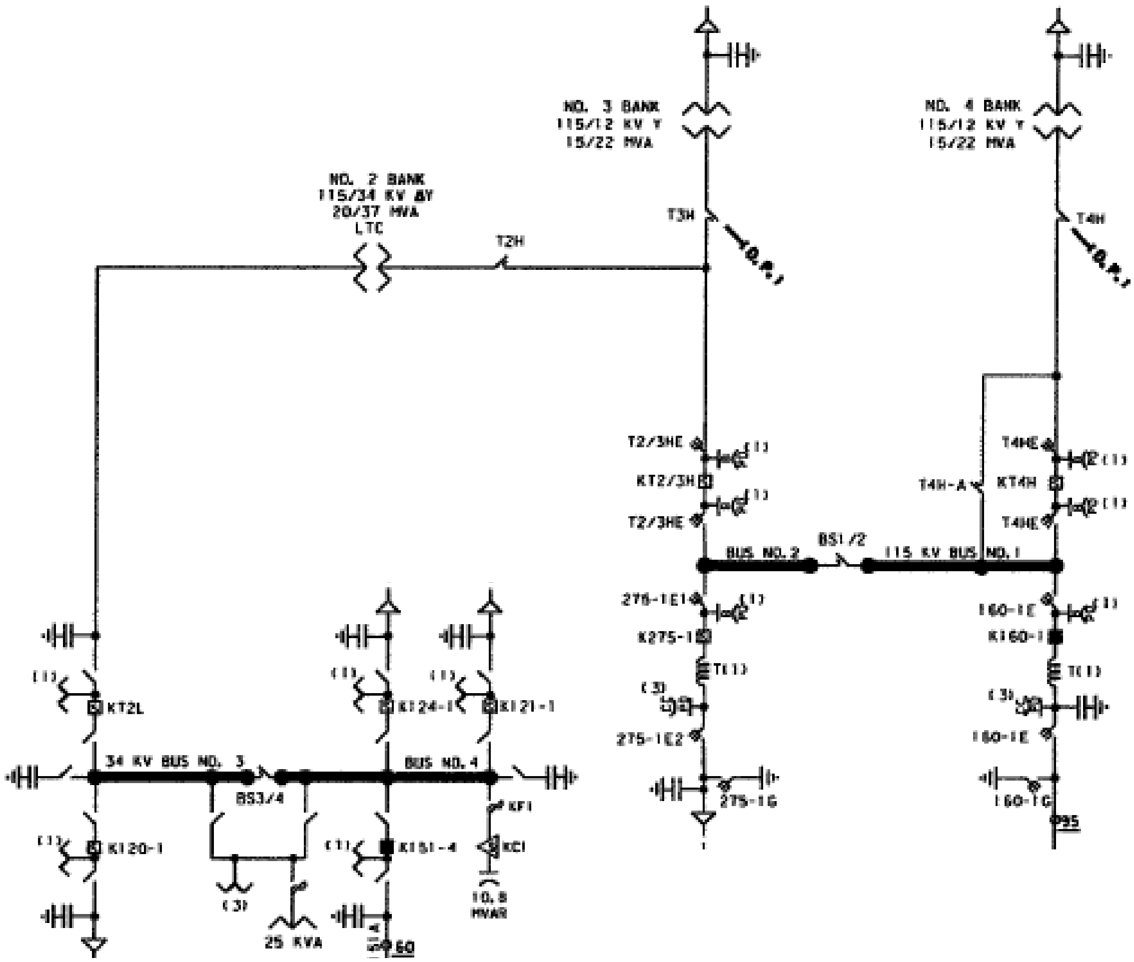
BHE-Washington-7 Substation



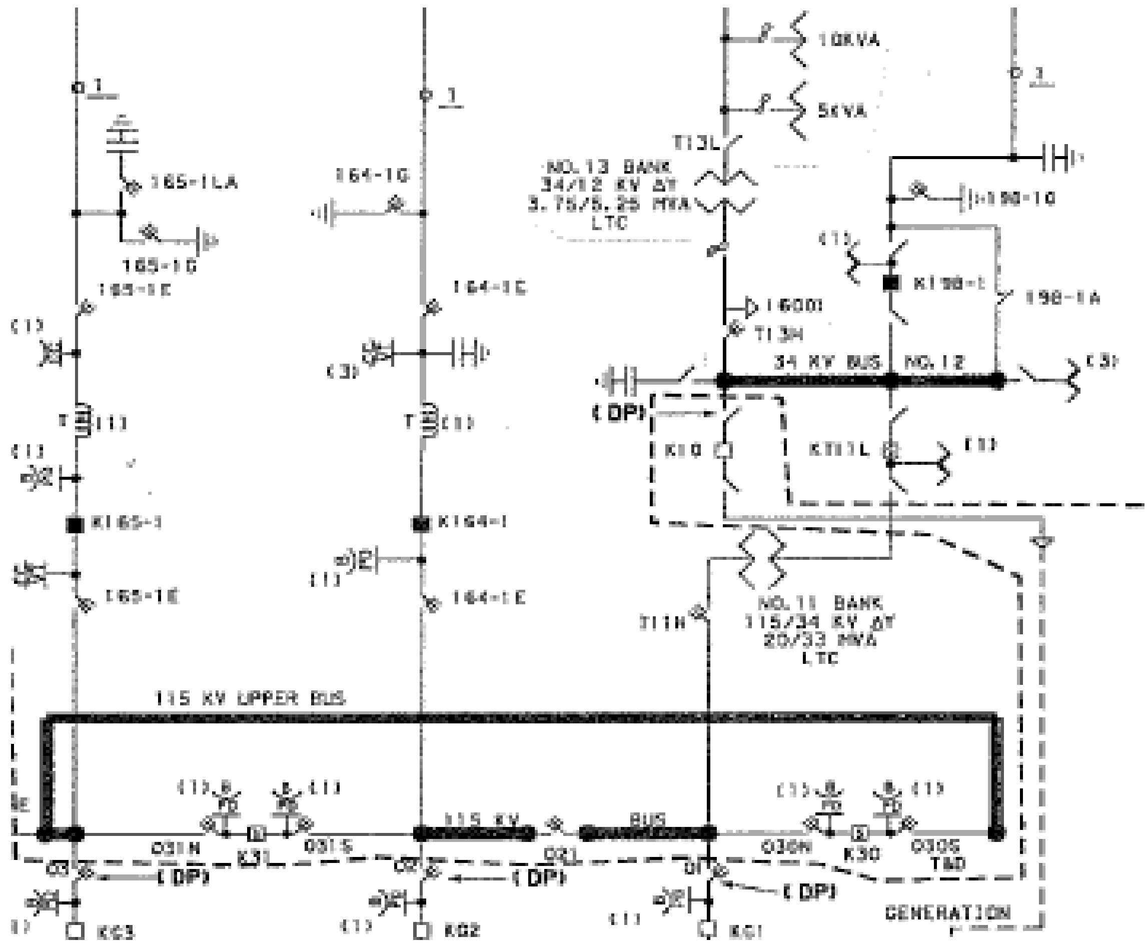
BHE-Washington-8 Substation



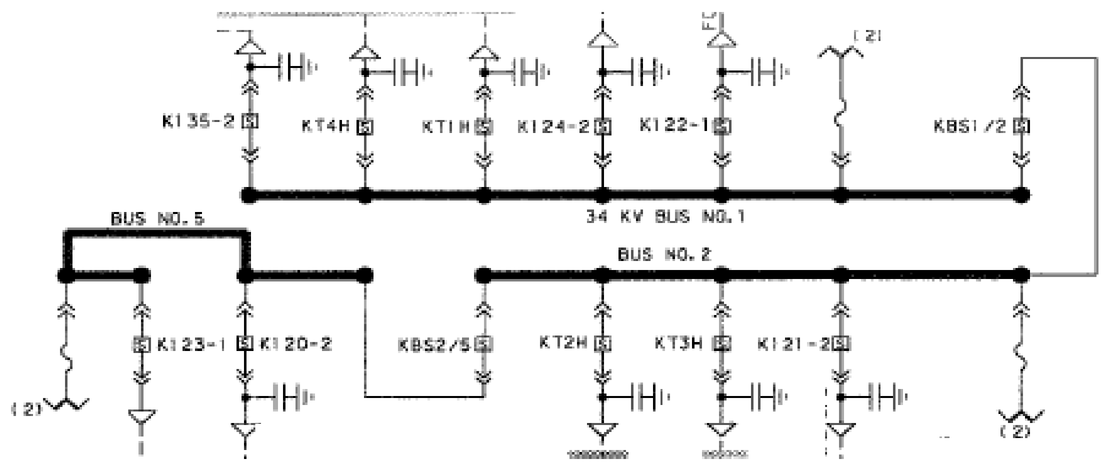
CMP-Cumberland-1 Substation



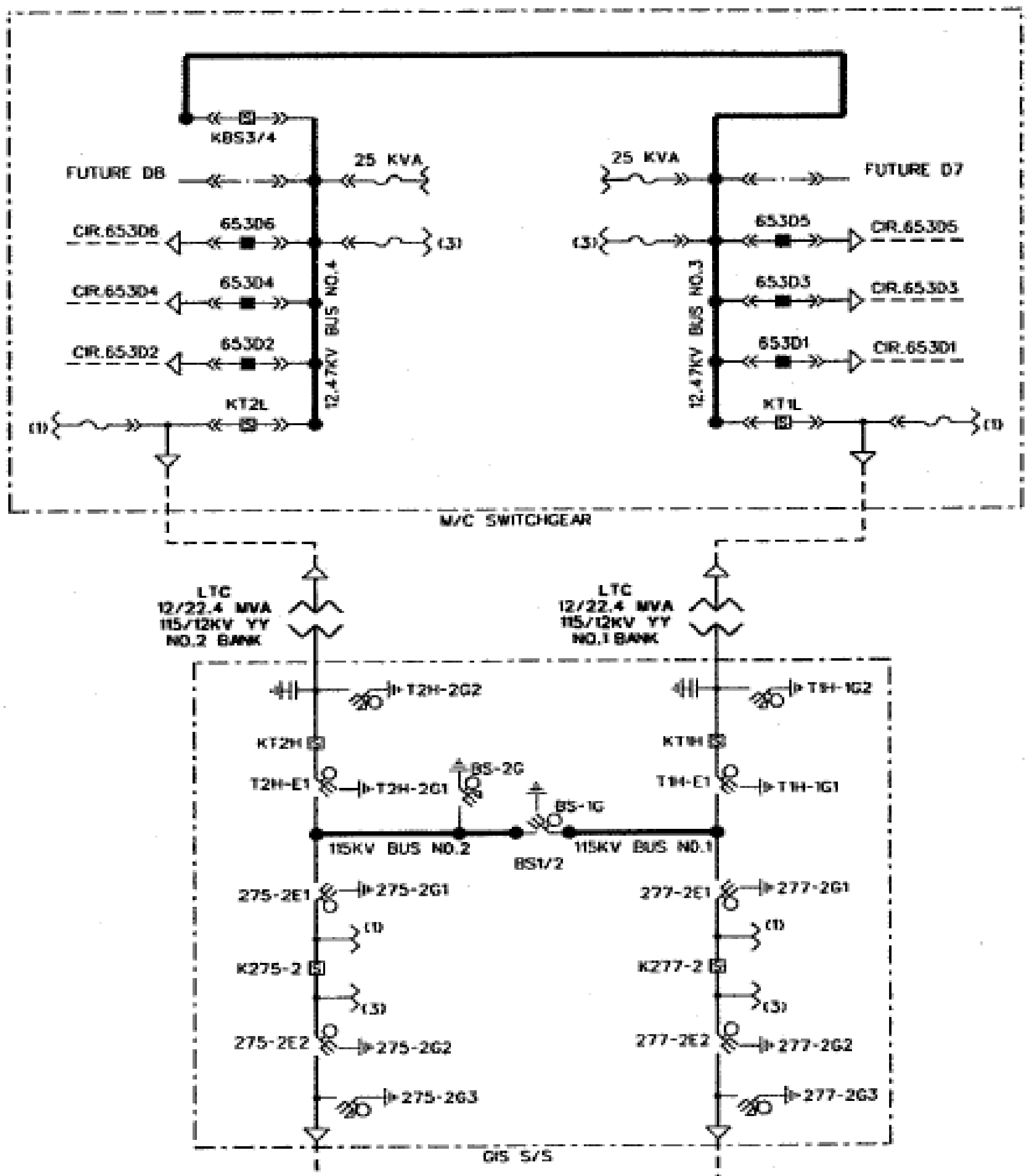
CMP-Cumberland-10 Substation



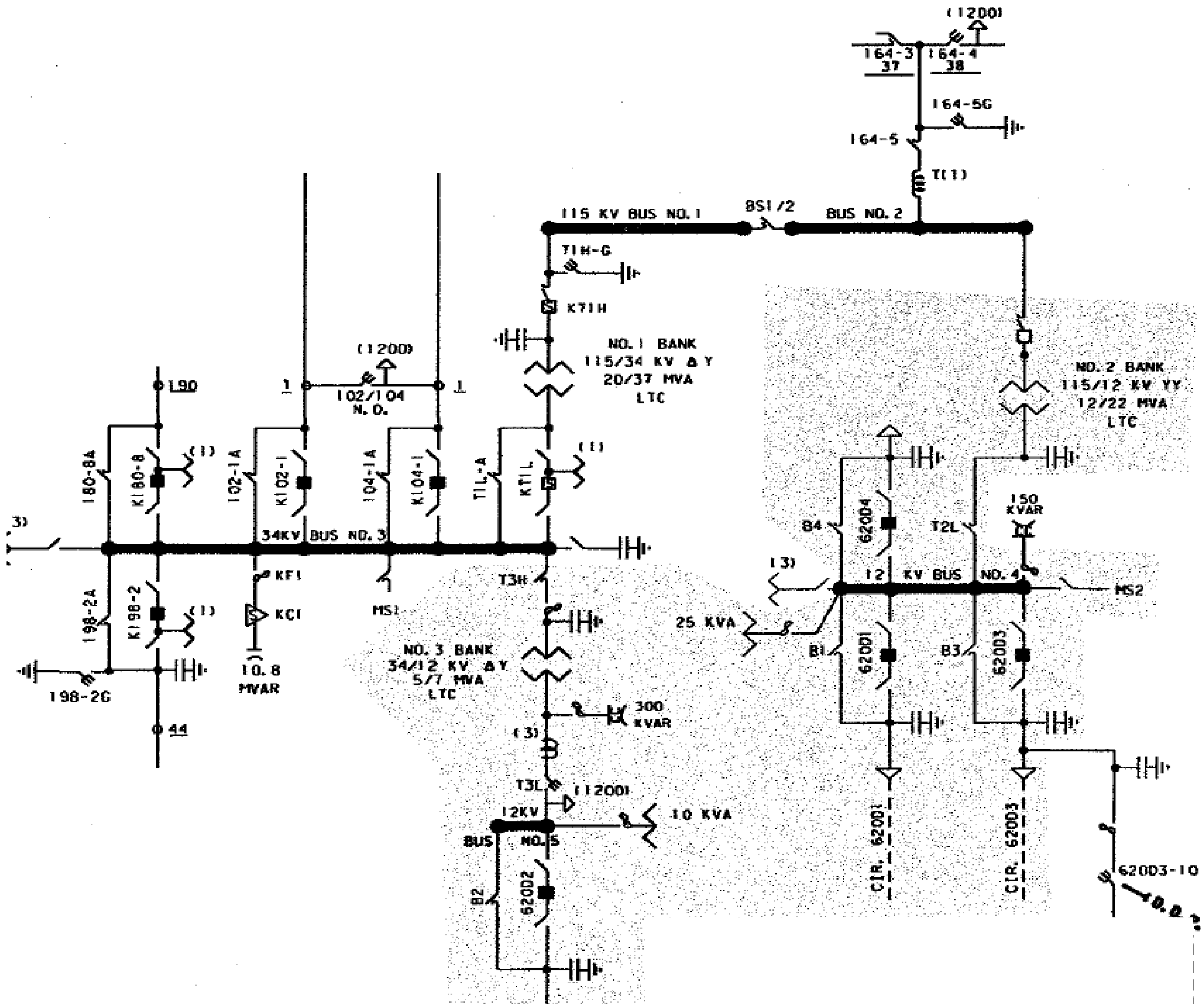
CMP-Cumberland-11 Substation



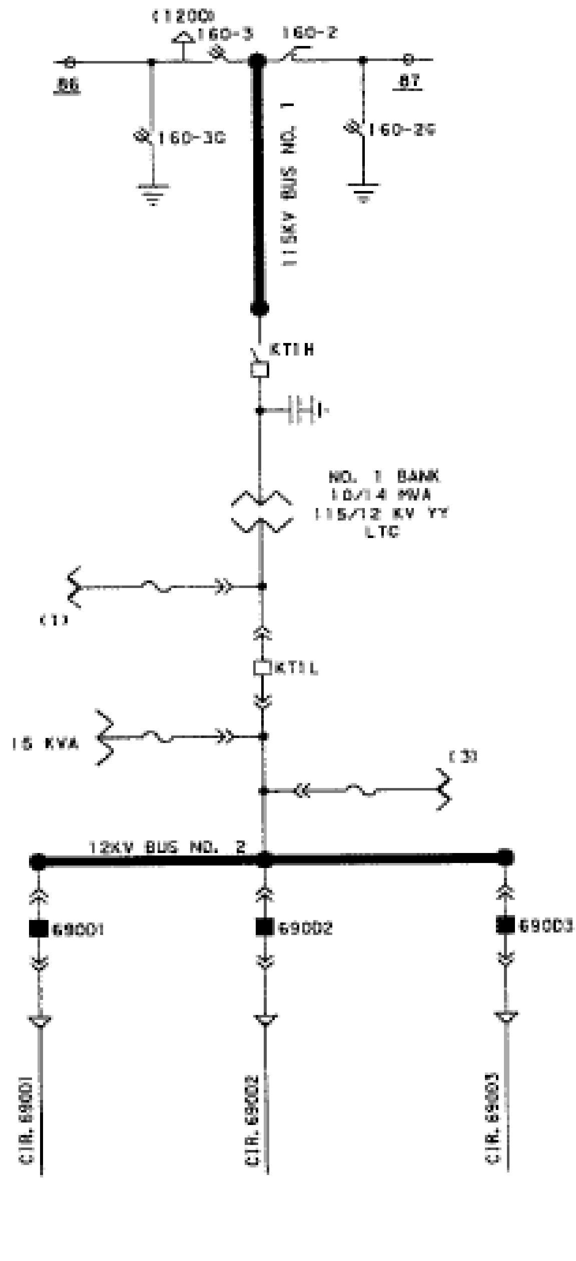
CMP-Cumberland-15 Substation



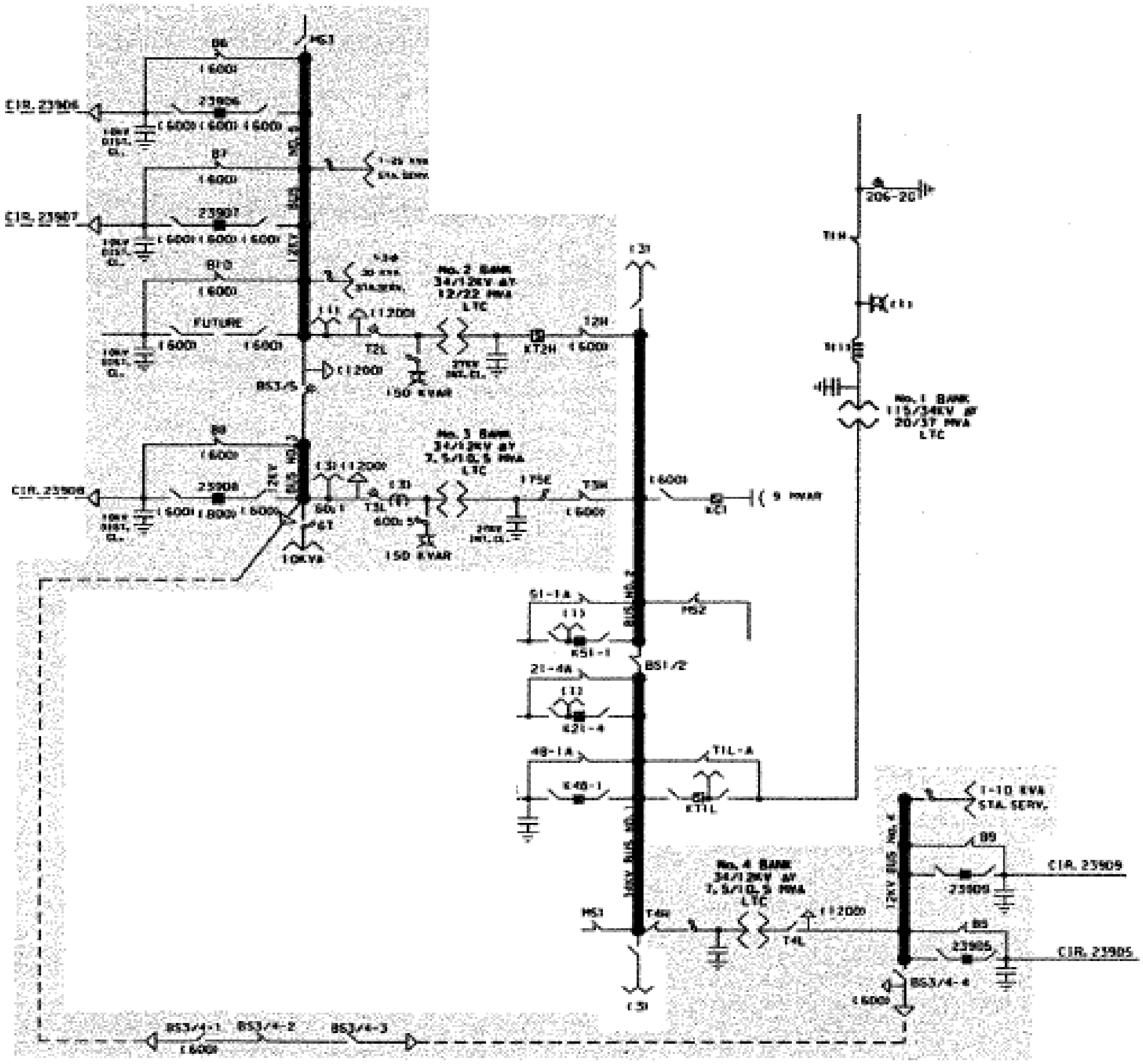
CMP-Cumberland-5 Substation



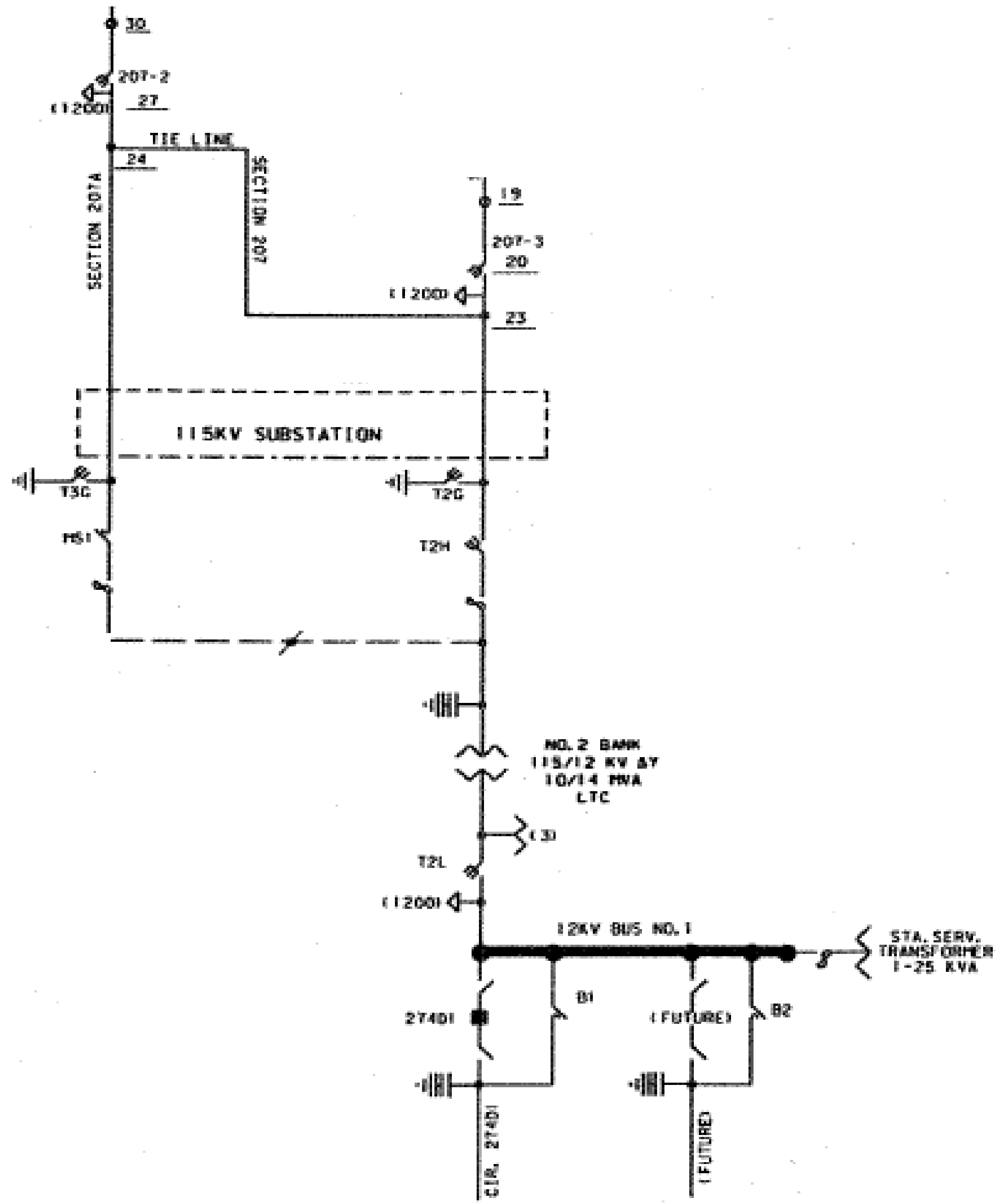
CMP-Cumberland-8 Substation



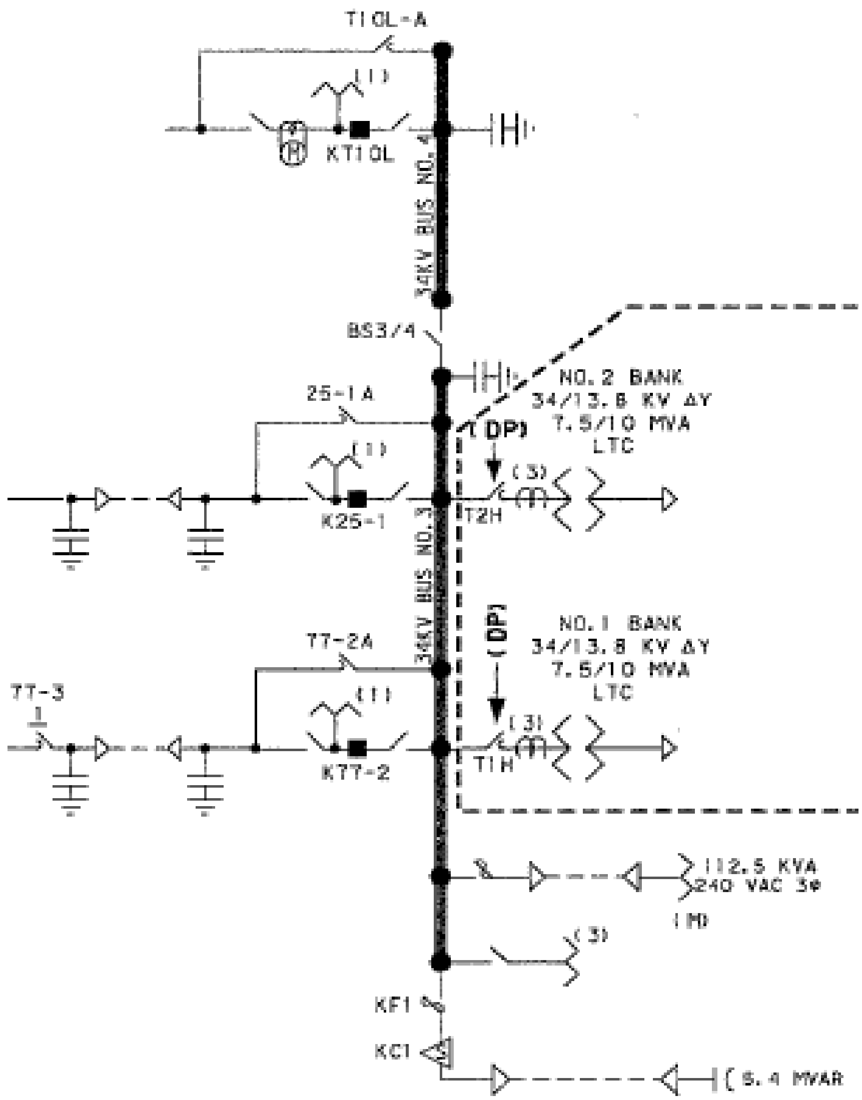
CMP-Knox-4 Substation



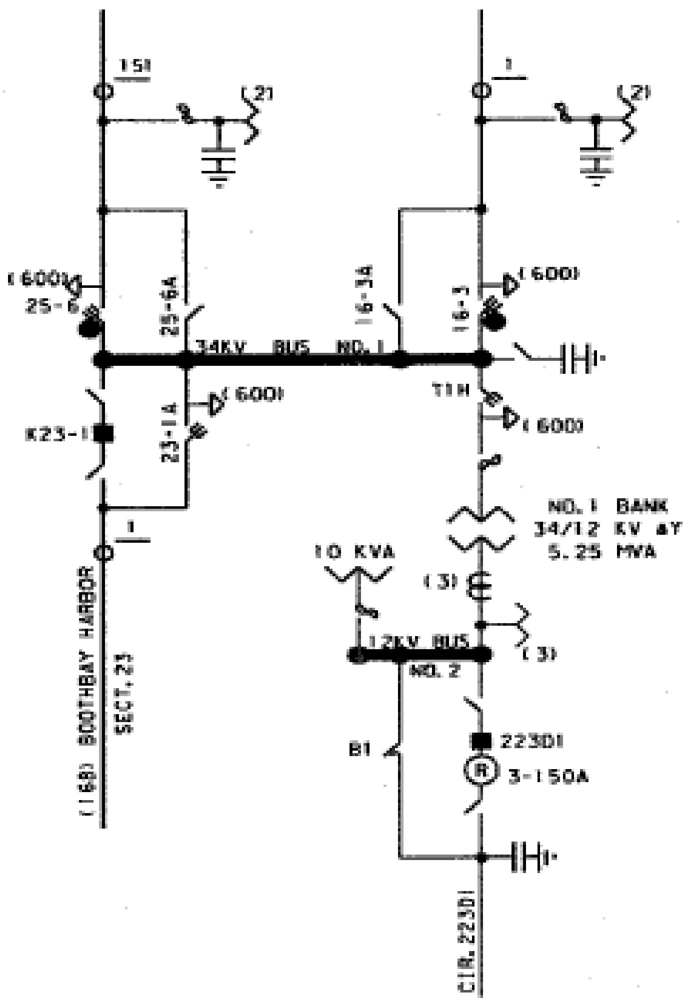
CMP-Lincoln-3 Substation



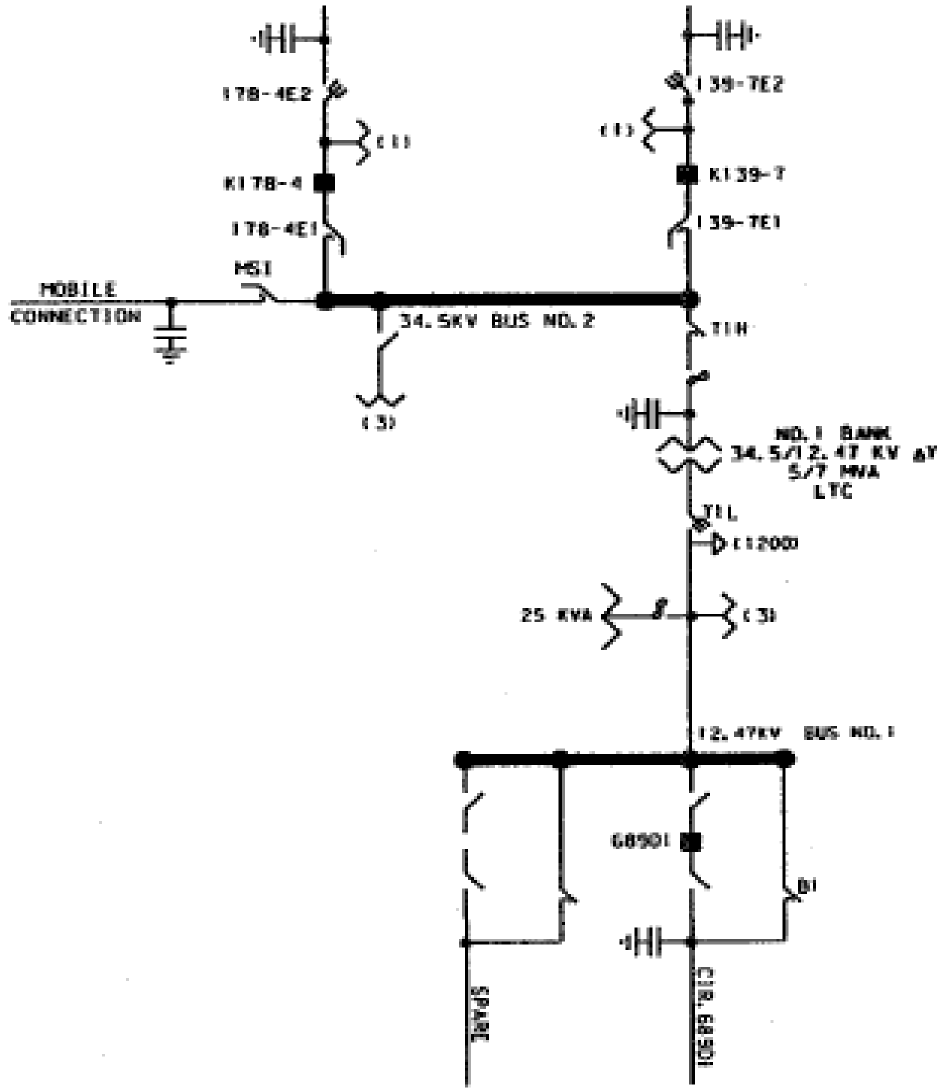
CMP-Lincoln-4



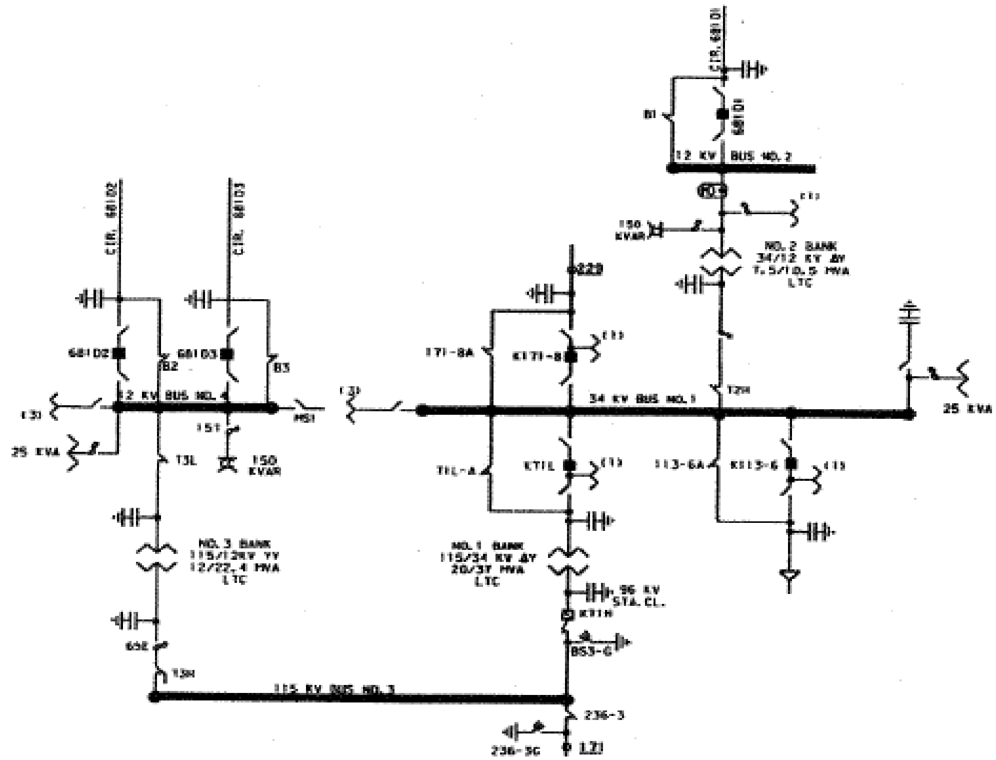
CMP-Lincoln-7 Substation



CMP-York-1 Substation

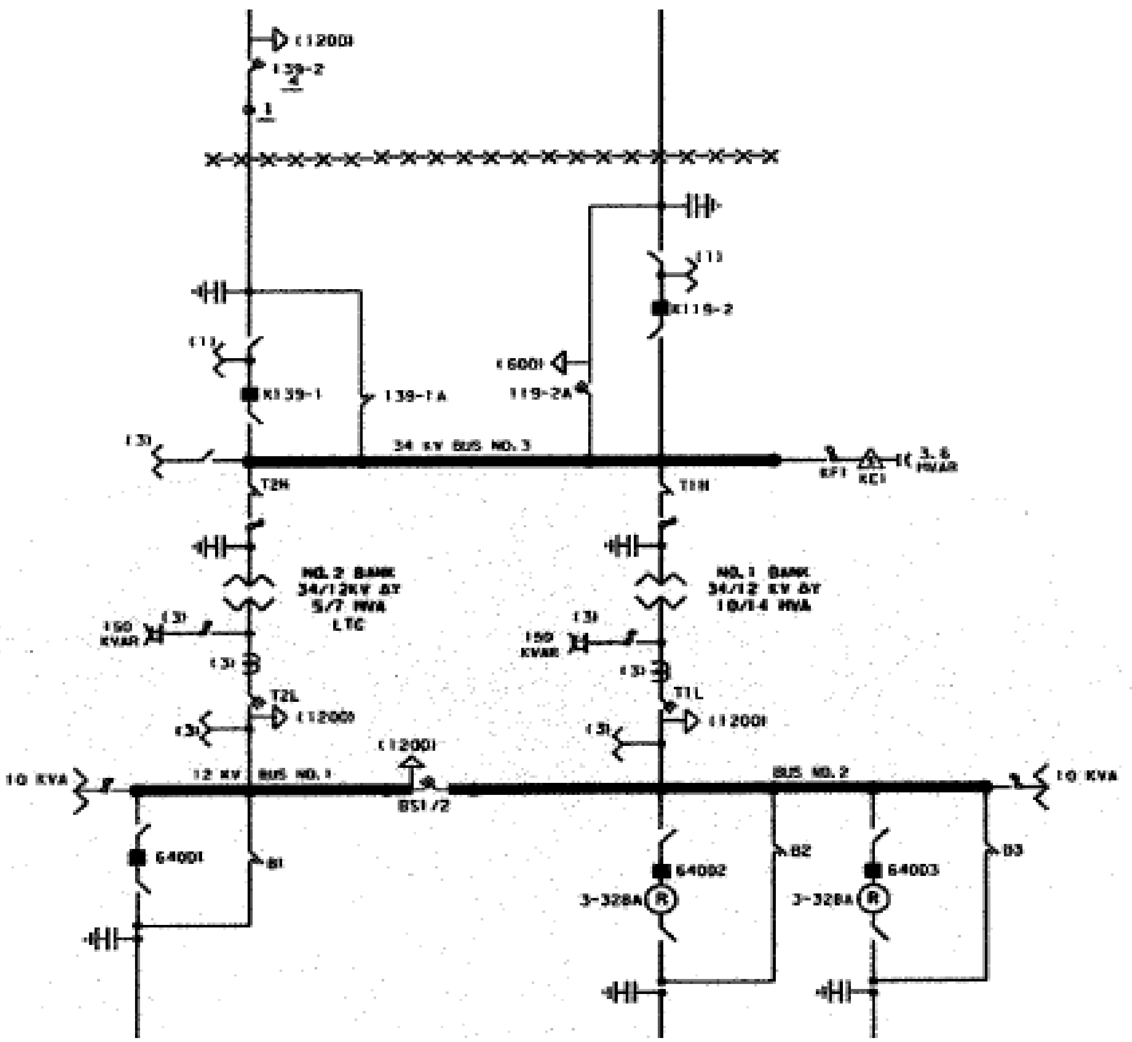


CMP-York-2

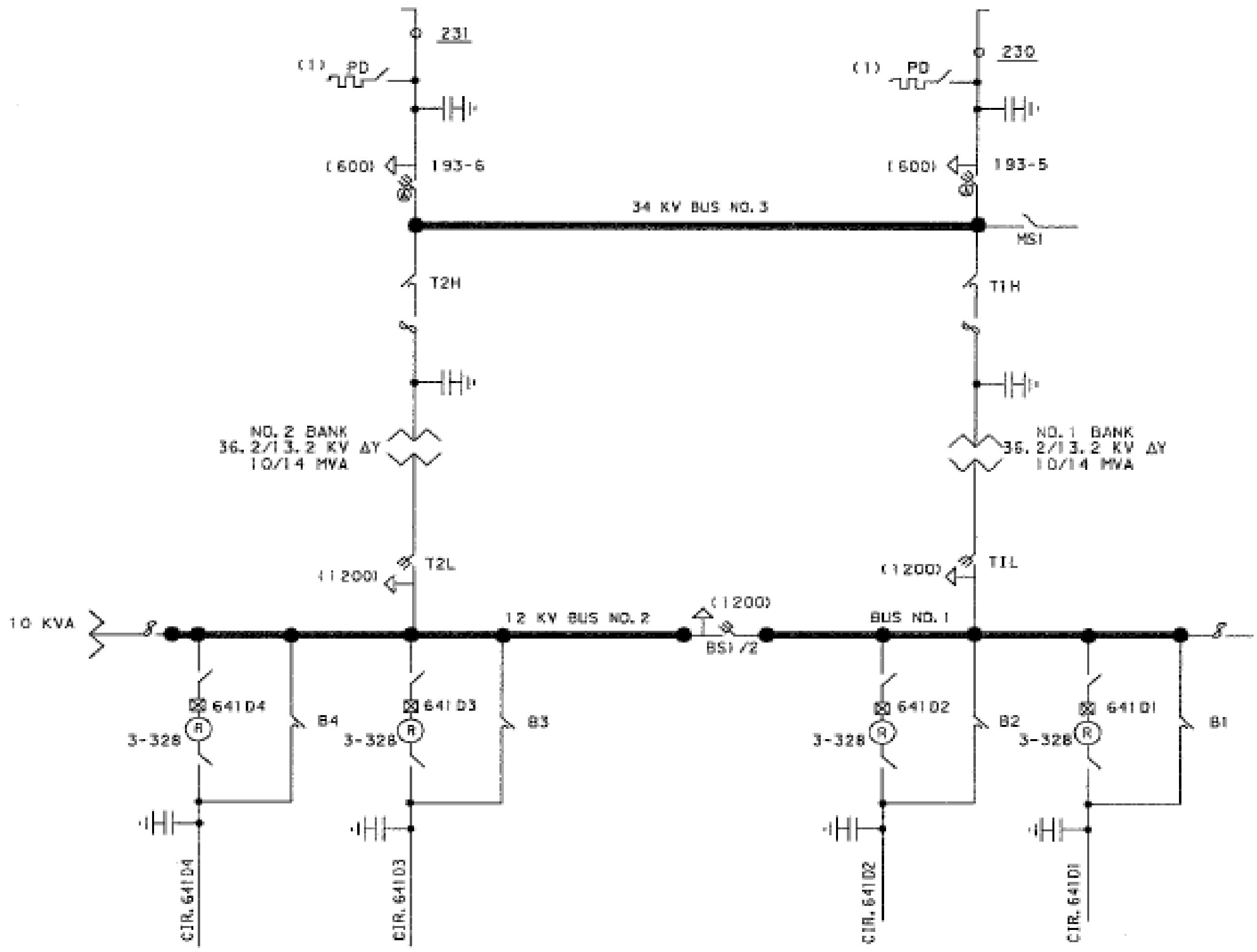


CIR. 68101
B1
68101
12 KV BUS NO. 2
150 KVAR
NO. 2 BANK
34/12 KV ΔY
7.5/10.5 MVA
LTC
T2H
CIR. 68102
CIR. 68103
68102
68103
B2
B3
12 KV BUS NO. 4
25 KVA
T3L
150 KVAR
MS1
229
171-8A
K171-8
34 KV BUS NO. 1
T1L-A
KT1L
113-6A
K113-6
25 KVA
NO. 3 BANK
115/12KV YY
12/22.4 MVA
LTC
NO. 1 BANK
115/34 KV ΔY
20/37 MVA
LTC
96 KV
STA. CL.
KT1H
BS3-G
T3H
115 KV BUS NO. 3
236-3
236-3G
171

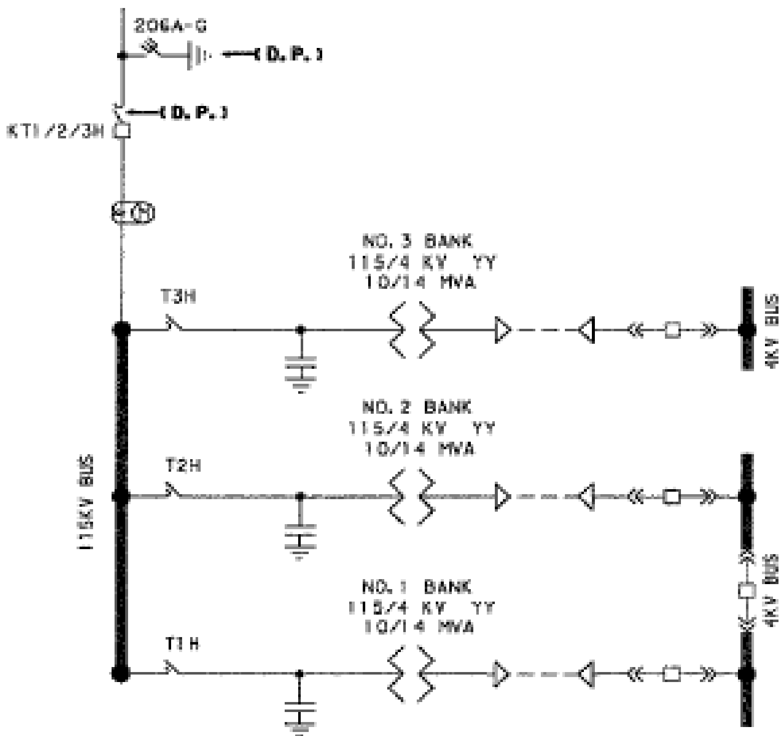
CMP-York-7 Substation



CMP-York-8 Substation



Private-Knox-1 Substation



10.3.2 Appendix C.2 – Subsea Cable Data Sheets

Design data for TFVA 36 kV 3x1x240 mm² KQ **15 MW**

Conductor	Diameter of conductor Round stranded compressed copper conductor of 37 wires filled with a semiconducting compound	18.4 mm
Conductor screen	Extruded layer of semiconducting crosslinked compound	
Insulation	Nominal thickness Diameter over insulation Extruded layer of insulating crosslinked polyethylene (XLPE)	8.0 mm 36.8 mm
Insulation screen	Extruded layer of semiconducting crosslinked compound	
Metallic screen	Thickness of tape One layer of copper tape overlapped	0.1 mm
Laying up	The cores are laid up. Polypropylene yarn fillers and a fiber optic cable are located in the interstices between the cores. Binder tapes are applied over the phases.	
Inner sheath	Thickness Extruded sheath of semiconducting polyethylene	2.0 mm
Bedding	One layer of semiconducting nylon tape	
Armor	Shape of armor wires Dimension of armor wires Number of armor wires, approx. Two layers of flat galvanized steel wires applied in opposite direction	Flat 7.5x2.5 mm 35/37
Outer serving	Two layers of polypropylene yarn and bitumen	
Diameter	Diameter of cable, approx.	108 mm
Weight	Total weight of cable in air, approx. Total weight of cable in water, approx.	23 kg/m 14 kg/m

Mechanical data for TFVA 36 kV 3x1x240 mm² KQ **15 MW**

Bending radius	Minimum permissible bending radius during laying	1.9 m
Pulling tension	Maximum permissible pulling tension	150 kN

Electrical data for TFVA 36 kV 3x1x240 mm² KQ **15 MW**

Current rating	Current rating in seabed	555 A
Conductor temperature	Max. permissible conductor temperature	90 °C
Ambient conditions	Max. ambient temperature for the cable in seabed at burial depth Max. burial depth in seabed Thermal resistivity of seabed Metallic screens and armor are bonded and earthed at both ends	15 °C 1.0 m 0.7 K.m/W
Frequency	Frequency	60 Hz
Short circuit current	Permissible thermal short circuit current in the conductor for 1 second	34 kA
Rated voltage	Rated RMS system voltage between conductor and metallic screen/between conductors (U_0/U)	18/33 kV
Operating voltage	Normal operating voltage	34.5 kV
Highest voltage	Highest continuous RMS system voltage (U_m)	36 kV
Basic insulation level	Lightning impulse withstand voltage (1.2/50 μsec.)	170 kV
Electrical stress	Maximum electrical stress in insulation at highest system voltage U_m	3.5 kV/mm
Conductor resistance	Max. DC resistance at 20 °C AC resistance at 90 °C	0.0754 Ω/km 0.099 Ω/km
Cable impedance	Cable impedance at 257 A (15 MW)	0.10 + j0.13 Ω/km
Capacitance	Capacitance between conductor and screen	0.24 μF/km
Charging current	Charging current at 34.5 kV	1.8 A/km
Loss angle	Maximum value at ambient temperature and rated voltage	0.004
Losses	Losses at 34.5 kV and 257 A (15 MW): - conductor losses - dielectric losses - metallic screen losses - armor loss Total losses per cable	 3x5.4 W/m 3x0.1 W/m 3x0.1 W/m 3.7 W/m 20.5 W/m
Voltage drop	Voltage drop at 15 MW, 34.5 kV, 257 A, 60 km and compensation of the charging current at both ends	7.7 %
Compensation	Compensation of charging current at each end	3.2 MVAr

Power	100 % 15 MW	80 % 12 MW	50 % 7.5 MW	0% 0 MW
Max. current	257 A	208 A	137 A	54 A
Voltage drop	7.7 %	6.1 %	3.7 %	0.0 %
Power losses	1160 kW	740 kW	295 kW	17 kW

Design data for TFVA 36 kV 3x1x800 mm² KQ — 30 MW

Conductor	Diameter of conductor Round stranded compressed copper conductor of 61 wires filled with a semiconducting compound	35.0 mm
Conductor screen	Extruded layer of semiconducting crosslinked compound	
Insulation	Nominal thickness Diameter over insulation Extruded layer of insulating crosslinked polyethylene (XLPE)	8.0 mm 54.4 mm
Insulation screen	Extruded layer of semiconducting crosslinked compound	
Metallic screen	Thickness of tape One layer of copper tape overlapped	0.1 mm
Laying up	The cores are laid up. Polypropylene yarn fillers and a fiber optic cable are located in the interstices between the cores. Binder tapes are applied over the phases.	
Inner sheath	Thickness Extruded sheath of semiconducting polyethylene	2.2 mm
Bedding	One layer of semiconducting nylon tape	
Armor	Shape of armor wires Dimension of armor wires Number of armor wires, approx. Two layers of flat galvanized steel wires applied in opposite direction	Flat 7.5x2.5 mm 51/54
Outer serving	Two layers of polypropylene yarn and bitumen	
Diameter	Diameter of cable, approx.	149 mm
Weight	Total weight of cable in air, approx. Total weight of cable in water, approx.	48 kg/m 33 kg/m

Mechanical data for TFVA 36 kV 3x1x800 mm² KQ — 30 MW

Bending radius	Minimum permissible bending radius during laying	2.7 m
Pulling tension	Maximum permissible pulling tension	290 kN

Nexans

Electrical data for TFVA 36 kV 3x1x800 mm^2 KQ **30 MW**

Current rating	Current rating in seabed	895 A
Conductor temperature	Max. permissible conductor temperature	90 °C
Ambient conditions	Max. ambient temperature for the cable in seabed at burial depth Max. burial depth in seabed Thermal resistivity of seabed Metallic screens and armor are bonded and earthed at both ends	15 °C 1.0 m 0.7 K.m/W
Frequency	Frequency	60 Hz
Short circuit current	Permissible thermal short circuit current in the conductor for 1 second	114 kA
Rated voltage	Rated RMS system voltage between conductor and metallic screen/between conductors (U_0/U)	18/33 kV
Operating voltage	Normal operating voltage	34.5 kV
Highest voltage	Highest continuous RMS system voltage (U_m)	36 kV
Basic insulation level	Lightning impulse withstand voltage (1.2/50 µsec.)	170 kV
Electrical stress	Maximum electrical stress in insulation at highest system voltage U_m	3.1 kV/mm
Conductor resistance	Max. DC resistance at 20 °C AC resistance at 90 °C	0.0221 Ω/km 0.036 Ω/km
Cable impedance	Cable impedance at 510 A (30 MW)	0.055 + j0.11 Ω/km
Capacitance	Capacitance between conductor and screen	0.39 µF/km
Charging current	Charging current at 34.5 kV	2.9 A/km
Loss angle	Maximum value at ambient temperature and rated voltage	0.004
Losses	Losses at 34.5 kV and 510 A (30 MW): - conductor losses - dielectric losses - metallic screen losses - armor loss Total losses per cable	 3x8.4 W/m 3x0.2 W/m 3x0.6 W/m 15.5 W/m 43.1 W/m
Voltage drop	Voltage drop at 30 MW, 34.5 kV, 510 A, 60 km and compensation of the charging current at both ends	8.3 %
Compensation	Compensation of charging current at each end	5.2 MVAr

Power	100 % 30 MW	80 % 24 MW	50 % 15 MW	0% 0 MW
Max. current	510 A	411 A	266 A	87 A
Voltage drop	8.3 %	6.6 %	4.0 %	0.0 %
Power losses	2480 kW	1570 kW	620 kW	25 kW

10.4 APPENDIX D – CONSTRUCTION AND ASSEMBLY SUPPLEMENTAL INFORMATION

10.4.1 Appendix D.1 – Offshore Wind Supplier List

Appendix D.1

The following is a list of Maine companies with ability to provide products, support or services to the development of offshore wind energy.

 → Indicates Experience in providing products or services to wind and/or ocean energy industries.

Contents:

Metal Fabrication

***Bath Iron Works* (BIW) -** Part of General Dynamics Marine Systems, Bath Iron Works is a full-service shipyard that specializes in the manufacturing of highly outfitted and complex modules. www.gdbiw.com

Cianbro is an Employee Owned Company with over 2300 employees in the northeast, Cianbro is positioned to take on all phases of wind projects from development through start up and commissioning. In house engineering, fabrication, logistics, in addition to construction services on shore and offshore provide unparalleled efficiencies for a wide range of projects. **www.Cianbro.com**

M.C. Faulkner & Sons Welding and Fabrication. Steel and Aluminum Fabrication – we have an 8' X 12' burning table to cut out steel and aluminum parts out of up to 4" thick plate, certified welders, a full time draftsman and a machine shop. We are an innovative, but also practical manufacturing shop for both prototype manufacturing and production line manufacturing. **www.mcfaulkner.com**

- **Certifications:**
- **Processes/Qualifications:**
- **Specialized Equipment and Processes:**
- **Material Handling Capacity:**
- **Metal Fabrication:**

Accidental ANOMALIES, Inc. located in Turner, Maine is a fabricated structural metal manufacturer that specializes in the construction of commercial and residential stairs, handrails, platforms and catwalks. www.accidentalanomalies.com

Bangor Steel Service, Inc. located in Bangor, Maine is a fabricated structural metal manufacturer that specializes in fabrication of catwalks, railing, guarding and structural steel members. Bangor steel has experience serving electrical, gas and wood power plants. www.bangorsteel.com

- **Certifications:** AISC MEMBER
- **Processes/Qualifications:** D1.A
- **Specialized Equipment and Processes:** 220 TON PRESS BRAKE, 1/2 X 10' METAL CUTTING SHEAR
- **Material Handling Capacity:** 10 tons
- **Metal Fabrication:** CARBON STEEL AND ALUMINUM

Alexander's Welding & Machine, Inc. located in Greenfield, Maine is a fabricated metal and machine shop providing mechanical problem solutions, design, fabrication, machining and prototyping services to numerous industries including the ocean energy industry. www.AlexandersMechanicalSolutions.com.

- **Certifications:** Individual employees hold various welding certifications through the American Welding Society
- **Specialized Equipment and Processes:** 1 Mazak CNC 3-Axis Vertical Machining Center, 40" x 20" travel, 4,000 rpm, 1 Milltronics 3 Axis Vertical Machining Center, 18" x 20" travel, 8,000 rpm, 1 Milltronics 10" x 50" 2 Axis CNC Lathe, 1 Mori-Seiki AL-2 15" x 24" CNC 2 Axis Lathe (continued within cell but not visible), 1 5' x 12' Torchmate CNC Burning Machine with Water Table, (6" capacity flame cut; ¾" plasma cut, Torchmate Software)
- **Material Handling Capacity:** 5000 lbs
- **Metal Fabrication:** All steels including stainless, aluminum, titanium, plastic, composites

Metal Fabrication (cont)

Flu Gas Solution, Inc. located in Windham, Maine fabricates fabric and metallic expansion joints - louver, butterfly and guillotine dampers for the Power Generation Industries. www.flugassolutions.com.

- **Material Handling Capacity:** 5000 lbs

Megquier & Jones, Inc. located in South Portland, Maine is a fabricator of structural steel, miscellaneous metals and light gauge steel truss and framing components with experience manufacturing barges for a variety of industries including power co-generation industries. Www.megjones.com

- **Certifications:** AISC; AWS
- **Processes/Qualifications:** Certified Welding Inspectors (CWI); Complex Steel Bridges; Major Steel Bridges; Sophisticated Paint Endorsement
- **Specialized Equipment and Processes:** Shot blasting (SSPC Requirements); Steel Plate Burning Table; Automated Welding & Drilling Equipment
- **Material Handling Capacity:** 30 Tons (Interior Overhead Cranes); 25 Ton (Fork Lift)
- **Metal Fabrication:** Carbon Steel A36, A572, A588, A992; Light Gauge Steel Framing

Newport Industrial Fabrication, located in Newport, Maine performs sophisticated welding and coatings including heavy welments (up to 4"). NIF has the ability to meet Q&A for demanding clients and perform work to meet international certifications.

- **Certifications/Processes/Qualifications:** AICS, AWS certified Weld Inspector, AWS D1.1 & D1.5, ASME & AWS Welders, NACE & SSPC-CI Certified Coatings Inspector, Level II NDT UT and MT Testing
- **Specialized Equipment and Processes:** Automated Welding

Morrison Manufacturing Inc. located in Perry Maine is a fabricated structural metal manufacturer with experience providing services for maritime transportation, aquaculture and energy industries including specialized barge construction for tidal energy.

- **Certifications:** AWS Certified Welders, Master Mariner Licensed.
- **Material Handling Capacity:** 3 in-house cranes with access to cranes to 100 tons
- **Metal Fabrication:** MIG, TIG for Aluminum, Stainless and Carbon.

TW Dick Steel Co. Inc. located in Gardiner Maine is a fabricated structural metal manufactures with experience providing welding, steel fabrication and steel sales for wind and other energy industries.

- **Specialized Equipment and Processes:** Steel Rolling, 144 inch diameter, 10 ft length, 1/2 inch thickness
- **Material Handling Capacity:** 10 tons
- **Metal Fabrication:** Steel, Aluminum, Stainless

Precision Manufacturing and Machining

D&G Machine Products Inc. is fully ISO certified precision machining company providing services to the energy industry member including turbine parts for clients such as GE Power. Precision Design, Precision Engineering, Precision Quality Control, Precision Installation. www.dgmachine.com

- **Certifications:** ISO 9000, AS 9100, NDT, NADCAP

MIDCorp: Manufacturer and supplier of assemblies and sub assemblies focused on generating systems generally up to 100KW – expect to have full line production facility on line Fall of 09 – R&D focus on turbine performance enhancements and co-generation systems. E-mail: **jcmonroe@maine.rr.com**

Midstate Machine: Manufacturer of precise equipment for IGT, Steam, and wind generation, oil and gas and defense industries with ability to machine in various alloys to meet customers specifications.

- **Certifications:** ISO 9000, AS 9100, qualified for ASME pressure welding

Titan Machine Products Inc. is a full service high quality contract manufacturing company. Titan provides its Defense and Commercial customers with precision products, components, assemblies, fabrications and services. **www.Titanmachineproductsinc.com**

- **Certifications:** ISO 9000, AS 9100,

Kennebec Technologies: Precision machining and grinding for aerospace and defense industries. Providing services to Aerospace, Defense, Semiconductor, Telecommunication, Investment Castings, Propulsion, Homeland Security, Commerical Products.

- **Certifications:** ISO 9000, AS 9100, Nadcap EDM
- **Equipment:** CNC Grinding, EDM, CNC Mill/Turn, CNC Milling, CNC Turning, Light Assembly

Composites Manufacturing

ACSM, Inc. (GRP Gurur); providing composites-related services to manufacturers in the renewable energy field. Past clients include start up of the GE wind blade plant in Pensacola, FL, in 2003-2004. Services and expertise for the Wind Energy sector include: engineering and process-development of blade manufacturing plants; personnel training; trouble-shooting and auditing of operational manufacturing units; development and testing of structural laminates; rapid-response team for field inspections, failure analysis and repair of installed blades. **www.GRPguru.com**

Custom Composite Technologies, Inc.
Fabrication, Consultation and Design of Advanced Composite
Structures for Renewable Energy, Aerospace, and Infrastructure Industries. Demonstrated success in large-scale infusion and pre-preg methods. **www.customcomposite.com**

Flotation Technologies is a world leader in the design, engineering and manufacture of deepwater buoyancy systems, and serves the offshore oil, oceanographic, seismic and government markets. The company specializes in syntactic foam and urethane elastomers. It has additional manufacturing capability in composites, metal fabrication and rotational molding. **www.flotec.com**

Kenway Corporation specializes in technically advanced industrial composite manufacturing, bringing products from engineering and design, through fabrication, to on-site installation, using processes from open-molding, to filament winding, to Light RTM and vacuum infusion. **www.kenway.com**

Lyman Morse: Composite and aluminum construction of custom yachts from 25-120' and Power Cubes. Service provided for all yachts around the world. Use of SCRIMP infusion process and prepreg composites as well as the usual vacuum bagging and hand laid construction.
Metal fabrication shop – fully certified for 5086 and 6061 aluminum and coast guard certified for all steel fabrication.
www.Lymanmorse.com

US Wind Blade: Design and fabrication of composite blades for wind and tidal turbines.
www.USWindblade.com

West Bay Boats: Custom composite boat manufacture with a capacity to provide offshore energy service and crew vessels and composite components for energy production. **www.westbayboats.com**

Janseneering, Inc. located in Falmouth, Maine fabricates patterns and molds for the composites industry utilizing three 5-axis CNC machines with the largest having a 35' long capacity. Janseneering has experience serving the wind and ocean energy industries. Www.janseneering.com.

Yale Cordage provides engineered synthetic mooring lines , deep sea anchoring systems, and industrial cordage for any size and application for the most demanding ocean environment applications.**www.yalecordage.com**

Engineering and Environmental Services/Consulting

Forristall Ocean Engineering, Inc.: We provide meteorological and oceanographic (metocean) design specifications for offshore projects. Our research into extreme values statistics for wave and crest heights has been incorporated into ISO standards. We have written metocean criteria for projects all over the world, from near shore to very deep water. www.forocean.com

James W. Sewall Company: Founded in 1880, Sewall is a geospatial, engineering and forestry consulting firm that provides integrated solutions to government and industry. Sewall provides services in wind site assessment, design, and development and environmental and transportation engineering, throughout the United States. **www.sewall.com**

Maritime Applied Physics Corp (MAPC) has a 20-year history of engineering, prototyping, and production of emerging technology systems. MAPC provides engineering and design solutions to technically challenging problems and environments. MAPC has received more than 25 awards under the Small Business Innovation Research (SBIR) program. Our international experience includes projects in South Korea, Italy, France and the United Arab Emirates. **www.mapcorp.com**

Stantec is an integrated environmental, engineering, and construction management firm offering site planning, environmental studies, permitting, project management, and complete engineering services for both onshore and offshore wind projects. With 10,000 staff, 130 offices, and experience on more than 200 wind farms in North America, Stantec provides Global Expertise and Local Delivery of innovative wind power solutions. www.stantec.com

SGC Engineering, LLC offers expertise in the planning and design of wind power projects. SGC provides engineering expertise, design high voltage electrical transmission, collection and distribution systems. SGC also provides civil engineers and land surveyors for layout, design and permitting of access roads, turbine and transmission line right-of-ways, and substation site development.
SGC has a skilled land acquisition staff to identify and negotiate the purchase of parcels, easements, and leases needed for a project. **www.sgceng.com**

Terracon is an employee-owned consulting engineering firm providing geotechnical, environmental, construction materials, and facilities services. We offer practical, cost effective solutions suited for projects of all sizes from nearly 100 offices nationwide. By anticipating project requirements and adapting to challenges, we make it easy for you to work with us. You'll benefit from a flexible partner focused on your business objectives. For projects large and small, single- or multi-site, our clients can rely on consistent results. **www.terracon.com**

HDR|DTA Has experience siting, permitting, and designing nearly 17,000 MW of the 28,000 MW developed in the United States, and supporting the licensing and permitting of some of the first offshore and near shore energy projects in the US. It's engineers, scientists, and regulatory specialists, serving clients in the renewable energy industry, provide consulting services for hydropower and alternative technologies in ocean energy and wind power. **www.devinetarbell.com**

TRC is a full service company providing solutions for a broad range of project requirements including strategic planning, environmental surveys and assessment, permitting, engineering, wind modeling and construction management/quality assurance. TRC staff has successfully permitted over 40,000 MW of generation capacity nationwide. TRC has over 300 experienced power delivery staff located in 27 offices from Augusta, Maine to San Diego, California. Our wind energy project services include:_Site Selection Support, Permitting Support, Engineering Support. **www.trcsolutions.com**

Engineering and Environmental Services/Consulting (continued)

Delorme Publishing Company: Integrating Map Data, GIS, and GPS into Affordable and Easy-to-Use Solutions. **www.delorme.com**

NBT Solutions LLC: provides data management and visualization systems, GIS mapping, and related services to the wind energy market. NBT's sensor network data integration offerings facilitate analysis and monitoring of critical environmental and meteorological data. NBT's core GIS expertise assists energy project development through site analysis, permitting, and communications mapping. **www.nbtsolutions.com**

Normandeau Associates Inc. is a natural resources environmental consulting firm with experience supporting both onshore and offshore wind projects. Normandeau conducts wildlife, wetlands, fisheries, water quality, benthos, plankton, and environmental assessment studies to provide the basis for work plans that ensure the information adequately addresses project licensing and permitting requirements. **www.normandeau.com**

Legal , Insurance and Financial Services

The Allen Agency has partnered with Insurance Industry leaders to offer cutting edge products for the full array of insurance and risk management programs for the renewable sector including wind (on and offshore) solar, tidal, bio and hydro. **www.allenagency.com**

Bernstein Shur represents on-and-offshore wind developers and alternative energy interests by providing energy, environmental permitting and compliance, financing, contract negotiation, tax incremental financing, governmental relations, and real estate (including title insurance) services through our 100-plus attorneys and our subsidiaries—Stratex Energy, Monument Title, and Government Solutions. **www.bernsteinshur.com**

Norton Insurance & Financial Services is an independent agency, brokerage and consulting company serving the needs of successful, entrepreneurial, forward thinking business of New England.
Our Commitment to serving all renewable energy initiatives is evidenced by our dedication to keeping insurance costs low and value high. **www.nortonne.com**

Norman Hanson and Detroy is a full service law firm serving the needs of construction, development and energy industry members of New England.
We are commitment to serving all renewable energy initiatives . **www.nhdlaw.com**

Pierce Attwood has long been recognized as a leading New England commercial law firm providing a full spectrum of services to regional, national and international alternative energy clients. **www.pierceatwood.com.**

Verril Dana Verrill Dana's Energy Group combines deep experience with broad expertise to provide proven results for clients. Verrill Dana represents and has successfully permitted every operational or permitted grid-scale wind energy facility in Maine (amounting to over 270 MW of capacity), and has been successful in every appeal brought against its wind-power clients. Verrill Dana is able to assist clients in every aspect of wind power development.

Transportation and Logistics

Bangor Hydro Electric Company is a electric utility wholly owned by Emera, Inc. of Halifax. Nova Scotia, Canada. The Company provides transmission and distribution services to a population of 192,000 in eastern Maine . Bangor Hydro is a member of the New England Power Pool and is interconnected with other New England utilities to the south and with the New Brunswick Power Corporation of New Brunswick, Canada to the north. **www.bhe.com**

Chase, Leavitt & Co. Provides agents for the vessels owners/operators and performs condition and discharge surveys for various principals involved with the shipping and receiving of these windmill components. **www.chaseleavitt.com**

The Maine Port Authority develops and maintains Maine's port infrastructure. Maine's ports play a key role in the import, export, staging, assembly and servicing of the wind industry in the North East. **www.maineports.com**

The Port of Eastport is Maine's Deep Water Cargo Port; the deepest natural seaport in the continental United States. As an international cargo port it serves both import and export markets including the wind energy market. **www.portofeastport.org**

Ports America: Terminal and stevedoring service in the Port of Portland. Terminal delivery of import units and receipt of export units. Stevedoring, loading export units from FPOR to vessel and unloading import units from vessel to FPOR .**www.portsamerica.com**

Sprague Energy Corp : one of the largest suppliers of energy and materials handling services in New England. The company has a network deep-water terminals and rail connections that serve as a gateway for goods into and out of the Northeast U.S., Canada and the Midwest markets. Sprague has the expertise and experience in transporting a wide range of products including wind turbine components. **www.spragueenergy.com**

Research and Development

AEWC is a one-stop-shop for developing a composite product or structure from the conceptual stage through research, manufacturing of prototypes, comprehensive testing and evaluation. The 70,000 sq. ft AEWC laboratories are adding an integrated design, prototyping and testing facility for advanced composite materials with the ability to manufacture and test up to 70 meter wind blades under one roof. **www.aewc.umaine.edu**

The Marine Maritime Academy - Maine Maritime Academy provides technical marine support in collaboration with the University of Maine research projects. **www.mainemaritime.edu**

The Ocean Energy Institute - is an independent think tank with the mission to accelerate the technological development of innovations that harness the ocean's power. With a current focus on far offshore wind in the State of Maine, the Institute identifies emerging opportunities through deep technical, policy and business expertise, and by coordinating the efforts of businesses, policy leaders, researchers and innovators. **www.oceanenergy.org.**

The Gulf of Maine Research Institute catalyzes solutions to the complex challenges of ocean stewardship and economic growth in the Gulf of Maine bioregion through a dynamic fusion of science, education, and community. **www.gmri.org.**

Education and Industry Training

Northern Maine Community College provides educational programs for Associate in Applied Science degrees in Wind Power Technology, Electrical Construction & Maintenance, and Precision Metals Manufacturing. We also provide courses toward certificate programs in Machine Tool Technology and also Welding & Fabrication. **www.nmcc.edu**

Maine Advanced Technology Center (MATC): Develop and implement training which supports the workforce training needs of advanced manufacturing companies and utilize advanced composites materials and other integrated manufacturing processes. **www.matc.smcce.edu**

The Marine Maritime Academy
Situated in a waterfront setting along the Bagaduce River in Castine, a tidal estuary, the Maine Maritime Academy's close proximity to the University of Maine uniquely positions it to be a conduit for cooperative engineering efforts around renewable energy. The two universities are currently collaborating: UMaine allows MMA to use the tow tank in exchange for MMA assistance on the tidal turbine. For more, visit: **www.mainemaritime.edu**

The University of Maine educational programs applicable to renewable energy and so much more. Study is led by world-class scholars and includes groundbreaking research in one of the world's most beautiful natural landscapes. Applicable studies include: College of Engineering; College of Business, Public Policy, and Health; College of Natural Sciences. **www.umaine.edu.**

10.5 APPENDIX E – MAINE PUBLIC UTILITIES COMMISSION RFP DOCUMENTS

10.5.1 Appendix E.1 – An Act To Implement the Recommendations of the Governor's Ocean Energy Task Force (LD1810)

Public Law

124th Legislature

Second Regular Session

Chapter 615
S.P. 710 - L.D. 1810

An Act To Implement the Recommendations of the Governor's Ocean Energy Task Force

Emergency preamble. Whereas, acts and resolves of the Legislature do not become effective until 90 days after adjournment unless enacted as emergencies; and

Whereas, in 2008, crude oil prices reached $147 per barrel, and gasoline and heating oil prices reached over $4 per gallon, highlighting our State's long over-reliance on oil for home-heating and fuel for our vehicles and on natural gas and other fossil fuels to produce electricity; and

Whereas, along with the foreseeable prospect of prolonged high or higher fossil fuel prices, the implications of climate change, driven by greenhouse gas emissions from combustion of fossil fuels, and its attendant threats to the environment, economy, social fabric and human health underscore the urgent need to significantly reduce and minimize our State's dependence on oil and gas; and

Whereas, renewable ocean energy holds enormous promise to address our state and regional energy goals, including energy independence and security and limiting exposure to fossil fuels' price and supply volatility; to ensure attainment of our greenhouse gas emissions reduction goals; and to provide significant economic opportunities for our citizens; and

Whereas, state and adjoining federal waters feature significant offshore wind, tidal and wave power energy resources, including world-class and untapped deep-water wind resources with the potential to make a significant contribution to the State's energy sources to meet the State's changing needs for renewable sources of light and power, heat and transportation fuel; to meet the State's ambitious renewable energy portfolio standards; and to position the State to be an exporter of clean, renewable indigenous energy; and

Whereas, the Governor's Ocean Energy Task Force identified and made recommendations to overcome economic, technical and regulatory obstacles and to provide economic incentives for vigorous and efficient development of these promising indigenous, renewable ocean energy resources in ways that recognize the concurrent need to sustain the ongoing biological integrity of the State's waters, the vitality and productivity of ocean harvests and the differing needs and uses of the seas and other natural resources and to ensure the provision of these benefits to the people of the State by careful use of such public resources for renewable ocean energy production; and

Whereas, although additional research and related technological advances are needed for efficient commercialization of deep-water offshore wind power, varied and significant potential public benefits attributable to development and transition over time to optimal use of this resource and the State's other renewable ocean energy resources necessitates timely action to position the State to capture these benefits for the people of the State; and

Whereas, in the judgment of the Legislature, these facts create an emergency within the meaning of the Constitution of Maine and require the following legislation as immediately necessary for the preservation of the public peace, health and safety; now, therefore,

Be it enacted by the People of the State of Maine as follows:

PART A

Sec. A-1. 35-A MRSA §3132, sub-§6, as amended by PL 2009, c. 309, §3, is further amended to read:

6. Commission order; certificate of public convenience and necessity. In its order, the commission shall make specific findings with regard to the public need for the proposed transmission line. If the commission finds that a public need exists, it shall issue a certificate of public convenience and necessity for the transmission line. In determining public need, the commission shall, at a minimum, take into account economics, reliability, public health and safety, scenic, historic and recreational values, state renewable energy generation goals, the proximity of the proposed transmission line to inhabited dwellings and alternatives to construction of the transmission line, including energy conservation, distributed generation or load management. If the commission orders or allows the erection of the transmission line, the order is subject to all other provisions of law and the right of any other agency to approve the transmission line. The commission shall, as necessary and in accordance with subsections 7 and 8, consider the findings of the Department of Environmental Protection under Title 38, chapter 3, subchapter 1, article 6, with respect to the proposed transmission line and any modifications ordered by the Department of Environmental Protection to lessen the impact of the proposed transmission line on the environment. A person may submit a petition for and obtain approval of a proposed transmission line under this section before applying for approval under municipal ordinances adopted pursuant to Title 30A, Part 2, Subpart 6A; and Title 38, section 438A and, except as provided in subsection 4, before identifying a specific route or route options for the proposed transmission line. Except as provided in subsection 4, the commission may not consider the petition insufficient for failure to provide identification of a route or route options for the proposed transmission line. The issuance of a certificate of public convenience and necessity establishes that, as of the date of issuance of the certificate, the decision by the person to erect or construct was prudent. At the time of its issuance of a certificate of public convenience and necessity, the commission shall send to each municipality through which a proposed corridor or corridors for a transmission line extends a separate notice that the issuance of the certificate does not override, supersede or otherwise affect municipal authority to regulate the siting of the proposed transmission line. The commission may deny a certificate of public convenience and necessity for a transmission line upon a finding that the transmission line is reasonably likely to adversely affect any transmission and distribution utility or its customers.

Sec. A-2. 35-A MRSA §3402, sub-§1, as enacted by PL 2007, c. 661, Pt. A, §4, is amended to read:

1. Contribution of wind energy development. The Legislature finds and declares that the wind energy resources of the State constitute a valuable indigenous and renewable energy resource and that wind energy development, which is unique in its benefits to and impacts on the natural environment, makes a significant contribution to the general welfare of the citizens of the State for the following reasons:

A. Wind energy is an economically feasible, large-scale energy resource that does not rely on fossil fuel combustion or nuclear fission, thereby displacing electrical energy provided by these other sources and avoiding air pollution, waste disposal problems and hazards to human health from emissions, waste and by-products; consequently, wind energy development may address energy needs while making a significant contribution to achievement of the State's renewable energy and greenhouse gas reduction objectives, including those in Title 38, section 576; ~~and~~

B. At present and increasingly in the future with anticipated technological advances that promise to increase the number of places in the State where grid-scale wind energy development is economically viable, and changes in the electrical power market that favor clean power sources, wind energy may be used to displace electrical power that is generated from fossil fuel combustion and thus reduce our citizens' dependence on imported oil and natural gas and improve environmental quality and state and regional energy security~~.~~ ; and

C. Renewable energy resources within the State and in the Gulf of Maine have the potential, over time, to provide enough energy for the State's homeowners and businesses to reduce their use of oil and liquid petroleum-fueled heating systems by transition to alternative, renewable energy-based heating systems and to reduce their use of petroleum-fueled motor vehicles by transition to electric-powered motor vehicles. Electrification of heating and transportation has potential to increase the State's energy independence, to help stabilize total residential and commercial energy bills and to reduce greenhouse gas emissions.

Sec. A-3. 35-A MRSA §3404, sub-§1, as enacted by PL 2007, c. 661, Pt. A, §6, is amended to read:

1. Encouragement of wind energy-related development. It is the policy of the State ~~that,~~ in furtherance of the goals established in subsection 2, ~~its political subdivisions, agencies and public officials take every reasonable action~~ to encourage the attraction of appropriately sited development related to wind energy, including any additional transmission and other energy infrastructure needed to transport additional offshore wind energy to market, consistent with all state environmental standards; the permitting and financing of wind energy projects; and the siting, permitting, financing and construction of wind energy research and manufacturing facilities.

Sec. A-4. 35-A MRSA §3404, sub-§2, as enacted by PL 2007, c. 661, Pt. A, §6, is amended to read:

2. State wind energy generation goals. The goals for wind energy development in the State are that there be:

A. At least 2,000 megawatts of installed capacity by 2015; ~~and~~

B. At least 3,000 megawatts of installed capacity by 2020, ~~of which there is a potential to produce~~ including 300 megawatts or more from generation facilities located in coastal waters, as defined by Title 12, section 6001, subsection 6, or in proximate federal waters~~.~~ ; and

C. At least 8,000 megawatts of installed capacity by 2030, including 5,000 megawatts from generation facilities located in coastal waters, as defined by Title 12, section 6001, subsection 6, or in proximate federal waters.

Sec. A-5. 38 MRSA §631, sub-§3 is enacted to read:

3. Encouragement of tidal and wave power development. It is the policy of the State to encourage the attraction of appropriately sited development related to tidal and wave energy, including any additional transmission and other energy infrastructure needed to transport such energy to market, consistent with all state environmental standards; the permitting and siting of tidal and wave energy projects; and the siting, permitting, financing and construction of tidal and wave energy research and manufacturing facilities.

Sec. A-6. Competitive solicitation; long-term contracts; deep-water offshore wind energy pilot projects and tidal energy demonstration projects. By September 1, 2010, in accordance with the Maine Revised Statutes, Title 35-A, section 3210-C, except as otherwise provided by this section, the Public Utilities Commission shall conduct a competitive solicitation for proposals for long-term contracts to supply installed capacity and associated renewable energy and renewable energy credits from one or more deep-water offshore wind energy pilot projects or tidal energy demonstration projects.

The commission shall consult with the University of Maine, Department of Industrial Cooperation, Office of Research and Economic Development and the Department of Economic and Community Development in developing the request for proposals under this section and in its review of proposals submitted in response to the request.

Subject to the requirements of this section, the commission may direct one or more transmission and distribution utilities, as appropriate, to enter into a long-term contract of up to 20 years for the installed capacity and associated renewable energy and renewable energy credits of one or more deep-water offshore wind energy pilot projects or tidal energy demonstration projects.

For purposes of this section, “deep-water offshore wind energy pilot project” means a wind energy development, as defined by Title 35-A, section 3451, subsection 11, that is connected to the electrical transmission system located in the State and employs one or more floating wind energy turbines in the Gulf of Maine at a location 300 feet or greater in depth no less than 10 nautical miles from any land area of the State other than coastal wetlands, as defined by Title 38, section 480B, subsection 2, or an uninhabited island. “Tidal energy demonstration project” has the same meaning as in Title 38, section 636A, subsection 1, paragraph A.

1. Following review of proposals submitted in response to the competitive solicitation, the commission may negotiate with one or more potential suppliers to supply an aggregate total of no more than 30 megawatts of installed capacity and associated renewable energy and renewable energy credits from deep-water offshore wind energy pilot projects or tidal energy demonstration projects as long as no more than 5 megawatts of the total is supplied by tidal energy demonstration projects. Consistent with such negotiations, the commission may direct one or more transmission and distribution utilities, as appropriate, to enter into a long-term contract under this section only if the commission determines that the potential supplier:

A. Proposes sale of renewable energy produced by a deep-water offshore wind energy pilot project or a tidal energy demonstration project, referred to in this section as “the project;”

B. Has the technical and financial capacity to develop, construct, operate and, to the extent consistent with applicable federal law, decommission and remove the project in the manner provided by Title 38, section 480HH, subsection 3, paragraph G;

C. Has quantified the tangible economic benefits of the project to the State, including those regarding goods and services to be purchased and use of local suppliers, contractors and other professionals, during the proposed term of the contract;

D. Has experience relevant to tidal power or the offshore wind energy industry, as applicable, including, in the case of a deep-water offshore wind energy pilot project proposal, experience relevant to the construction and operation of floating wind turbines, and has the potential to construct a deep-water offshore wind energy project 100 megawatts or greater in capacity in the future to provide electric consumers in the State with project-generated power at reduced rates;

E. Has demonstrated a commitment to invest in manufacturing facilities in the State that are related to deep-water offshore wind energy or tidal energy, as applicable, including, but not limited to, component, turbine, blade, foundation or maintenance facilities; and

F. Has taken advantage of all federal support for the project, including subsidies, tax incentives and grants, and incorporated those resources into its bid price.

2. To mitigate any impacts of a long-term contract entered into under this section on electric rates, the commission shall:

A. Require the supplier, as part of the long-term contract, to take advantage of future federal support that may become available to the project over the contract term to mitigate impacts of the contract on electric rates;

B. Use the following funds to the full extent that such funds are available to mitigate impacts of the long-term contract on electric rates over the contract term:

(1) A portion of federal revenues from leasing areas of the Outer Continental Shelf for the project that is received by the State;

(2) A portion of the rent received by the State for leasing state submerged lands;

(3) A portion of the funds collected in the energy independence fund under Title 5, section 282, subsection 9; and

(4) Any other sources of revenue or funds accessible to the commission to mitigate impacts on ratepayers;

C. Develop and market an ocean wind green power offer, in accordance with provisions governing green power offers under Title 35-A, section 3212A, that is composed of electricity or renewable energy credits for electricity generated from deep-water offshore wind energy pilot projects to coincide with the start-up date of any deep-water offshore wind energy pilot project that secures a long-term contract under this section. In its annual report under Title 35-A, section 120, subsection 7, the commission shall report on the development, marketing and purchase of the ocean wind green power offer.

The commission may not approve any long-term contract under this section that would result in an increase in electric rates in any customer class that is greater than the amount of the assessment charged under Title 35-A, section 10110, subsection 4 at the time that the contract is entered.

Any contract entered into pursuant to this section must require that the deep-water offshore wind energy pilot project or tidal energy demonstration project, as appropriate, be constructed and operating within 5 years of the date the contract is finalized, unless the commission and project developer mutually agree to a longer time period.

In purchasing electricity for state-owned buildings pursuant to Title 5, section 1766A, the State shall consider the ocean wind green power offer. In purchasing electricity for the university system, the University of Maine System shall consider the ocean wind green power offer.

Sec. A-7. Review of terms and conditions for long-term contracts for renewable ocean energy. No later than January 15, 2012, the Executive Department, Governor's Office of Energy Independence and Security shall make a recommendation to the joint standing committee of the Legislature having jurisdiction over utilities and energy matters regarding terms and conditions for long-term contracts for installed capacity and associated renewable energy and renewable energy credits produced by renewable ocean energy projects, except for those addressed in section 8. For the purposes of this section, "renewable ocean energy project" has the same meaning as in the Maine Revised Statutes, Title 12, section 1862, subsection 1, paragraph F1. In making a recommendation under this section, the office shall, at a minimum, consider the following issues:

1. Risks to ratepayers associated with fossil fuel price volatility over the next 20 years;

2. State goals for the reduction of greenhouse gas emissions established in Title 38, section 576;

3. State wind energy generation goals under Title 35-A, section 3404, subsection 2; and

4. Other potential benefits attributable to the development of offshore wind, tidal and wave energy projects, including but not limited to public health, job creation and other economic benefits and energy security.

Sec. A-8. State energy plan amendment. No later than September 15, 2010, the Executive Department, Governor's Office of Energy Independence and Security shall amend the state energy plan under Title 2, section 9 to acknowledge the need for new transmission capacity to support attainment of state offshore wind energy generation goals established in the Maine Revised Statutes, Title 35-A, section 3404, subsection 2.

Sec. A-9. Assess the need for port-side land acquisition. No later than January 15, 2011, the Maine Port Authority shall assess existing port facilities in the State and make a recommendation to the joint standing committees of the Legislature having jurisdiction over transportation matters and utilities and energy matters regarding acquisition of real estate needed to facilitate renewable ocean energy development opportunities.

PART B

Sec. B-1. 12 MRSA §1862, as amended by PL 2009, c. 270, Pt. B, §1 and c. 316, §§1 to 6 and affected by §7, is further amended to read:

§ 1862. Submerged and intertidal lands owned by State

1. Definitions. As used in this section, unless the context otherwise indicates, the following terms have the following meanings.

A. “Commercial fishing activity” means any activity involving the landing or processing of shellfish, finfish or other natural products of the sea or other activities directly related to landing or processing shellfish, finfish or natural sea products. “Commercial fishing activity” includes loading or selling those products and fueling.

B. “Dockominium” means slip space that is sold or leased by a lessee of submerged lands to a boat or vessel owner for more than one year.

C. “Fair market rental value,” for all uses of submerged lands except slip space rented or otherwise made available for private use for a fee, means the municipally assessed value per square foot for the adjacent upland multiplied by a reduction factor plus a base rate based on the use of the leased submerged land as specified in this section. This value is then multiplied by the square foot area of the proposed lease area to determine the annual rental rate. For slip space rented or otherwise made available for private use for a fee, the fair market rental value is the gross income from that space multiplied by a reduction factor as specified in this section based on the use of the leased submerged land.

D. “Gross income” means the total annual income received by a lessee from seasonal or transient rental to the general public of slip space over submerged land. For dockominiums, slips that are part of a residential condominium, boat clubs and other facilities with slip space that is not rented or leased to the general public, the director shall determine gross income by calculating a regional average slip space rental fee and applying that to the portion of total linear length of slip space made available to private users for any portion of that year.

E. “Occupying,” in terms of a structure or alteration, means covering the total area of the structure or alteration itself to the extent that the area within its boundaries is directly on or over the state-owned lands.

E-1. ”Offshore project” means a project that extends beyond localized development adjacent to a single facility or property. “Offshore project” includes, but is not limited to, tanker ports, ship berthing platforms requiring secondary transport to shore, an interstate or international pipeline or cable and similar projects. “Offshore project” does not include a shore-based pier, marina or boatyard or utility cable and pipelines serving neighboring communities or islands. “Offshore project” does not include a wind ~~farms~~, tidal ~~and~~ , wave ~~energy facilities~~ or other ~~offshore~~ renewable ocean energy ~~projects~~ project.

F. “Permanent” means occupying submerged and intertidal lands owned by the State during 7 or more months during any one calendar year.

F-1. ”Renewable ocean energy project” means one or more of the following located in coastal wetlands, as defined by Title 38, section 480-B, subsection 2:

(1) An offshore wind power project, as defined by Title 38, section 480-B, subsection 6-A or by Title 38, section 482, subsection 8, and with an aggregate generating capacity of 3 megawatts or more;

(2) A community-based offshore wind energy project, as defined by section 682, subsection 19;

(3) A hydropower project, as defined by Title 38, section 632, subsection 3, that uses tidal or wave action as a source of electrical or mechanical power; or

(4) Other development activity that produces electric or mechanical power solely through use of wind, waves, tides, currents, ocean temperature clines, marine biomass or other renewable sources in, on or over the State's coastal waters, as defined by section 6001, subsection 6, to the 3-mile limit of state ownership recognized under the federal Outer Continental Shelf Lands Act, 43 United States Code, Chapter 29, Subchapter III (2009), and that includes both "generating facilities," as defined by Title 35-A, section 3451, subsection 5 and "associated facilities," as defined by Title 35-A, section 3451, subsection 1.

G. "Slip space" means the area adjacent to a pier or float that is used for berthing a boat.

2. Submerged lands leasing program. The director may conduct a submerged lands leasing ~~progam~~ program under which, except as otherwise provided by subsection 13, the director may lease, for a term of years not exceeding 30 and with conditions the director considers reasonable, the right to dredge, fill or erect permanent causeways, bridges, marinas, wharves, docks, pilings, moorings or other permanent structures on submerged and intertidal land owned by the State. The director may refuse to lease submerged lands if the director determines that the lease will unreasonably interfere with customary or traditional public access ways to or public trust rights in, on or over the intertidal or submerged lands and the waters above those lands.

A. For fill, permanent causeways, bridges, marinas, wharves, docks, pilings, moorings or other permanent structures and for nonpermanent structures occupying a total of 500 square feet or more of submerged land or occupying a total of 2,000 square feet or more of submerged land if used exclusively for commercial fishing activities:

(1) ~~The~~ Except as otherwise provided by subsection 13, the director shall charge the lessee a rent that practically approximates the fair market rental value of the submerged land. The reduction factors and base rate for use categories are as follows:

(a) A reduction factor of 0% with no base rate or rental fee for nonprofit organizations or publicly owned facilities that offer free public use or public use with nominal user fees. Public uses include, but are not limited to, municipal utilities and facilities that provide public access to the water, town wharves, walkways, fishing piers, boat launches, parks, nature reserves, swimming or skating areas and other projects designed to allow or enhance public recreation, fishing, fowling and navigation and for which user fees are used exclusively for the maintenance of the facility;

(b) A reduction factor of 0.1% plus a base rate of $0.025 per square foot for commercial fishing uses of renewable aquatic resources. Commercial uses of renewable aquatic resources include, but are not limited to, facilities that are directly involved in commercial fishing activities. Such facilities include, but are not limited to, fish piers, lobster impoundments, fish processing facilities and floats or piers for the storage of gear;

(c) A reduction factor of 2% for any slip space rented or otherwise made available for private use by commercial fishing boats for a fee;

(d) A reduction factor of 0.2% plus a base rate of $0.05 per square foot for water-dependent commerce, industry and private uses. Water-dependent commerce, industry and private uses other than commercial uses of renewable aquatic resources include, but are not limited to, all facilities that are functionally dependent upon a waterfront location, can not reasonably be located or operated on an upland site or are essential to the operation of the marine industry. Such facilities include, but are not limited to, privately owned piers and docks, cargo ports, private boat ramps, shipping and ferry terminals, tug and barge facilities, businesses that are engaged in watercraft construction, maintenance or repair, aquariums and the area within marinas occupied by service facilities, gas docks, breakwaters and other structures not used for slip space;

(e) A reduction factor of 4% for any slip space rented or otherwise made available for private use for recreational boats for a fee; and

(f) A reduction factor of 0.2% for upland uses and fill located on submerged lands prior to July 1, 2009 and 0.4% for new upland uses and fill after July 1, 2009 plus a base rate of $0.05 per square foot. Upland uses include, but are not limited to, all uses that can operate in a location other than on the waterfront or that are not essential to the operation of the marine industry. These facilities include, but are not limited to, residences, offices, restaurants and parking lots. Fill must include the placement of solid material other than pilings or other open support structures upon submerged lands.

If the director determines that the municipally assessed value of the adjacent upland is not an accurate indicator of the value of submerged land, the director may make adjustments in the municipally assessed value so that it more closely reflects the value of comparable waterfront properties in the vicinity or require the applicant to provide an appraisal of the submerged land. The appraisal must be approved by the director.

For offshore projects where municipally assessed value for the adjacent upland or submerged lands appraisals are unavailable or the director determines that such assessment or appraisals do not accurately indicate the value of the submerged land, the director may establish the submerged lands annual rental rate and other public compensation as appropriate by negotiation between the bureau and the applicant. In such cases the annual rent and other public compensation must take into account the proposed use of the submerged lands, the extent to which traditional and customary public uses may be diminished, the public benefit of the project, the economic value of the project and the avoided cost to the applicant. If the State’s ability to determine the values listed in this paragraph or to carry out negotiations requires expertise beyond the program’s capability, the applicant must pay for the costs of contracting for such expertise;

(2) After October 1, 1990, the director may revalue all existing rents to full fair market rental value. Rents for all uses except slip space may be adjusted annually as needed over a period not to exceed 5 years until the full fair market rental value is reached. After the full fair market rental value is reached, the director may revalue rents for all uses except slip space every 5 years based on changes in municipally assessed value and programmatic cost

adjustments to the base rate. Adjustments to the base rate may not exceed 4% per year. Rents for slip space may fluctuate annually depending on the gross income of the facility;

(3) ~~The~~ Except as otherwise provided by subsection 13, the director may also lease a buffer zone of not more than 30 feet in width around a permanent structure located on submerged or intertidal land, ~~provided that~~ as long as the lease is necessary to preserve the integrity and safety of the structure and that the Commissioner of Marine Resources consents to that lease;

(4) Any existing or proposed lease may be subleased for the period of the original lease for the purpose of providing berthing space for any boat or vessel;

(5) No portion of an existing or proposed lease may be transferred from a person subleasing that portion to provide berthing space for any boat or vessel except for a transfer to heirs upon death of the sublessee holder or a transfer to the original leaseholder subject to terms agreed to by the lessor and sublessee at the time of the sublease. This subparagraph does not apply to any subleasing arrangements entered into before June 15, 1989; and

(6) The director may grant the proposed lease if the director finds that, in addition to any other findings that the director may require, the proposed lease:

(a) Will not unreasonably interfere with navigation;

(b) Will not unreasonably interfere with fishing or other existing marine uses of the area;

(c) Will not unreasonably diminish the availability of services and facilities necessary for commercial marine activities; and

(d) Will not unreasonably interfere with ingress and egress of riparian owners.

~~The bureau shall adopt rules pertaining to this subparagraph by March 15, 1990.~~

B. For dredging, impounded areas and underwater cables and pipelines, the director shall develop terms and conditions the director considers reasonable.

C. The director shall charge an administrative fee of $100 for each lease in addition to any rent. A fee of $200 must be charged for a lease application that is received after work has begun for the proposed project.

D. ~~The~~ Except as otherwise provided by subsection 13, the minimum rent to which any lease is subject is $150 per year.

F. Within 15 days of receipt of a copy of an application submitted to the Department of

Environmental Protection for a general permit under Title 38, section 480-HH or Title 38, section 636-A, the director shall, if requested by the applicant, provide the applicant a lease option, to be effective on the date of receipt of the application, for use of state-owned submerged lands that are necessary to fulfill the project purposes as identified in the application. Within 30 days of receiving notice and a copy of a general permit granted pursuant to Title 38, section 480-HH or Title 38, section 636A, the director shall waive the review procedures and standards under this section and issue a submerged lands lease for the permitted activity. The term of the lease must be consistent with that of the permit, including any extension of the permit, and the period of time needed to fully implement the project removal plan approved pursuant to Title 38, section 480-HH or Title 38, section 636-A, as applicable. The director may include lease conditions that the director determines reasonable, except that the conditions may not impose any requirement more stringent than those in a permit granted under Title 38, section 480-HH or Title 38, section 636-A, as applicable, and may not frustrate achievement of the purpose of the project.

In making findings pursuant to this subsection regarding a renewable ocean energy project, the director shall adopt all pertinent findings and conclusions in a permit issued for the project pursuant to chapter 206-A or pursuant to Title 38, chapter 3, subchapter 1, article 5-A or 6 or Title 38, chapter 5, subchapter 1, article 1, subarticle 1-B, as applicable, and may condition issuance of a lease for such a project on receipt of all pertinent approvals by the Department of Environmental Protection or the Maine Land Use Regulation Commission, as applicable, and other conditions the director considers reasonable.

2-A. Lease renewal. A lessee who is in compliance with all terms of that person's lease may apply at any time to renew the lease. The director shall approve the lease renewal if the existing lease complies with or can be amended to comply with all applicable laws, rules and public trust principles in effect at the time of the renewal application. This subsection applies to all leases in effect on the effective date of this subsection and to all leases executed on or subsequent to the effective date of this subsection.

3. Easements. The director may grant, upon terms and conditions the director considers reasonable, assignable easements for a term not to exceed 30 years for the use of submerged and intertidal lands for the purposes permitted in subsection 2. The grantee shall pay an administrative fee of $100 for each easement at the time of processing and a registration fee of $50 due every 5 years. An administrative fee of $200 must be charged for an easement application that is received after work has begun for the proposed project. The director may refuse to grant an easement for the use of submerged and intertidal lands if the director determines that the easement will unreasonably interfere with customary or traditional public access ways to or public trust rights in, on or over the intertidal or submerged lands and the waters above those lands. The director may grant an easement for submerged and intertidal lands if a structure:

A. Is for the exclusive benefit of the abutting upland owner for charitable purposes as defined in the United States Internal Revenue Code, Section 501, (c) (3);

B. Occupies a total of not more than 500 square feet of submerged and intertidal land for any lawful purpose and is permanent; or

C. Occupies a total of not more than 2,000 square feet of submerged and intertidal land for the exclusive purpose of commercial fishing activities and is permanent.

4. Adjustment of terms. The director may adjust from time to time, consistent with the provisions of this section, conditions applicable to any leasehold or easement entered into under this section in any parcel of state-owned submerged or intertidal land. Rent may not be charged for leases entered into before July 1, 1984 if the actual use of the leased land is eligible for an easement under subsection 3.

5. Review of uses. In the case of easements, the director shall review from time to time the purposes for which the land conveyed has actually been used, and, in the event any such purpose is found to be inconsistent with the criteria set forth in subsection 3 for eligibility for an easement, the easement must terminate and the director may enter into a leasehold agreement with the holder of the easement in accordance with subsection 2.

6. Constructive easements. The owner of any structure actually upon submerged and intertidal lands on October 1, 1975 is deemed to have been granted a constructive easement for a term of 30 years on the submerged land directly underlying the structure. Beginning on January 1, 1991, the bureau shall undertake a registration program for all structures granted constructive easements. Constructive easements are subject to administrative and registration fees for easements pursuant to subsection 3. The director shall develop procedures, rules and registration forms necessary to accomplish the purposes of this subsection. The bureau shall complete the registration of constructive easements on or before December 31, 1996.

7. Consultation. The director shall consult with the commissioner, the Commissioner of Marine Resources, the Commissioner of Inland Fisheries and Wildlife and any other agencies or organizations the director considers appropriate in developing and implementing terms, conditions and consideration for conveyances under this section. When rental terms under subsection 13 for a renewable ocean energy project are at issue, the director also shall consult with the Public Utilities Commission. The director may determine to make proprietary conveyances under this section solely on the basis of the issuance of environmental or regulatory permits by other appropriate state agencies.

9. Public compensation. ~~With~~ Except as otherwise provided by subsection 13, with respect to any lease, including, but not limited to, leases for offshore projects, when the director determines that the public should be compensated for the loss or diminution of traditional and customary public uses resulting from the activities proposed by the lessee, the director may negotiate with the lessee to provide public access improvements such as walkways, boat launching ramps, parking space or other facilities or negotiate a fee in lieu of such improvements as a condition of the lease. The determination of loss or diminution of traditional and customary public uses and appropriate public compensation must be made in consultation with local municipal officials.

10. Aquaculture exemption. A lease for the use of lands under this section is not required for the development and operation of any aquaculture facility if the owner or operator of the facility has obtained a lease from the Commissioner of Marine Resources under section 6072. Ancillary equipment and facilities permanently occupying submerged lands on the lease site and not explicitly included in the lease granted by the Commissioner of Marine Resources are not exempt from the requirements of this section.

11. Revenues. ~~All~~ Except as otherwise provided by subsection 13, all revenues from the bureau's activities under this section accrue to the Submerged Lands Fund established in section 1861.

12. Annual report dealing with submerged lands. The bureau shall prepare and submit a written report on or before March 1st of each year to the joint standing committee of the Legislature having jurisdiction over submerged lands matters. The report must include the following information:

A. A complete account of the income and expenditures pertaining to submerged lands during the preceding calendar year;

B. A summary of the bureau's management activities during the preceding calendar year regarding leases, easements and other appropriate subjects;

C. A summary of any Shore and Harbor Management Fund grants made under section 1863; and

D. A description of the proposed budget, including allocations for the bureau's dedicated funds and any revenues of the bureau from leases and easements for the following fiscal year.

The joint standing committee of the Legislature having jurisdiction over submerged lands matters shall review the report and submit a written recommendation regarding the bureau's proposed budget to the joint standing committee of the Legislature having jurisdiction over appropriations and financial affairs on or before March 15th of each year.

13. Special provisions regarding renewable ocean energy projects. The provisions in this subsection govern renewable ocean energy projects.

A. The Legislature finds that:

(1) The State's coastal waters and submerged lands provide unique and valuable opportunities for development of wind and tidal power and, potentially, other indigenous, renewable ocean energy resources, such as wave power;

(2) Climate change and related degradation or loss of marine resources and related human uses make development of and transition to use of renewable ocean energy resources consistent with sound stewardship of the State's public trust resources;

(3) Proper and efficient functioning of certain generation and associated facilities that use the energy potential of the State's indigenous, renewable ocean energy resources depends upon their deployment in a marine environment and, accordingly, such facilities may to the extent necessary be located in, on or over state-owned submerged lands; and

(4) With appropriate provision for avoidance and minimization of and compensation for harm to existing public trust-related uses and resources, such as fishing and navigation; consideration of potential adverse effects on existing uses of the marine environment; restoration of affected lands upon completion of authorized uses pursuant to permitting criteria; and adequate compensation to the public for use of its trust resources pursuant to state submerged lands leasing criteria, development of these renewable ocean energy resources in appropriate locations promises significant public trust-related benefits to the people of this State for whom the State holds and manages submerged lands and their resources.

B. In accordance with the findings in paragraph A, the following provisions apply to an application for a lease or easement for a renewable ocean energy project.

(1) No more than 30 days prior to filing applications in accordance with this paragraph, an applicant for a lease or easement for a renewable ocean energy project shall participate in a

joint interagency preapplication meeting that includes the Department of Marine Resources and is in accordance with permitting procedures of the Department of Environmental Protection or the Maine Land Use Regulation Commission, as applicable.

(2) An applicant for a lease or easement for a renewable ocean energy project must file and certify to the director that it has filed completed applications for requisite state permits under chapter 206-A or Title 38, chapter 3, subchapter 1, article 5-A or 6 or Title 38, chapter 5, subchapter 1, article 1, subarticle 1-B, as applicable, prior to or concurrently with submission of its submerged lands lease application under this section and shall provide a copy of any such applications to the director upon request.

(3) The director shall provide notice to the Marine Resources Advisory Council under section 6024 and any lobster management policy council established pursuant to section 6447 in whose or within 3 miles of whose designated lobster management zone created pursuant to section 6446 the proposed development is located. The Marine Resources Advisory Council and any lobster management policy council notified pursuant to this subparagraph may provide comments within a reasonable period established by the director, and the director shall consider the comments in making findings pursuant to subsection 2, paragraph A, subparagraph (6).

(4) The director may issue a lease or easement for a hydropower project, as defined in Title 38, section 632, subsection 3, that uses tidal or wave action as a source of electrical or mechanical power, for a term not to exceed 50 years, as long as the lease term is less than or equal to the term of the license for the project issued by the Federal Energy Regulatory Commission.

(5) If requested by an applicant, and with provision for public notice and comment, the director may issue one or more of the following for a renewable ocean energy project prior to issuance of a 30-year lease for the project:

(a) A lease option, for a term not to exceed 2 years, that establishes that the leaseholder, for purposes of consideration of its application for state permit approvals under chapter 206-A or Title 38, chapter 3, subchapter 1, article 5A or 6 or Title 38, chapter 5, subchapter 1, article 1, subarticle 1-B, as applicable, has title, right or interest in a specific area of state submerged lands needed to achieve the purposes of the project as described in conceptual plans in the lease application;

(b) A submerged lands lease, for a term not to exceed 3 years, that authorizes the leaseholder to undertake feasibility testing and predevelopment monitoring for ecological and human use impacts as described in conceptual plans in the lease application and conditioned on receipt of requisite federal, state and local approvals; and

(c) A submerged lands lease, for a term not to exceed 5 years, that authorizes the leaseholder to secure requisite federal, state and local approvals and complete preoperation construction, as long as the applicant provides detailed development plans describing all operational conditions and restrictions.

(6) Except as otherwise provided in this paragraph, the annual rent for a wind energy demonstration project for which a general permit has been issued under Title 38, section

480HH is $10,000 per year for the term of the general permit. The annual rent for a tidal energy demonstration project for which a general permit has been issued under Title 38, section 636A is $100 per acre of submerged lands occupied by the project for the term of the general project, except that the annual rent may not exceed $10,000. As used in this paragraph, "submerged lands occupied" includes the sum of the area on which turbines, testing and monitoring equipment, anchoring or mooring lines, submerged transmission cables or other structures are placed and any additional area from which the director finds it necessary to exclude transient public trust uses to avoid unreasonable interference with the project's purposes. An annual rent is not required for an offshore wind energy demonstration project located in the Maine Offshore Wind Energy Research Center, as designated by the department under section 1868, subsection 2.

(7) The director shall charge a lessee an annual rent in accordance with a fee schedule, established by the bureau by rule, that balances state goals of assurance of fair compensation for use and mitigation of potential adverse effects on or conflict with existing uses of state-owned submerged lands that are held in trust for the people of the State with state renewable ocean energy-related goals, including state wind energy generation goals established in Title 35-A, section 3404, subsection 2. Rules adopted pursuant to this subparagraph are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A.

(8) The director may not require additional public compensation pursuant to subsection 9.

(9) The director may issue a lease for a buffer zone comprising a land or water area around permanent structures located on submerged or intertidal land if:

(a) The director determines such a buffer zone is necessary to preserve the integrity or safety of the structure or fulfill the purposes of the project; and

(b) The director consults with the Commissioner of Marine Resources regarding the need for such a buffer, its location and size and options to minimize its potential effects on existing uses.

Sec. B-2. 12 MRSA §1863, sub-§3, as repealed and replaced by PL 1999, c. 401, Pt. I, §1, is amended to read:

3. Fund sources. Annual revenues, less funds deposited in the Renewable Ocean Energy Trust pursuant to section 1863-A and operating expenses from the submerged and intertidal lands program and the abandoned watercraft program and conveyances of submerged and intertidal lands by the Legislature, must be deposited in the fund.

Sec. B-3. 12 MRSA §1863-A is enacted to read:

§ 1863-A. Renewable Ocean Energy Trust

1. Trust established. The Renewable Ocean Energy Trust, referred to in this section as "the trust," is established as a nonlapsing, dedicated fund to be used to protect and enhance the integrity of public trust-related resources and related human uses of the State's submerged lands.

2. Administration. The Treasurer of State shall administer the trust as provided in this section.

3. Sources of funds. The following funds must be transferred on receipt to the Treasurer of State for deposit in the trust:

A. Eighty percent of the submerged lands leasing rental payments for renewable ocean energy projects under section 1862, subsection 13 and offshore wind energy demonstration projects and tidal energy demonstration projects for which a general permit has been issued under Title 38, section 480HH or Title 38, section 636A, respectively; and

B. The State's share, pursuant to 43 United States Code, Section 1337(p)(2)(B), of federal revenues from alternative energy leasing.

4. Disbursement of funds; required uses. The Treasurer of State shall annually disburse the funds in the trust for credit to the Ocean Energy Fund established within the Department of Marine Resources, in consultation with the Marine Resources Advisory Council established under section 6024, for use as follows:

A. Fifty percent to fund research, monitoring and other efforts to avoid, minimize and compensate for potential adverse effects of renewable ocean energy projects, as defined in section 1862, subsection 1, paragraph F-1, on noncommercial fisheries, seabirds, marine mammals, shorebirds, migratory birds and other coastal and marine natural resources, including but not limited to development, enhancement and maintenance of map-based information resources developed to guide public and private decision making on siting issues and field research to provide baseline or other data to address siting issues presented by renewable ocean energy projects. The department shall consult with the Department of Inland Fisheries and Wildlife and the Executive Department, State Planning Office in allocating funds it receives pursuant to this paragraph; and

B. Fifty percent to fund resource enhancement, research on fish behavior and species abundance and distribution and other issues and other efforts to avoid, minimize and compensate for potential adverse effects of renewable ocean energy projects, as defined in section 1862, subsection 1, paragraph F-1, on commercial fishing and related activities.

Sec. B-4. Establishment of fee schedule for renewable ocean energy development projects. No later than one year from the effective date of this section and in accordance with the Maine Revised Statutes, Title 12, section 1862, subsection 13, paragraph B, subparagraph (6), the Department of Conservation, Bureau of Parks and Lands shall amend its submerged lands leasing rules to establish a fee schedule for leasing submerged lands for a renewable ocean energy project as defined in Title 12, section 1862, subsection 1, paragraph F-1 that balances state goals of assurance of fair compensation for use and mitigation of potential adverse effects on or conflict with existing uses of state-owned submerged lands that are held in trust for the people of the State with state renewable ocean energy-related goals, including state wind energy generation goals established in Title 35-A, section 3404, subsection 2. Rules adopted pursuant to this section are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A. Prior to adoption of such a fee schedule, the Director of the Bureau of Parks and Lands shall determine the rent on a case-by-case basis. In developing rules pursuant to this section, the bureau shall:

1. Establish fees that are commercially reasonable and comparable to pertinent lease fees in other jurisdictions both in terms of the fee amounts and provision for a graduated fee schedule that reflects consideration of energy production levels and debt service obligations in the initial years of a renewable ocean energy project;

2. Consider renewable ocean energy-related submerged lands leasing fees in other states; fees provided for by the United States Department of Interior, Minerals Management Service's Renewable Energy Program; current market practices in the wind power industry regarding lease arrangements; and other

pertinent information;

3. Include in the fee schedule an amount adequate to cover the bureau's pertinent administrative costs;

4. Allow the developer of a renewable ocean energy project to enter into a contract for sale or use of project-generated power that, through reduced rates or otherwise, provides the State or electric consumers in this State a portion of the dollar value of the pertinent rental fee for use of state submerged lands and obligates the developer to provide monetary payment to the State for the remaining portion of the rental fee as provided in this Act;

5. Consult with and consider the recommendations of the Public Utilities Commission regarding provisions in the rules regarding subsection 4 and related permit terms and conditions for a lease for a renewable ocean energy project;

6. Clarify that potential adverse effects on existing uses, such as fishing, are addressed through the fee schedule and that the bureau may not require case-by-case payment of an amount in addition to rent as compensation for such project-specific effects;

7. Incorporate the annual rent and exemption established in Title 12, section 1862, subsection 13, paragraph B, subparagraph (5); and

8. Otherwise amend its rules for consistency with the provisions of this Act.

PART C

Sec. C-1. Personal property-related taxation; renewable ocean energy development. No later than November 1, 2010, the Department of Administrative and Financial Regulation, Bureau of Revenue Services shall develop and provide to the joint standing committees of the Legislature having jurisdiction over taxation matters and utilities and energy matters an analysis of whether and under what circumstances renewable ocean energy-generating machinery, equipment and related components, including but not limited to turbines, support structures, transmission cables and their component parts, that are in transit to be located in, on or above state submerged lands as defined in the Maine Revised Statutes, Title 12, section 1801, subsection 9 and that are in the State on the first day of April on the applicable tax year are exempt from taxation under Title 36, section 655, subsection 1, paragraph A, B, G or H.

PART D

Sec. D-1. 12 MRSA §682, sub-§1, as amended by PL 1999, c. 333, §1, is further amended to read:

1. Unorganized and deorganized areas. "Unorganized and deorganized areas" includes all unorganized and deorganized townships, plantations that have not received commission approval under section 685-A, subsection 4 to implement their own land use controls, municipalities that have organized since 1971 but have not received commission approval under section 685-A, subsection 4 to implement their own land use controls and all other areas of the State that are not part of an organized municipality except Indian reservations. For the purposes of permitting a community-based offshore wind energy project and structures associated with resource analysis activities necessary for such an intended project, the area of submerged land to be occupied for such a project and resource analysis structures is considered to be in the unorganized or deorganized areas.

Sec. D-2. 12 MRSA §682, sub-§19 is enacted to read:

19. Community-based offshore wind energy project. "Community-based offshore wind energy project" means a wind energy development, as defined by Title 35-A, section 3451, subsection 11, with an aggregate generating capacity of less than 3 megawatts that meets the following criteria: the generating facilities are wholly or partially located on or above the coastal submerged lands of the State; the generating facilities are located within one nautical mile of one or more islands that are within the unorganized and deorganized areas of the State and the project will offset part or all of the electricity requirements of those island communities; and the development meets the definition of "community-based renewable energy project" as defined by Title 35-A, section 3602, subsection 1.

Sec. D-3. 12 MRSA §685-B, sub-§2-C, as repealed and replaced by PL 2009, c. 492, §1, is amended to read:

2-C. Wind energy development; community-based offshore wind energy projects; determination deadline. The following provisions govern wind energy development.

A. The commission shall consider any wind energy development in the expedited permitting area under Title 35A, chapter 34A with a generating capacity of 100 kilowatts or greater or a community-based offshore wind energy project a use requiring a permit, but not a special exception, within the affected districts or subdistricts. For an offshore wind energy project that is proposed within one nautical mile of an island within the unorganized or deorganized areas, the commission shall review the proposed project to determine whether the project qualifies as a community-based offshore wind energy project and therefore is within the jurisdiction of the commission. The commission may require an applicant to provide a timely notice of filing prior to filing an application for, and may require the applicant to attend a public meeting during the review of, a wind energy development or a community-based offshore wind energy project. The commission shall render its determination on an application for such a development or project within 185 days after the commission determines that the application is complete, except that the commission shall render such a decision within 270 days if it holds a hearing on the application. The chair of the Public Utilities Commission or the chair's designee shall serve as a nonvoting member of the commission and may participate fully but is not required to attend hearings when the commission considers an application for an expedited wind energy development or a community-based offshore wind energy project. The chair's participation on the commission pursuant to this subsection does not affect the ability of the Public Utilities Commission to submit information into the record of the commission's proceedings. For purposes of this subsection, "expedited permitting area," "expedited wind energy development" and "wind energy development" have the same meanings as in Title 35-A, section 3451.

B. At the request of an applicant, the commission may stop the processing time for a period of time agreeable to the commission and the applicant. The expedited review period specified in paragraph A does not apply to the associated facilities, as defined in Title 35-A, section 3451, subsection 1, of the wind energy development or community-based offshore wind energy project if the commission determines that an expedited review time is unreasonable due to the size, location, potential impacts, multiple agency jurisdiction or complexity of that portion of the development or project.

Sec. D-4. 12 MRSA §685-B, sub-§4, as amended by PL 2009, c. 492, §2, is further amended to read:

4. Criteria for approval. In approving applications submitted to it pursuant to this section, the commission may impose such reasonable terms and conditions as the commission may consider appropriate. In making a decision under this subsection regarding an application for a community-based offshore wind energy project, the commission may not consider whether the project meets the specific criteria designated in section 1862, subsection 2, paragraph A, subparagraph (6), divisions (a) to (d). This limitation is not intended to restrict the commission's review of related potential impacts of the project as determined by the commission.

The commission may not approve an application, unless:

A. Adequate technical and financial provision has been made for complying with the requirements of the State's air and water pollution control and other environmental laws, and those standards and regulations adopted with respect thereto, including without limitation the minimum lot size laws, sections 4807 to 4807G, the site location of development laws, Title 38, sections 481 to 490, and the natural resource protection laws, Title 38, sections 480A to 480Z, and adequate provision has been made for solid waste and sewage disposal, for controlling of offensive odors and for the securing and maintenance of sufficient healthful water supplies;

B. Adequate provision has been made for loading, parking and circulation of land, air and water traffic, in, on and from the site, and for assurance that the proposal will not cause congestion or unsafe conditions with respect to existing or proposed transportation arteries or methods;

C. Adequate provision has been made for fitting the proposal harmoniously into the existing natural environment in order to ensure there will be no undue adverse effect on existing uses, scenic character and natural and historic resources in the area likely to be affected by the proposal. In making a determination under this paragraph regarding development to facilitate withdrawal of groundwater, the commission shall consider the effects of the proposed withdrawal on waters of the State, as defined by Title 38, section 361A, subsection 7; water-related natural resources; and existing uses, including, but not limited to, public or private wells, within the anticipated zone of contribution to the withdrawal. In making findings under this paragraph, the commission shall consider both the direct effects of the proposed withdrawal and its effects in combination with existing water withdrawals.

In making a determination under this paragraph regarding an expedited wind energy development, as defined in Title 35A, section 3451, subsection 4, or a community-based offshore wind energy project, the commission shall consider the development's or project's effects on scenic character and existing uses related to scenic character in accordance with Title 35A, section 3452.

In making a determination under this paragraph regarding a wind energy development, as defined in Title 35A, section 3451, subsection 11, that is not a grid-scale wind energy development, that has a generating capacity of 100 kilowatts or greater and that is proposed for location within the expedited permitting area, the commission shall consider the development's or project's effects on scenic character and existing uses relating to scenic character in the manner provided for in Title 35A, section 3452;

D. The proposal will not cause unreasonable soil erosion or reduction in the capacity of the land to absorb and hold water and suitable soils are available for a sewage disposal system if sewage is to be disposed on-site;

E. The proposal is otherwise in conformance with this chapter and the regulations, standards and plans adopted pursuant thereto; and

F. In the case of an application for a structure upon any lot in a subdivision, that the subdivision has received the approval of the commission.

The burden is upon the applicant to demonstrate by substantial evidence that the criteria for approval are satisfied, and that the public's health, safety and general welfare will be adequately protected. Except as otherwise provided in Title 35A, section 3454, the commission shall permit the applicant and other parties to provide evidence on the economic benefits of the proposal as well as the impact of the proposal on energy resources.

Sec. D-5. 12 MRSA §685-B, sub-§4-B, as enacted by PL 2007, c. 661, Pt. C, §4, is amended to read:

4-B. Special provisions; wind energy development or project. In the case of a wind energy development, as defined in Title 35-A, section 3451, subsection 11, with a generating capacity greater than 100 kilowatts, or a community-based offshore wind energy project, the developer must demonstrate, in addition to requirements under subsection 4, that the proposed generating facilities, as defined in Title 35-A, section 3451, subsection 5:

A. Will meet the requirements of the Board of Environmental Protection's noise control rules adopted pursuant to Title 38, chapter 3, subchapter 1, article 6;

B. Will be designed and sited to avoid undue adverse shadow flicker effects;

C. Will be constructed with setbacks adequate to protect public safety, as provided in Title 35-A, section 3455. In making findings pursuant to this paragraph, the commission shall consider the recommendation of a professional, licensed civil engineer as well as any applicable setback recommended by a manufacturer of the generating facilities; and

D. Will provide significant tangible benefits, as defined in Title 35-A, section 3451, subsection 10, within the State, as provided in Title 35-A, section 3454, if the development is an expedited wind energy development, as defined in Title 35-A, section 3451, subsection 4.

Sec. D-6. Maine Land Use Regulation Commission to adopt rule. No later than December 1, 2010, the Maine Land Use Regulation Commission shall adopt a rule amending its land use districts and standards to provide that offshore wind power projects, as defined in the Maine Revised Statutes, Title 38, section 480-B, subsection 6A, and community-based offshore wind energy projects, as defined in Title 12, section 682, subsection 19, are uses requiring a permit, but not a special exception, in all subdistricts. Prior to the commission's adoption of a rule in accordance with this section, an offshore wind power project or a community-based offshore wind energy project is considered a use requiring a permit, but not a special exception, in all subdistricts.

Rules adopted by the Maine Land Use Regulation Commission pursuant to this section are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A.

PART E

Sec. E-1. 38 MRSA §341-D, sub-§2, as amended by PL 2007, c. 661, Pt. B, §1, is further amended to read:

2. Permit and license applications. Except as otherwise provided in this subsection, the board shall decide each application for approval of permits and licenses that in its judgment:

A. Involves a policy, rule or law that the board has not previously interpreted;

B. Involves important policy questions that the board has not resolved;

C. Involves important policy questions or interpretations of a rule or law that require reexamination; or

D. Has generated substantial public interest.

The board shall assume jurisdiction over applications referred to it under section 344, subsection 2-A, when it finds that the criteria of this subsection have been met.

The board may vote to assume jurisdiction of an application if it finds that one or more of the criteria in this subsection have been met.

Any interested party may request the board to assume jurisdiction of an application.

The board may not assume jurisdiction over an application for an expedited wind energy development as defined in Title 35A, section 3451, subsection 4 ~~or~~ <u>,</u> for a certification pursuant to Title 35A, section 3456 <u>or for a general permit pursuant to section 480HH or section 636A</u>.

Sec. E-2. 38 MRSA §341-D, sub-§4, ¶D, as enacted by PL 2007, c. 661, Pt. B, §4, is amended to read:

D. License or permit decisions regarding an expedited wind energy development as defined in Title 35-A, section 3451, subsection 4 <u>or a general permit pursuant to section 480HH or section 636A</u>. In reviewing an appeal of a license or permit decision by the commissioner ~~on an application for an expedited wind energy development~~ <u>under this paragraph</u>, the board shall base its decision on the administrative record of the department, including the record of any adjudicatory hearing held by the department, and any supplemental information allowed by the board using the standards contained in subsection 5 for supplementation of the record. The board may remand the decision to the department for further proceedings if appropriate. The chair of the Public Utilities Commission or the chair's designee ~~shall serve~~ <u>serves</u> as a nonvoting member of the board and is entitled to fully participate but is not required to attend hearings when the board considers an appeal pursuant to this paragraph. The chair's participation on the board pursuant to this paragraph does not affect the ability of the Public Utilities Commission to submit information to the department for inclusion in the record of any proceeding before the department.

Sec. E-3. 38 MRSA §344, sub-§2-A, ¶A, as amended by PL 2007, c. 661, Pt. B, §5, is further amended to read:

A. Except as otherwise provided in this paragraph, the commissioner shall decide as expeditiously as possible if an application meets one or more of the criteria set forth in section 341-D, subsection 2 and shall request that the board assume jurisdiction of that application. If at any subsequent time during the review of an application the commissioner decides that the application falls under section 341-D, subsection 2, the commissioner shall request that the board assume jurisdiction of the application.

(1) The commissioner may not request the board to assume jurisdiction of an application for any permit or other approval required for an expedited wind energy development, as defined in Title 35A, section 3451, subsection 4, ~~or~~ a certification pursuant to Title 35A, section 3456 or a general permit pursuant to section 480HH or section 636A. Except as provided in subparagraph (2), the commissioner shall issue a decision on an application for an expedited wind energy development, an offshore wind power project or a hydropower project, as defined in section 632, subsection 3, that uses tidal action as a source of electrical or mechanical power within 185 days of the date on which the department accepts the application as complete pursuant to this section or within 270 days of the department's acceptance of the application if the commissioner holds a hearing on the application pursuant to section 345A, subsection 1A.

(2) The expedited review periods of 185 days and 270 days specified in subparagraph (1) do not apply to the associated facilities, as defined in Title 35A, section 3451, subsection 1, of the development if the commissioner determines that an expedited review time is unreasonable due to the size, location, potential impacts, multiple agency jurisdiction or complexity of that portion of the development. If an expedited review period does not apply, a review period specified pursuant to section 344-B applies.

The commissioner may stop the processing time with the consent of the applicant for a period of time agreeable to the commissioner and the applicant.

Sec. E-4. 38 MRSA §344-A, first ¶, as amended by PL 2009, c. 270, Pt. A, §1, is further amended to read:

The commissioner may enter into agreements with individuals, partnerships, firms and corporations outside the department, referred to throughout this section as "outside reviewers," to review applications or portions of applications submitted to the department. The commissioner has sole authority to determine the applications or portions of applications to be reviewed by outside reviewers and to determine which outside reviewer is to perform the review. When selecting an outside reviewer, all other factors being equal, the commissioner shall give preference to an outside reviewer who is a public or quasi-public entity, such as state agencies, the University of Maine System or the soil and water conservation districts. Except for an agreement for outside review regarding review of an application for a wind energy development as defined in Title 35A, section 3451, subsection 11, a certification pursuant to Title 35-A, section 3456, an application for an offshore wind power project as defined in section 480-B, subsection 6A or a general permit pursuant to section 480-HH or section 636-A or an application for a hydropower project, as defined in section 632, subsection 3, that uses tidal action as a source of electrical or mechanical power, the commissioner may enter into an agreement with an outside reviewer only with the consent of the applicant and only if the applicant agrees in writing to pay all costs associated with the outside review.

Sec. E-5. 38 MRSA §346, sub-§4, as enacted by PL 2007, c. 661, Pt. B, §8, is amended to read:

4. Appeal of decision. A person aggrieved by an order or decision of the board or commissioner regarding an application for an expedited wind energy development, as defined in Title 35A, section 3451, subsection 4, or a general permit pursuant to section 480HH or section 636A may appeal to the Supreme Judicial Court sitting as the law court. These appeals to the law court must be taken in the manner provided in Title 5, chapter 375, subchapter 7.

Sec. E-6. 38 MRSA §480-B, sub-§6-A is enacted to read:

6-A. Offshore wind power project. "Offshore wind power project" means a project that uses a windmill or wind turbine to convert wind energy to electrical energy and is located in whole or in part within coastal wetlands. "Offshore wind power project" includes both generating facilities as defined by Title 35-A, section 3451, subsection 5 and associated facilities as defined by Title 35-A, section 3451, subsection 1, without regard to whether the electrical energy is for sale or use by a person other than the generator.

Sec. E-7. 38 MRSA §480-D, first paragraph, as amended by PL 2007, c. 353, §9, is further amended to read:

The department shall grant a permit upon proper application and upon such terms as it considers necessary to fulfill the purposes of this article. The department shall grant a permit when it finds that the applicant has demonstrated that the proposed activity meets the standards set forth in subsections 1 to ~~9~~ 11, except that when an activity requires a permit only because it is located in, on or over a community public water system primary protection area the department shall issue a permit when it finds that the applicant has demonstrated that the proposed activity meets the standards set forth in subsections 2 and 5.

Sec. E-8. 38 MRSA §480-D, sub-§1, as amended by PL 2007, c. 661, Pt. B, §10, is further amended to read:

1. Existing uses. The activity will not unreasonably interfere with existing scenic, aesthetic, recreational or navigational uses.

In making a determination under this subsection regarding an expedited wind energy development, as defined in Title 35A, section 3451, subsection 4, or an offshore wind power project, the department shall consider the development's or project's effects on scenic character and existing uses related to scenic character in accordance with Title 35A, section 3452. In making a decision under this subsection regarding an application for an offshore wind power project, the department may not consider whether the project meets the specific criteria designated in Title 12, section 1862, subsection 2, paragraph A, subparagraph (6), divisions (a) to (d). This limitation is not intended to restrict the department's review of related potential impacts of the project as determined by the department.

Sec. E-9. 38 MRSA §480-D, sub-§11 is enacted to read:

11. Offshore wind power project. This subsection applies to an offshore wind power project.

A. If an offshore wind power project does not require a permit from the department pursuant to article 6, the applicant must demonstrate that the generating facilities:

(1) Will meet the requirements of the noise control rules adopted by the board pursuant to article 6;

(2) Will be designed and sited to avoid unreasonable adverse shadow flicker effects; and

(3) Will be constructed with setbacks adequate to protect public safety, while maintaining existing uses to the extent practicable. In making a finding pursuant to this paragraph, the department shall consider the recommendation of a professional, licensed civil engineer as well as any applicable setback recommended by a manufacturer of the generating facilities.

B. If an offshore wind power project does not require a permit from the department pursuant to article 6, the applicant must demonstrate adequate financial capacity to decommission the offshore wind power project.

C. An applicant for an offshore wind power project is not required to demonstrate compliance with requirements of this article that the department determines are addressed by criteria specified in Title 12, section 1862, subsection 2, paragraph A, subparagraph (6).

Sec. E-10. 38 MRSA §480-E, sub-§1, as enacted by PL 1989, c. 656, §4 and affected by c. 890, Pt. A, §40 and amended by Pt. B, §73, is repealed and the following enacted in its place:

1. Municipal and other notification. The department shall provide notice according to this subsection.

A. Except as otherwise provided in paragraph B, the department may not review a permit without notifying the municipality in which the proposed activity is to occur. The municipality may provide comments within a reasonable period established by the commissioner and the commissioner shall consider any such comments.

B. The department may not review an application for an offshore wind power project without providing:

(1) Notice to the Maine Land Use Regulation Commission when the proposed development is located within 3 miles of an area of land within the jurisdiction of the Maine Land Use Regulation Commission; and

(2) Notice to any municipality with land located within 3 miles of the proposed development and any municipality in which development of associated facilities is proposed.

The Maine Land Use Regulation Commission and any municipality notified pursuant to this paragraph may provide comments within a reasonable period established by the commissioner and the commissioner shall consider such comments.

Sec. E-11. 38 MRSA §480-E-1, first ¶, as repealed and replaced by PL 2005, c. 330, §14, is amended to read:

The Maine Land Use Regulation Commission shall issue all permits under this article for activities that are located wholly within its jurisdiction and are not subject to review and approval by the department under any other article of this chapter, except as provided in subsection 3.

Sec. E-12. 38 MRSA §480-E-1, sub-§3 is enacted to read:

3. Offshore wind power project. The department shall issue all permits under this article for offshore wind power projects except for community-based offshore wind energy projects as defined in Title 12, section 682, subsection 19.

Sec. E-13. 38 MRSA §482, sub-§2, ¶D, as amended by PL 1999, c. 468, §6, is further amended to read:

D. Is a subdivision as defined in this section; ~~or~~

Sec. E-14. 38 MRSA §482, sub-§2, ¶F, as enacted by PL 1997, c. 502, §5, is amended to read:

F. Is an oil terminal facility as defined in this section~~.~~ ; or

Sec. E-15. 38 MRSA §482, sub-§2, ¶J is enacted to read:

J. Is an offshore wind power project with an aggregate generating capacity of 3 megawatts or more.

Sec. E-16. 38 MRSA §482, sub-§8 is enacted to read:

8. Offshore wind power project. "Offshore wind power project" means a project that uses a windmill or wind turbine to convert wind energy to electrical energy and is located in whole or in part within coastal wetlands as defined in section 480-B, subsection 2. "Offshore wind power project" includes both generating facilities as defined by Title 35-A, section 3451, subsection 5 and associated facilities as defined by Title 35-A, section 3451, subsection 1, without regard to whether the electrical energy is for sale or use by a person other than the generator.

Sec. E-17. 38 MRSA §484, sub-§3, ¶G, as enacted by PL 2007, c. 661, Pt. B, §11, is amended to read:

G. In making a determination under this subsection regarding an expedited wind energy development, as defined in Title 35-A, section 3451, subsection 4, or an offshore wind power project with an aggregate generating capacity of 3 megawatts or more, the department shall consider the development's or project's effects on scenic character and existing uses related to scenic character in accordance with Title 35-A, section 3452.

Sec. E-18. 38 MRSA §484, sub-§10, as enacted by PL 2007, c. 661, Pt. B, §12, is amended to read:

10. Special provisions; wind energy development or offshore wind power project. In the case of a grid-scale wind energy development, or an offshore wind power project with an aggregate generating capacity of 3 megawatts or more, the proposed generating facilities, as defined in Title 35-A, section 3451, subsection 5:

A. Will be designed and sited to avoid unreasonable adverse shadow flicker effects;

B. Will be constructed with setbacks adequate to protect public safety. In making a finding pursuant to this paragraph, the department shall consider the recommendation of a professional, licensed civil engineer as well as any applicable setback recommended by a manufacturer of the generating facilities; and

C. Will provide significant tangible benefits as determined pursuant to Title 35-A, section 3454, if the development is an expedited wind energy development.

The Department of Labor, the Executive Department, State Planning Office and the Public Utilities Commission shall provide review comments if requested by the primary siting authority.

For purposes of this subsection, "grid-scale wind energy development," "primary siting authority," "significant tangible benefits" and "expedited wind energy development" have the same meanings as in Title 35-A, section 3451.

Sec. E-19. 38 MRSA §488, sub-§9, as repealed and replaced by PL 2005, c. 330, §19, is amended to read:

9. Development within unorganized areas. A development located entirely within an area subject to the jurisdiction of the Maine Land Use Regulation Commission, other than a metallic mineral mining or advanced exploration activity ~~or~~ <u>,</u> an oil terminal facility <u>or an offshore wind power project with an aggregate generating capacity of 3 megawatts or more that is not a community-based offshore wind energy project as defined in Title 12, section 682, subsection 19</u>, is exempt from the requirements of this article.

A. If a development is located in part within an organized area and in part within an area subject to the jurisdiction of the Maine Land Use Regulation Commission, that portion of the development within the organized area is subject to review under this article if that portion is a development pursuant to this article. That portion of the development within the jurisdiction of the commission is exempt from the requirements of this article except as provided in paragraph B.

B. If a development is located as described in paragraph A, the department may review those aspects of a development within the jurisdiction of the Maine Land Use Regulation Commission if the commission determines that the development is an allowed use within the subdistrict or subdistricts for which it is proposed pursuant to Title 12, section 685-B. A permit from the Maine Land Use Regulation Commission is not required for those aspects of a development approved by the department under this paragraph.

Review by the department of subsequent modifications to a development approved by the department is required. For a development or part of a development within the jurisdiction of the Maine Land Use Regulation Commission, the director of the commission may request and obtain technical assistance and recommendations from the department. The commissioner shall respond to the requests in a timely manner. The recommendations of the department must be considered by the Maine Land Use Regulation Commission in acting upon a development application.

Sec. E-20. 38 MRSA §488, sub-§25 is enacted to read:

<u>**25. Offshore wind power project and certain standards.** An offshore wind power project with an aggregate generation capacity of 3 megawatts or more is exempt from review under the existing use standard in section 484, subsection 3, insofar as the department determines that review is required under criteria specified in Title 12, section 1862, subsection 2, paragraph A, subparagraph (6).</u>

Sec. E-21. Rulemaking. No later than June 1, 2011, the Department of Environmental Protection shall adopt rules pursuant to the Maine Revised Statutes, Title 38, chapter 3, subchapter 1, article 5-A and Title 38, section 344, subsection 7 to provide permit by rule standards for meteorological towers in coastal wetlands that are associated with resource analysis activities in anticipation of an offshore wind power project as defined by Title 38, section 480-B, subsection 6-A. The rules must specify the class of eligible activities and may establish standards of location, design, construction or use that the department considers necessary to avoid adverse environmental impacts. These rules are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A.

PART F

Sec. F-1. 12 MRSA §685-B, sub-§1-A, ¶E, as enacted by PL 2009, c. 270, Pt. D, §4, is amended to read:

E. A permit or other approval by the commission is not required for a hydropower project that uses tidal or wave action as a source of electrical or mechanical power or is located partly within an organized municipality and partly within an unorganized territory.

Sec. F-2. 38 MRSA §634-A, sub-§1, ¶B, as enacted by PL 2009, c. 270, Pt. D, §5, is amended to read:

B. Uses tidal or wave action as a source of electrical or mechanical power, regardless of the hydropower project's location.

Sec. F-3. 38 MRSA §634-A, sub-§2, as enacted by PL 2009, c. 270, Pt. D, §5, is amended to read:

2. Maine Land Use Regulation Commission. The Maine Land Use Regulation Commission shall administer the permit process for a hydropower project that is located wholly within the State's unorganized and deorganized areas as defined by Title 12, section 682, subsection 1 and that does not use tidal or wave action as a source of electrical or mechanical power.

Sec. F-4. 38 MRSA §636, sub-§5, as amended by PL 2009, c. 270, Pt. D, §7, is further amended to read:

5. Maine Land Use Regulation Commission. Within the jurisdiction of the Maine Land Use Regulation Commission, the project is consistent with zoning adopted by the commission. This criterion does not apply to any project that uses tidal or wave action as a source of electrical or mechanical power.

PART G

Sec. G-1. 30-A MRSA §4352, sub-§4, as amended by PL 2007, c. 656, Pt. A, §2, is further amended to read:

4. Exemptions. Real estate used or to be used by a public utility, as defined in Title 35-A, section 102, subsection 13, ~~or~~ by a person who is issued a certificate by the Public Utilities Commission under Title 35-A, section 122 or by a renewable ocean energy project as defined in Title 12, section 1862, subsection 1, paragraph F-1 is wholly or partially exempt from an ordinance only when on petition, notice and public hearing the Public Utilities Commission determines that the exemption is reasonably necessary for public welfare and convenience. The Public Utilities Commission shall adopt by rule procedures to implement this subsection. Rules adopted pursuant to this subsection are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A.

Sec. G-2. 30-A MRSA §4361 is enacted to read:

§ 4361. Coordination of state and municipal decision making; renewable ocean energy projects

1. Definitions. As used in this section, unless the context otherwise indicates, the following terms have the following meanings.

A. "Coastal area" has the same meaning as in Title 38, section 1802, subsection 1.

B. "Renewable ocean energy project" has the same meaning as in Title 12, section 1862, subsection 1, paragraph F-1.

C. "Submerged lands" has the same meaning as in Title 12, section 1801, subsection 9.

2. Location of renewable ocean energy projects. A municipality may not enact or enforce a land use ordinance that prohibits siting of renewable ocean energy projects, including but not limited to their associated facilities, within the municipality. Nothing in this section is intended to authorize a municipality to enact or enforce a land use ordinance as applied to submerged lands.

3. Boundaries; rebuttable presumption. A municipality may not enact or enforce any land use standard or other requirement regarding a renewable ocean energy project unless the project or part of the project over which the municipality asserts approval authority is located within its boundaries, as established in its legislative charter, prior to the effective date of this subsection. In any proceeding regarding the location of a municipality's boundaries for purposes of this section, there is a rebuttable presumption that the boundaries of a municipality in the coastal area do not extend below the mean low-water line on waters subject to tidal influence.

PART H

Sec. H-1. Appropriations and allocations. The following appropriations and allocations are made.

MARINE RESOURCES, DEPARTMENT OF

Bureau of Resource Management 0027

Initiative: Establishes the Ocean Energy Fund with a base allocation.

OTHER SPECIAL REVENUE FUNDS	2009-10	2010-11
All Other	$500	$500
OTHER SPECIAL REVENUE FUNDS TOTAL	$500	$500

Emergency clause. In view of the emergency cited in the preamble, this legislation takes effect when approved.

Effective April 7, 2010.

10.5.2 Appendix E.2 – Maine Public Utilities Commission RFP

http://www.maine.gov/mpuc/electricity/rfps/standard_offer/deepwater2010/RFP%20for%20off-shore%20energy.doc

Request for Proposals for Long-term Contracts for Deep-Water Offshore Wind Energy Pilot Projects

and

Tidal Energy Demonstration Projects

Issued by the Maine Public Utilities Commission

September 1, 2010

1. Overview

1.1 Legislative Authority

During its 2010 session, the Maine Legislature enacted An Act To Implement the Recommendations of the Governor's Ocean Energy Task Force (Act). P.L. 2009, ch. 615. Section A-6 of the Act directs the Maine Public Utilities Commission (Commission), in accordance with the Maine Revised Statutes, Title35-A, section 3210-C, to conduct a competitive solicitation for proposals for long-term contracts to supply installed capacity and associated renewable energy and renewable energy credits (RECs) from one or more deep-water offshore wind energy pilot projects or tidal energy demonstration projects. http://www.mainelegislature.org/ros/LOM/LOM124th/124R2/PUBLIC615_ptA.asp. The Act requires the Commission to initiate the solicitation by September 1, 2010.

For purposes of the competitive solicitation, "deep-water offshore wind energy pilot project" means a wind energy development, as defined by Title 35-A, section 3451, subsection 11,[1] that is connected to the electrical transmission system located in the State and employs one or more floating wind energy turbines in the Gulf of Maine at a location 300 feet or greater in depth no less than 10 nautical miles from any land area of the State other than coastal wetlands, as defined by Title 38, section 480B, subsection 2,[2] or an uninhabited island. "Tidal energy demonstration project" has the same meaning as in Title 38, section 636A, subsection 1, paragraph A.[3]

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[1] "Wind energy development" is defined as a development that uses a windmill or wind turbine to convert wind energy to electrical energy for sale or use by a person other than the generator. A wind energy development includes generating facilities and associated facilities.

[2] "Coastal wetlands" is defined as all tidal and subtidal lands; all areas with vegetation present that is tolerant of salt water and occurs primarily in a salt water or estuarine habitat; and any swamp, marsh, bog, beach, flat or other contiguous lowland that is subject to tidal action during the highest tide level for the year in which an activity is proposed as identified in tide tables published by the National Ocean Service. Coastal wetlands may include portions of coastal sand dunes.

[3] "Tidal energy demonstration project" or "project" means a hydropower project that uses tidal action as a source of electrical power and that: (1) has a total installed generating capacity of 5 megawatts or less; and (2) is proposed for the primary purpose of testing tidal energy generation technology, which may include a mooring or anchoring system and transmission line, and collecting and assessing information on the environmental and other effects of the technology.

As specified in the Act, the Commission may authorize one or more long-term contracts for an aggregate total of no more than 30 megawatts of installed capacity and associated renewable energy and RECs from deep-water offshore wind energy pilot projects or tidal energy demonstration projects as long as no more than 5 megawatts of the total is supplied by tidal energy demonstration projects.

Proposal qualification, evaluation and acceptance or rejection will be determined by the Commission consistent with applicable laws and rules, the provisions of this RFP, and the Commission's statutory public interest obligations. In making its determinations, the Commission may consult with other State entities, which may include Maine's transmission and distribution utilities, Office of Public Advocate, Department of Environmental Protection, State Planning Office, Department of Economic and Community Development, and the University of Maine. To the extent that proposals contain confidential or proprietary information, they will be provided to other entities subject to protective order.

The Commission may accept or reject any proposal, or it may reject all proposals, based on its assessment of the proposals, including but not limited to, whether a proposal meets the requirements of the RFP, satisfies the policies and objectives of the Act, is within the contracting authority of the Commission, and conforms with generally accepted business practices. As noted above, the Commission can not authorize proposals that in the aggregate would exceed 30 megawatts of installed capacity. There is no minimum or required level of installed capacity.

Initial Proposals for deep-water offshore wind energy pilot projects and tidal energy demonstration projects will be due on or before May 1, 2011

1.2 Counterparties

The counterparty to any long-term contract resulting from this solicitation will be one or more of Maine's investor-owned transmission and distribution (T&D) utilities as determined by Commission order. These are Central Maine Power Company (CMP) http://www.cmpco.com/, Bangor Hydro-Electric Company (BHE) http://www.bhe.com/index.cfm, and Maine Public Service Company (MPS) http://www.mainepublicservice.com/.

2. Summary of Key Proposal Attributes and Requirements

2.1 General Requirements

The Commission may direct one or more T&D utilities, as appropriate, to enter into a long-term contract pursuant to this RFP only if it determines that the bidder:

A. Proposes sale of renewable energy produced by a deep-water offshore wind energy pilot project or a tidal energy demonstration project as defined in this RFP;

B. Has the technical and financial capacity to develop, construct, operate and, to the extent consistent with applicable federal law, decommission and remove the project in the manner provided by Title 38, section 480HH, subsection 3, paragraph G http://www.mainelegislature.org/legis/statutes/38/title38sec480-HH.html ;

C. Has quantified the tangible economic benefits of the project to the State, including those regarding goods and services to be purchased and use of local suppliers, contractors and other professionals, during the proposed term of the contract;

D. Has experience relevant to tidal power or the offshore wind energy industry, as applicable, including, in the case of a deep-water offshore wind energy pilot project proposal, experience relevant to the construction and operation of floating wind turbines, and has the potential to construct a deep-water offshore wind energy project 100 megawatts or greater in capacity in the future to provide electric consumers in Maine with project-generated power at reduced rates;

E. Has demonstrated a commitment to invest in manufacturing facilities in Maine that are related to deep-water offshore wind energy or tidal energy, as applicable, including, but not limited to, component, turbine, blade, foundation or maintenance facilities; and

F. Has taken advantage of all federal support for the project, including subsidies, tax incentives and grants, and incorporated those resources into its bid price.

2.2 Price Mitigation

As required by the Act, to mitigate any impacts of a long-term contract entered into pursuant to this RFP on electric rates in Maine, the supplier will be required to seek out and take advantage of future federal support applicable to the project over the contract term and to use all such support funds obtained to lower the price of the contract to mitigate impacts of the contract on electric rates.

As required by the Act, long-term contracts pursuant to this RFP may not result in an increase in electric rates in any customer class that is greater than the amount of the assessment charged under Title 35-A, section 10110, subsection 4 at the time that the contract is entered. The current assessment is $1.45 per MWh.

2.3 Pricing Structures

Bidders may offer pricing within one of the following frameworks: (1) physical transaction, e.g., unit-specific capacity purchase/sale; or (2) financial transaction, i.e., contract for differences.

Prices may be fixed, or defined by formula or indices.

The bidder must provide an expected energy production schedule.

All pricing must be in nominal dollar terms.

The same project may submit multiple pricing proposals, as long as they are mutually exclusive. A pricing proposal for one project cannot be contingent on another project being accepted, but can be mutually exclusive.

2.4 Project Operation Date

Any contract entered into pursuant to this RFP will require that the deep-water offshore wind energy pilot project or tidal energy demonstration project, as appropriate, be constructed and operating within 5 years of the date the contract is finalized, unless the Commission and project developer mutually agree to a longer time period.

2.5 Contract

One or more of Maine’s T&D utilities (CMP, BHE or MPS) will be the contractual counterparties to winning bidders.

A bidder may include a proposed contract with its proposal.

Contracts may be physical or financial.

2.6 Term

Bidders may submit contract term lengths customized to their project. The contract term may be up to 20 years.

2.7 Security

Requirements for the Proposal Security Deposit and Project and Performance Security are described in RFP Section 5.

2.8 Proposal Information; Project Cost Data

The Commission reserves the right to ask bidders to provide additional information about a project or other aspect of a proposal, or to clarify or correct a proposal. In the event the Commission determines it to be necessary, bidders may be required to submit detailed and verifiable capital and operating cost data.

2.9 Indicative Bids; Firm and Final Bids

Indicative bids are acceptable with a bidder's Initial Proposal. Firm and final bids, when requested by the Commission, will be binding on the bidder. Changes to proposals will not be accepted after the submission of firm and final bids except to the extent requested by the Commission to clarify or correct a proposal.

2.10 Confidentiality

A bidder may designate information included in its proposal as proprietary or confidential information. The Commission will take every reasonable step, consistent with law, to protect information that is clearly identified as proprietary or confidential on the page on which it appears. As noted above, protected information may be made available to other State entities under appropriate protective order and non-disclosure agreements. The identity of bidders and general information about proposals selected will become public at the time of the Commission's decision. The selected long-term contracts and associated prices will ultimately become public; however, such information may be withheld for a period of time at the request of the bidder.

3. RFP Process

3.1 Overview of Process; Schedule; Evaluation

Initial Proposals for deep-water offshore wind energy pilot projects and tidal energy demonstration projects will be due on or before May 1, 2011.

The Commission staff and its consultants will review all proposals, and may ask for supplemental and/or clarifying information from bidders. Based on this review, the Commission staff may prioritize proposals for more in-depth discussions among the bidder, staff, T&D utilities and, if determined by the Commission, other State entities.

After discussions are completed for proposals, the Commission will formally deliberate and render a decision on whether to authorize a long-term contract or contracts.

Projects will be evaluated based on cost considerations, and overall project viability, including financial, environmental and other site approvals, construction schedule, operational characteristics, and the general requirements as described in RFP Section 2.1.

The Commission reserves the right to revise, suspend, or terminate the RFP at its sole discretion. In such event, the Commission will inform all bidders as soon as reasonably possible.

3.2 RFP Documents and Information; Contact Persons

The RFP and all related documents and information are available from the RFP Website at http://www.maine.gov/mpuc/electricity/rfps/standard_offer/deepwater2010/

Any changes to the RFP or related documents, and any supplemental RFP information and data, will be posted to the RFP Website. It is the bidders' responsibility to obtain these updates and additions.

The RFP Contact Person is:

Mitchell Tannenbaum
Maine Public Utilities Commission
mitchell.tannenbaum@maine.gov
207-287-1391 (Tel)

Bidders may submit questions or request additional information by contacting the RFP Contact Person. To the extent bidder inquiries elicit generally applicable information or corrections/clarifications to existing information, such information will be posted to the RFP Website. Bidder questions, information requests and the associated responses will not otherwise be made generally available.

The Commission will endeavor to respond to all questions and information requests, but it is under no obligation to do so.

4. Proposal Content Requirements

Initial Proposals should include the materials and information specified in this section. To the extent materials or information are not available when the initial proposals are due, bidders should so specify and indicate when they will be available.

4.1. Project Information

a. A statement demonstrating that the project satisfies the definition of a "deep-water offshore wind energy pilot project" or a "tidal energy demonstration project" as defined in the Act.

b. A statement of the total capacity of the project, whether the capacity of the project is, or would be, recognized as capacity by the ISO-NE and/or NMISA, and the project's expected capacity value in MW should be provided. In addition, proposals should discuss eligibility to participate in the ISO-NE or NMISA capacity and energy markets, as applicable.

c. A demonstration that there is or will be control or a right to acquire control over a site for the proposed project.

d. A description of the technology of the project, including expected operation and performance, and a demonstration that the technology is technically feasible.

e. Information demonstrating when the project is reasonably likely to be constructed and operating, including a detailed schedule for completion of all environmental reviews and the receipt of required permits.

f. Detailed information about the location of the project, including but not limited to the following:

i. geographical location of the project;

ii. ISO-NE nodal and zonal location applicable to the project;

iii. a detailed description of the interconnection point to the ISO-NE or NMISA transmission system. The proposal should include: (1) the status of the interconnection study; (2) the status of any required upgrades; (3) data that the project has or will provide to ISO-NE or NMISA regarding its interconnection.

g. Detailed information on the design, location, and cost of the undersea transmission facilities that will be necessary to connect the project to the electric grid, including the point of connection.

4.2. Financial and Technical Capability

a. Information and supporting documents sufficient to demonstrate the financial and technical capability of the project team and the project to develop, construct, operate and, to the extent consistent with applicable federal law, decommission and remove the project in the manner provided by Title 38, section 480HH, subsection 3, paragraph G. In particular, information regarding experience relevant to tidal power or the offshore wind energy industry, as applicable, including, in the case of a deep-water offshore wind energy pilot project proposal, experience relevant to the construction and operation of floating wind turbines and the potential to construct a deep-water offshore wind energy project of 100 MW or greater in capacity in the future to provide electric consumers in the Maine with project-generated power at reduced rates.

b. A financing plan for the project and a demonstration of a commitment to the plan from one or more qualified financial institutions. A commitment from financial institutions may be in the form of a letter indicating intent to provide the required financing. Proposals should include a description of the financing process, as well as the status of the bidder's effort to secure financing.

c. Audited financial statements of the project team companies, their most current credit agency rating reports, and documentation demonstrating sufficient technical experience and expertise to develop the project.

4.3. Tangible Economic Benefits

a. Information describing and quantifying the tangible economic benefits of the project to the State, including those regarding goods and services to be purchased and use of local suppliers, contractors and other professionals, during the construction and operation stages of the project.

b. Information demonstrating a commitment to invest in manufacturing facilities in Maine that are related to deep-water offshore wind energy or tidal energy, as applicable, including, but not limited to, component, turbine, blade, foundation or maintenance facilities.

4.4. Contract

a. A proposed contract may be provided (but is not required) at the Initial Proposal stage.

4.5. Pricing

a. Proposals should include the quantity and pricing for capacity, energy, and RECs for the proposed term. To the extent pricing is based on an index or formula, a detailed example of how the formula would operate using historic index values should also be provided. Pricing provided in Initial Proposals may be indicative.

b. Proposals should include information sufficient to demonstrate that the bidder has taken advantage of all federal support for the project, including subsidies, tax incentives and grants, and incorporated those resources into its bid price.

d. All contingencies associated with a proposal and/or pricing should be clearly indicated.

4.6. Proposal Security Deposit (see RFP Section 5)

5. Financial Security

5.1 Proposal Security Deposit

A Proposal Security Deposit must be provided with the Initial Proposal. Deposits should be submitted directly to the T&D utility that would be a contractual counterparty in the contract. The Proposal Security Deposit must be in the form of U.S. currency or an irrevocable, transferable and unconditional standby letter of credit issued by a U.S. commercial bank or a foreign bank with a U.S. branch with such bank having a minimum credit rating of A- from S&P or A3 from Moody's. Deposits provided in cash will be held by the T&D utility in an interest-bearing account. The Proposal Security Deposit will (1) be refunded if a proposal is not selected or (2) be replaced with the Project and Performance Security if a proposal is selected.

The Proposal Security Deposit required is $5 per kW of capacity proposed, with a cap of $100,000.

5.2 Project and Performance Security

Project and Performance Security will be determined on a project-specific basis. The amount of security required will be determined based on an assessment of the risks and benefits provided by the long-term contract. Project and Performance Security is not required to be posted with Initial Proposals, but Initial Proposals should include evidence of a bidder's intent and ability to fulfill the Project and Performance Security Requirements should the proposal be selected. The Commission will establish the structure and amount of the Project and Performance Security at the time a Final Proposal is requested from and becomes binding upon a bidder as described in RFP Sections 2.9 and 6.1.

Acceptable forms of Project and Performance Security are: (1) cash (U.S. currency); or (2) an irrevocable, transferable and unconditional standby letter of credit issued by a U.S. commercial bank or a foreign bank with a U.S. branch with such bank having a minimum credit rating of A- from S&P or A3 from Moody's.[4]

Winning bidders will be required to post Project and Performance Security within a reasonable time period following contract execution, at which time their Project Security Deposit will be refunded.

6. General

6.1 Proposals

Proposals must be submitted in accordance with this RFP or as otherwise specified by the Commission. The Commission reserves the right to seek clarification and request additional information, documentation and other material related to the

[4] Other forms of Project and Performance Security, e.g., parent guarantees or asset-based forms, are not preferred but are not necessarily precluded. The Commission will determine whether security in a form other than cash or an LOC is acceptable in the context of a specific proposal and prevailing economic conditions.

proposals. Failure to provide any such items within the timeframes requested may result in disqualification.

A bidder may amend or withdraw it proposal, or any portion of its proposal, or may withdraw entirely from the RFP, at any time prior to the submission of a Final Proposal.

Final Proposals, when requested as such, are binding. A change in Final Proposal terms, except as authorized or requested by the Commission, may result in disqualification and/or the forfeit of the Project Security Deposit. In addition, a bidder's failure to execute the contract or provide the required Project and Performance Security, should a bidder's Final Proposal be accepted, may also result in the forfeit of its Project Security Deposit. Final Proposals may include an expiration date such that the proposal would expire if not accepted by the Commission by the specified date.

6.2 Proprietary Information

A bidder may designate information included in its proposal as proprietary or confidential information. The Commission will take every reasonable step, consistent with law, to protect information that is clearly identified as proprietary or confidential on the page on which it appears. Protected information may be made available to other State entities in accordance with sections 1.1 and 2.10. The identity of bidders and projects, and the associated prices and long-term contracts, for proposals chosen in this process will become public information.

6.3 Proposal Costs

All costs associated with developing and submitting a proposal in response to this RFP and providing oral or written clarification of its contents are borne by the bidder.

6.4 Rights of the Commission

The Commission may accept or reject any proposal, or it may reject all proposals, based on its assessment of the proposal including but not limited to whether a proposal meets the requirements of the RFP, satisfies the policies and objectives of the Act, is within the contracting authority of the Commission, and conforms with generally accepted business practices.

The Commission reserves the right to withdraw or modify the RFP at any time, to negotiate with bidders and to solicit additional and/or modified proposals.

The type(s) of projects and quantity of capacity, energy and RECs that may be awarded a contract as a result of this RFP will be determined by the Commission in conformance with applicable laws and rules, the provisions of this RFP, and the Commission's statutory obligations.

The Commission shall not be responsible or liable in any manner for risks, costs, expenses, or other damages incurred by any bidder or other entity involved, directly or indirectly, with this RFP.

6.5 State Held Harmless

The State of Maine, its officers, agents, and employees, including the Maine Public Utilities Commission, Commissioners and the employees or agents of the Maine Public Utilities Commission or other State entities consulted in accordance with the provisions of this RFP shall be held harmless from any and all claims, costs, expenses, injuries, liabilities, losses and damages of every kind and description resulting from or arising out of this RFP, the designation of winning bidders or the performance of contract obligations as contemplated by this RFP.

6.6 Warranty

The information contained in the RFP and provided subsequently is prepared to assist bidders and does not purport to contain all of the information that may be relevant to bidders. The Commission makes no representation or warranty, expressed or implied, as to the accuracy or completeness of the information. The Commission, its staff and its agents shall not have any liability for any representations expressed or implied in, or any omissions from, the RFP or information obtained by bidders from the Commission, its staff, its agents or any other source.

10.5.3 Appendix E.3 – Rate Impact Limitation

STATE OF MAINE
PUBLIC UTILITIES COMMISSION

Docket No. 2010-235

September 28, 2010

MAINE PUBLIC UTILITIES COMMISSION
Long-Term Contracting for Offshore Wind Energy and Tidal Energy Projects

ORDER ON RATE IMPACT LIMITATION PROVISION

CASHMAN, Chairman; VAFIADES and LITTELL, Commissioners[1]

I. SUMMARY

Through this Order, the Commission interprets the rate impact limitation provision contained in recently enacted legislation that directs the Commission to conduct a competitive solicitation for proposals for long-term contracts from deep-water offshore wind energy pilot projects or tidal energy demonstration projects.

II. BACKGROUND

During its 2010 session, the Maine Legislature enacted An Act To Implement the Recommendations of the Governor's Ocean Energy Task Force (Act). P.L. 2009, ch. 615. Section A-6 of the Act directs the Commission, in accordance with the Maine Revised Statutes, Title35-A, section 3210-C, to conduct a competitive solicitation for proposals for long-term contracts to supply installed capacity and associated renewable energy and renewable energy credits from one or more deep-water offshore wind energy pilot projects or tidal energy demonstration projects. The Act requires the Commission to initiate the solicitation by September 1, 2010.

The Act contains the following rate impact limitation provision:

> The commission may not approve any long-term contract under this section that would result in an increase in electric rates in any customer class that is greater than the amount of the assessment charged under Title 35-A, section 10110, subsection 4 at the time that the contract is entered.

Id.

Title 35-A M.R.S.A. § 10110(4) states:

> **Funding level; base assessment.** The commission shall assess transmission and distribution utilities to collect funds for conservation programs and administrative costs in accordance with this subsection and shall make other assessments in accordance with subsection 5. The

[1] This matter was deliberated and decided prior to Commissioner Littell joining the Commission. He, therefore, did not participate in the decision.

> amount of all assessments by the commission under this subsection plus expenditures of a transmission and distribution utility associated with prior conservation efforts must result in conservation expenditures by each transmission and distribution utility, not including expenditures on assessments under subsection 5, that are fixed at a rate of 0.145 cent per kilowatt-hour.

Title 35-A M.R.S.A. § 10110(6) specifies that transmission and substransmission customers are not eligible for conservation programs funded by the assessments in subsection 4 and subsection 5 and those customers are not required to pay in rates amounts associated with those assessments.

III. REQUEST FOR COMMENTS

On July 20, 2010, the Commission requested comments on the proper interpretation of the rate impact limitation provision. Specifically, the Commission requested comments on the following possible interpretations:

1) Should the provision be interpreted to mean that all customers, in any customer class, may have a rate impact up to 0.145 cent/kWh (assuming no change to assessment under subsection 4 and no additional assessment under subsection 5) resulting from any above-market costs that might be associated with long-term contracts; or

2) Given the exclusion in subsection 6 noted above, should the provision be interpreted to mean that transmission and substransmission customers (i.e., industrial class customers) could have no rate increase resulting from any above-market costs that might be associated with long-term contracts, while distribution level customers (i.e., medium and small commercial customers and residential customers) may have a rate impact up to 0.145 cent/kWh (assuming no change to assessment under subsection 4 and no additional assessment under subsection 5).

In addition, the Commission requested comments on the proper interpretation of the following language in the rate impact limitation provision: "the amount of the assessment charged under Title 35-A, section 10110, subsection 4 at the time that the contract is entered."

3) Given that subsection 4 explicitly references subsection 5, should the provision be interpreted to include only the assessment specified in subsection 4 or should it include the assessment in subsection 4 and any additional assessment pursuant to subsection 5.

The Public Advocate, Industrial Energy Consumer Group, Representative Kenneth Fletcher, Eastport Tidal Power LLC and the National Energy Marketers' Association filed comments on the statutory interpretation issues.

IV. COMMENTS

A. Public Advocate

The Public Advocate commented that the rate impact limitation provision should be interpreted to mean that all customers may have a rate impact up to 0.145 cents/kWh. According to the Public Advocate, the reference to Title 35-A, section 10110, subsection 4 is only for the purpose of capping the amount that can be added to the rates of "any customer class" resulting from any long-term contract the Commission may approve under the Act. Subsection 4 deals only with the collection of funds for conservation programs, not with long-term contract rate impacts.

The Public Advocate further commented that the exclusion of transmission and subtransmission level customers in subsection 6 applies only to conservation programs and not to rate increases resulting from long-term contracts. The Public Advocate notes that, if the Legislature had intended to insulate transmission and subtransmission level customers from any rate increase that would result from the Act, it would have done so in a much more straightforward manner.

Finally, the Public Advocate views the rate impact limitation as including only the assessment amount in subsection 4 (currently 0.145 cents/kWh) and not any additional assessment that may be in place pursuant to subsection 5. The Public Advocate reaches this conclusion because the plain meaning of the reference to subsection 5 means "not including expenditures on assessments under subsection 5," leaving only those expenditures specified in subsection 4, and capping those expenditures by no more than 0.145 cents per kilowatt-hour.

B. Industrial Energy Consumer Group

The Industrial Energy Consumer Group (IECG) commented that the plain language of the Act is clear that under current law, transmission and subtransmission customers cannot face any rate increase resulting from costs that might be associated with long-term contracts for ocean energy resources. According to the IECG, the Legislature drafted this language to reflect the fact that transmission and subtransmission level customers do not currently pay a system benefit charge and that this is the entire purpose of the language. In the event the language is found to be ambiguous, the IECG stated that the legislative intent was to limit each customer class's rate exposure to ocean energy costs to a particular customer class's exposure to the system benefit charge, which is zero for transmission and subtransmission customers.

The IECG stated that, under established statutory construction principles, words and phrases shall be construed according to the common meaning of the language and to give the full effect to the entire statute. The IECG argued that, if the Legislature intended that all customers would be exposed to a rate impact of 0.145 cents/kWh, there would have been no need to include the phase "in any customer class." Instead, the Legislature would have referred merely to the "increase in electric rates."

With respect to the issue of whether the rate impact limitation provision should be interpreted to include only the assessment specified in subsection 4 (currently 0.145 cents/kWh) or should also include any additional assessment pursuant to subsection 5, the IECG agreed with the Public Advocate that the plain language dictates that the rate exposure to customers will be limited to only the charges specified in subsection 4.

C. Other Commenters

The other commenters generally agreed with the positions of the IECG, stating that the Legislature intended to exclude the transmission and subtransmission customer class from any rate impact that might result from long-term contracts for ocean energy.

V. DECISION

Although the rate limitation statutory provision could have been more clearly drafted, we conclude that the Legislature intended that customers that take service at transmission and subtransmission voltage would not have a rate impact resulting from any ocean energy long-term contracts.

As stated by the IECG, words and phrases in legislation must be interpreted to give full effect to the entire statute, and statutes should be interpreted to give effect to all of its provisions-so that no part will be inoperative, superfluous, void or insignificant. *Darling v. Ford Motor Co.,*1998 ME 232, ¶ 5, 719 A.2d. 111, 114; *Estate of Whittier,* 681 A.2d 1, 2 (Me. 1996); 73 Am. Jur. 2d Statutes §§ 164, 165. We agree with the IECG that, if the Legislature intended that all ratepayers may be exposed to a rate impact up to the assessment specified in subsection 4, there would not have been any need to include the phrase "in any customer class." An interpretation that all ratepayers could be exposed to an additional rate increase of up to 0.145 cents/kWh would render the phrase "in any customer class" superfluous and inoperative. Accordingly, we interpret the rate impact limitation provision of the Act to mean that customers may not experience a rate impact any greater than the assessment charged to their customer class pursuant to subsection 4. Because transmission and subtransmission level customers do not pay an assessment under subsection 4, they cannot be exposed to any rate impact from ocean energy long-term contracts.[2]

[2] In the event that subsection 4 is amended to allow for an assessment to transmission and subtransmission level customers, then those customers would be exposed to a rate impact from ocean energy project long-term contracts up to the amount of that assessment.

We also agree with the Public Advocate and the IECG that the rate impact limitation provision of the Act should be interpreted to include only the assessment specified in subsection 4, and not any additional assessment that might be imposed pursuant to subsection 5. The rate impact limitation provision specifies the "assessment of the amount charges under [subsection 4]," without any mention of additional assessment that might be charged under subsection 5. Because the language of the Act refers only to the assessment charges under subsection 4, the assessment charged pursuant to that subsection constitutes the rate impact limitation that may occur from ocean energy long-term contracts.

Dated at Hallowell, Maine, this 28th day of September, 2010.

BY ORDER OF THE COMMISSION

____
Karen Geraghty
Administrative Director

COMMISSIONERS VOTING FOR: Cashman
Vafiades

NOTICE OF RIGHTS TO REVIEW OR APPEAL

5 M.R.S.A. § 9061 requires the Public Utilities Commission to give each party to an adjudicatory proceeding written notice of the party's rights to review or appeal of its decision made at the conclusion of the adjudicatory proceeding. The methods of review or appeal of PUC decisions at the conclusion of an adjudicatory proceeding are as follows:

1. Reconsideration of the Commission's Order may be requested under Section 1004 of the Commission's Rules of Practice and Procedure (65-407 C.M.R.110) within 20 days of the date of the Order by filing a petition with the Commission stating the grounds upon which reconsideration is sought.

2. Appeal of a final decision of the Commission may be taken to the Law Court by filing, within 21 days of the date of the Order, a Notice of Appeal with the Administrative Director of the Commission, pursuant to 35-A M.R.S.A. § 1320(1)-(4) and the Maine Rules of Appellate Procedure.

3. Additional court review of constitutional issues or issues involving the justness or reasonableness of rates may be had by the filing of an appeal with the Law Court, pursuant to 35-A M.R.S.A. § 1320(5).

Note: The attachment of this Notice to a document does not indicate the Commission's view that the particular document may be subject to review or appeal. Similarly, the failure of the Commission to attach a copy of this Notice to a document does not indicate the Commission's view that the document is not subject to review or appeal.

10.5.4 Appendix E.4 – Experience Requirement Supplemental Information

2.1 General Requirements

D. Has experience relevant to tidal power or the offshore wind energy industry, as applicable, including, in the case of a deep-water offshore wind energy pilot project proposal, experience relevant to the construction and operation of floating wind turbines, and has the potential to construct a deep-water offshore wind energy project 100 megawatts or greater in capacity in the future to provide electric consumers in Maine with project-generated power at reduced rates;

RE: 2.1 D General Requirements
Supplemental Explanation:
This RFP requests proposals for projects not to exceed 30 megawatts in total generating capacity, and the Maine Public Utilities Commission has the authority to approve only that level of generation at this time. The selection criteria for the successful applicant includes past experience in applicable fields that demonstrate the capability of developing the proposed project in response to this RFP according to the budget and schedule AND:

- A demonstration by the applicant of related industry experience and capacity to develop a project of 100 megawatts or greater in response to future solicitations and approval by state regulators. Although the goal of the Maine Legislature is to encourage additional future development of deepwater wind and tidal energy, there is no requirement for bidders to propose or commit to build any additional power generation beyond the 30 MW.
- A demonstration by the applicant of the experience and capacity to realize costs savings as greater efficiencies of scale and development processes are refined over time consistent with the overall objective of improving technologies and methods and providing electricity at reduced rates in future projects. .

RE: 2.1 D General Requirements Reduced Rates
Supplemental Explanation: The Maine PUC has not determined or targeted a price for the long term power purchase agreement (PPA). The Maine State Legislature, however, has defined a **Rate Impact Limitation** that the Commission will consider in approving the final price of the PPA. The maximum price allowed under the Rate Impact Limitation may be affected by the inclusion or exclusion of either wind and/or tidal generation, and market forces as suggested in sections **2.2: Price Mitigation and 2.3: Pricing Structures**. Bidders may run different financial scenarios based on the Rate Impact Limitation to predict the potential results and are encouraged to submit proposals with the best possible pricing plan recognizing the financial requirements of the project, new technology risks, and the best interest of the Maine ratepayers. Additional information with respect to the Rate Impact Limitation is available on the Commission's website at**:**
http://www.maine.gov/mpuc/electricity/rfps/standard_offer/deepwater2010/rate_impact_limitation.html.

10.5.5 Appendix E.5 – Security Deposit Process

http://www.maine.gov/mpuc/electricity/rfps/standard_offer/longterm0210/docs/contact%20info%20for%20deposit_2010.doc

Maine Long-term Contract RFP
Instructions for Proposal Security Deposits

Proposal Security Deposits will be held by the utility that bidder proposes as the long-term contract counterparty. Contact information for the utilities is provided below.

Central Maine Power Company
LOCs can be sent to Richard Hevey at the address below. For additional instructions, such as wire instructions for cash, bidders should contact either Susan Clary or Richard Hevey.

Richard P. Hevey
Senior Counsel
Central Maine Power Company
83 Edison Drive
Augusta, ME 04336
Tel: (207) 621-6546
Fax: (207) 621-4714
Richard.Hevey@cmpco.com

Susan Clary
Manager, Settlement, Load Research & Supplier Services
Central Maine Power Company
83 Edison Drive
Augusta, ME 04336
Tel: (207) 621-7890
Fax: (207) 621-6538
Susan.Clary@cmpco.com

Bangor Hydro-Electric Company
For instructions, please contact:
Tim O'Connor – Controller
toconnor@bhe.com
Barbara Willey - GL Accountant
bwilley@bhe.com
Bangor Hydro-Electric Co., P.O. Box 932, Bangor, ME 04402-0932
(207) 945-5621

Maine Public Service Company
Michael I. Williams
Senior VP, CFO, Treasurer, and Asst. Secretary
Maine Public Service Company
P.O. Box 1209
Presque Isle, ME. 04769
(207) 760-2428
mwilliams@mainepublicservice.com

10.6 APPENDIX F – UNITS OF MEASURE AND ACRYONYMS

10.6.1 Appendix F.1 – Units of Measure

‘ – foot/feet
“ – inches
+ - plus
°C – degrees Celsius temperature
°F – degrees Fahrenheit
cm - centimeter
cm/hr – centimeter per hour
dB – decibels
ft – feet
GW – Gigawatt
hp - horsepower
Hz – Hertz (frequency)
kg/m – kilogram per meter
km – Kilometer
kN – kilonewton
kV – Kilovolt
kW – Kilowatt
kWh – Kilowatt-Hour
lb – pounds
m – meter
m/s – meters per second
mb – millibars
mi – (statute) mile
mm - millimeter
mm^2 – square millimeters
MW – Megawatt
nmi – nautical mile
Pa – pascals (1000 mb = 100 Pa)
psf – pounds per square foot
pu – price unit
sq. ft – square foot
sq. m – square meter
sq. mi – (statute) square mile

10.6.2 Appendix F.2 – Acronyms

A/C – Alternating Current
ACOEM - American College of Occupational and Environmental Medicine
ADCP – Acoustic Doppler Current Profiler
AEWC – Advanced Structures and Composites Center - UMaine
AIS – Automated Identification System (ships)
AISM – Association International de Signalisation Maritime
ALWTRP – Atlantic Large Whale Take Reduction Plan
ASCE – American Society of Civil Engineering
ASME – American Society of Mechanical Engineers
ASMFC – Atlantic States Marine Fisheries Commission
AWEA – American Wind Energy Association
AWOIS – (NOAA) Automated Wreck and Obstruction Information System Database
BACI – before-after, control-impact
BEP – (United States) Bureau of Environmental Protection
BGEPA – Bald and Golden Eagle Protection Act
BGR – Bangor International Airport
BHE – Bangor Hydro-Electric Company
BKM – Best Known Methods (for development strategies)
BLM – Bureau of Land Management
BMPs – Best Management Practices
BOEMRE – Bureau of Ocean Energy Management, Regulation and Enforcement (formerly MMS)
BP – Best Practices (for development activities)
BPL – (Maine) Bureau of Parks and Lands
BRP – Blue Ribbon Panel
BSEE – Bureau of Safety and Environmental Enforcement
BSH – Bundesamt für Seeschifffahrt und Hydrographie
Btu – British Thermal Units
BUZM3 – Buzzards Bay (NDBC buoy)
BWEA – British Wind Energy Association
CAA – Clean Air Act
CanWEA – Canadian Wind Energy Association
CBP – Customs and Border Patrol (division of DHS)
CEE – Civil and Environmental Engineering (University of Maine)
CEQ – (Federal) Council on Environmental Quality
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (a.k.a. Superfund)
CFR – Code of Federal Regulations

CLF – Conservation Law Foundation
C-MAN – Coastal Marine Automated Network (NOAA coastal meteorological observations)
CMGP – Coastal and Marine Geology Program
CMP – Central Maine Power
CLEAR - Consolidated Land, Energy, and Aquatic Resources (CLEAR) Act of 2009
COP – Construction and Operation Plan
COWRIE – Collaborative Offshore Wind Research Into the Environment (under BWEA)
CPCN – Certificate of Public Convenience and Necessity
CRS – Congressional Research Service
CMSP – Coastal and Marine Spatial Planning (see also MSP – Marine Spatial Planning)
CWA – Clean Water Act
CZM – Coastal Zone Management
CZMA – Coastal Zone Management Act
D/C – Direct Current
DAM – Dynamic Area Management (Zone) – regulated areas for North Atlantic Right Whales
DEP – (Maine) Department of Environmental Protection (also written as MEDEP for Maine DEP)
DHS – Department of Homeland Security
DHS – Department of Homeland Security (USCG is regulated by DHS)
DIFW – Department of Inland Fisheries and Wildlife
DMA – Dynamic Management Area (Zone)– regulated areas for North Atlantic Right Whales
DMR – (Maine) Department of Marine Resources
DMR – (Maine) Department of Marine Resources (also written as MEDMR for Maine DMR)
DNV – Det Norske Veritas
DOC – (Maine) Department of Conservation (also written as MEDOC for Maine DOC)
DOC – (United States) Department of Commerce
DOE – (United States) Department of Energy
DOE – (United States) Department of Energy
DOI – (United States) Department of the Interior
DOI – (United States) Department of the Interior
DOT – (Maine) Department of Transportation (also written as MEDOT for Maine DOT)
DOT – (United States) Department of Transportation
DPS – distinct population segment
E2Tech – Environmental and Energy Technology Council of Maine
EA – Environmental Assessment
EDF – Environmental Defense Fund

EERE – Energy Efficiency and Renewable Energy
EERE – Energy Efficiency and Renewable Energy division of DOE
EEZ – Economic Exclusive Zone (U. S./Canadian border)
EFH – Essential Fish Habitats
EIS – Environmental Impact Statement
EMF – electromagnetic field
ENC – Electronic Navigation Chart
envCanda – Environment Canada
EPA – (United States) Environmental Protection Agency
EPA – (United States) Environmental Protection Agency
EPAct 2005 – Energy Policy Act of 2005
EPRI – Electric Power Research Institute (http://oceanenergy.epri.com)
ESA – Endangered Species Act
ESI – Environmental Sensitivity Index (see also EVI for Environmental Vulnerability Index)
ESRI – Environmental Systems Research Institute, Inc. (developers of ArcGIS software products)
ESS – Earth System Science (University of Maine – Geology)
EVI – Environmental Vulnerability Index
EWEA – European Wind Energy Association
FAA – Federal Aviation Administration
FAD – Fish Aggregating Device
FERC – (United States) Federal Energy Regulatory Commission
FERC – Federal Energy Regulatory Commission
FGDC – Federal Geographic Data Committee
FIEC – Fox Islands Electric Cooperative
FONSI – Findings of No Significant Impact
FR – Federal Register
GALR – Great American Lighthouse Resource
GAP – General Activities Plan
GIS – Geographic Information System
GL – Germanischer Lloyd
GLCF – Global Land Cover Facility (University of Maryland)
GloVis – Global Visualization Viewer (NASA)
GMRI – Gulf of Maine Research Institute
GoM – Gulf of Maine
GOM – Gulf of Mexico
GOM ODP – Gulf of Maine Ocean Data Partnership
GOMMI – Gulf of Maine Mapping Initiative (facilitated by GMRI)
GoMOOS – Gulf of Maine Ocean Observing System
GPO – Government Printing Office
GPS – Geographic Positioning System
HDD – horizontal directional drilling

IALA – International Association of Lighthouse Authorities
IBA – Important Bird Areas
IBC – International Boundary Commission
ICJ – International Court of Justice
ICPC – International Cable Protection Committee
ICS – Inner Continental Shelf
IEC – International Electrotechnical Commission
IEEE – Institute of Electrical and Electronics Engineers
IFWS – Inland Fish and Wildlife Service (Federal)
IGLD 85 – International Great Lakes Datum of 1985 (identical to NAVD 88; Note: bench marks are referenced differently between NAVD 88 and IGLD 85)
IHO – International Hydrographic Organization
II-MWW – Island Institute Mapping Working Waters project
IMO – International Maritime Organization
IOOS – Integrated Ocean Observing Systems
IOSN3 – Isle of Shoals (NDBC buoy)
IPCC – Intergovernmental Panel on Climate Change
IRS – Internal Revenue Service
ISFMP – Interstate Fisheries Management Program
ISO – International Organization for Standardization
ISO-NE – Independent System Operator – New England
Ka – Kiloannum (1000 years)
KBGR – Bangor International Airport (NWS)
KCAR – Caribou, ME (NWS)
KPWM – Portland International Airport (NWS)
LIDAR – Light Detecting and Ranging (Laser RADAR)
LP – liquiefied peteroleum
LTE – Long Term Emergency Rating
LURC – (Maine) Land Use Regulation Commission
MA – Massachusetts state abbreviation
MACC – Maine Association of Charter Captains
MARAD - Maritime Administration (division of DOT)
MBTA – Migratory Bird Treaty Act
MCHT – Maine Coastal Heritage Trust
MDRM1 – Mt. Desert Rock (NDBC buoy)
MDWEPP – Maine Deepwater Wind Energy Pilot Project
ME – Maine state abbreviation
MEDEP – Maine Department of Environmental Protection
MEDOC – Department of Conservation (also written as ME DOC for Maine DOC)
MEDOT – Maine Department of Transportation
MEGIS – Maine GIS Clearinghouse (also written as MEgis)
MEIFW –Maine Inland Fisheries and Wildlife
MESA – Maine Endangered Species Act

METAR – Meteorological Aviation Report
MGET – Marine Geospatial Ecology Tools
(resource tools available at OBIS – SEAMAP site)
MGG – Marine Geology and Geophysics (NGDC under NESDIS)
MGS – Maine Geological Survey
MHHW – mean higher-high water (datum)
MHP – Maine Historic Preservation
MHPA – Maine Historic Preservation Act
MHPC – Maine Historic Preservation Commission
MHW – mean high water (datum)
MISM1 – Matinicus Rock (NDBC buoy)
MITA – Maine Island Trail Association
MLA – Maine Lobsterman's Association
MLLW – mean lower-low water (datum) – tidal height reference datum (NOAA charts re: 1980). See http://tidesandcurrents.noaa.gov/datum_options.html for more information.
MLW – mean low water (datum) – tidal height reference datum
MMA – Maine Maritime Academy
MMPA – Marine Mammal Protection Act
MMS – Minerals Management Service (controls leasing rights in Federal waters)
MMS – Minerals Management Services (now BOEMRE)
MPA – Maine Port Authority
MMPA – Marine Mammal Protection Act
MPE – Matinicus Plantation Electric Company
MPH – Maritime Heritage Program
MPPD – Monhegan Plantation Power District
MREA - Maine Renewable Energy Association
MSA – Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006
MSL – mean sea level
MSP – Marine Spatial Planning (see also CSMP for Coastal and Marine Spatial Planning)
MTL – mean tide level (datum)
MWII - Maine Wind Industry Initiative
N.B. – Nota Bene (Note Well)
NAD 27 – North American Datum of 1927
NAD 83 – North American Datum of 1983
NASA – National Aeronautics and Space Administration
NAVD 88 – North American Vertical Datum of 1988
NB – New Brunswick, Canadian province
NCDC – National Climate Data Center
NDBC – National Data Buoy Center (NOAA weather buoys)
NEFMC – New England Fisheries Management Council

NEFSC – Northeast Fisheries Science Center
NEP – National Estuary Program
NEPA – National Environmental Policy Act
NEPOOL GenIS – NEPOOL General Information System (to distinguish from GIS)
NERACOOS – Northeast Regional Association of Coastal Ocean Observing Systems
NERR – National Estuarine Research Reserve
NERRS – National Estuarine Research Reserve
NESDIS – National Environmental Satellite Data and Information Service (NOAA)
NF – Newfoundland, Canadian province
NGDC – National Geophysical Data Center (NESDIS)
NGO – Non-Governmental Organization
NGS – National Geodetic Survey
NGVD 29– National Geodetic Vertical Datum of 1929
NH – New Hampshire state abbreviation
NHD – National Hydrography Dataset (USGS product available at http://nhd.usgs.gov)
NHLPA – National Historic Lighthouse Preservation Act
NHPA – National Historic Preservation Act
NIST – National Institute of Standards and Technology
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NOAA –National Oceanic and Atmospheric Administration
NOAA-CSC – NOAA Coastal Services Center
NOAA-OCS – NOAA Office of Coast Survey
NOS – National Ocean Service
NPDES – National Pollutant Discharge Elimination System
NPS – National Park Service
NREL – National Renewal Energy Laboratory (United States Department of Energy (DOE))
NROC – Northeast Regional Ocean Council
NRPA – National Resources Protection Act
NS – Nova Scotia, Canadian province
NTDC 1980 – National Tidal Datum Convention of 1980 (standardizing the tidal datum to MLLW)
NTDE – National Tidal Datum Epoch (19 years for tidal records – current epoch is 1983 – 2001)
NWF – National Wildlife Federation
NWI – National Wetlands Inventory
NWS – National Weather Service (NOAA weather information)
OBIS – Ocean Biogeographic Information System
OCRM – Office of Ocean and Coastal Resource Management (NOAA)
OCS – Outer Continental Shelf (Lease Blocks)
OCSLA – Outer Continental Shelf Lands Act

OEI – Ocean Energy Institute
OETF – Ocean Energy Task Force
OHW – ordinary high water (water level in water bodies not substantially affected by tides)
OPA – Oil Pollution Act of 1990
OPRC – Ocean Renewable Power Company
OWEGIS – (University of Maine) Offshore Wind Energy GIS Database Decision Tool
PEIS – Programmatic Environmental Impact Statement
pers. comm. – personal communication
PhOG – Physical Oceanography Group at the University of Maine
P.L. – Public Law
PNNL – Pacific Northwest National Laboratory
PSBM1 – Eastport (NDBC buoy)
PTC – Production Tax Credit
PUC – (Maine) Public Utilities Commission
PWM – Portland International Airport
R & D – Research and Development
RADAR – Radio Detecting and Ranging
REPC – Renewable Energy Production Credit
REPI – Renewable Energy Production Incentive
RFI – Request for Interest (BOEMRE)
RFP – Request for Proposals
RHA – Rivers and Harbors Act
RI – Rhode Island state abbreviation
RNC – Raster Navigational Chart
ROV – remotely operated vehicle
ROV – remotely operated vehicle
RPS – Renewable Portfolio Standard
SAM – Seasonal Area Management (Zone) – regulated areas for Northern Atlantic Right Whales
SAP – Site Assessment Plan
SBA – United States Small Business Administration
SBIC – Small Business Investment Company (Program) under which the SBA is licensed
SEAMAP – Spatial Ecological Analysis of Megavertebrate Populations
Sewall – James W. Sewall Company
SHARP - OSHA Safety and Health Achievement Program
SHPO – (Maine) State Historic Preservation Officer
SHRU – Salmon habitat recovery units
SLODA – Site Location of Development Act
SMA – Seasonal Management Area (Zone) – regulated areas for Northern Atlantic Right Whales
SMS – School of Marine Sciences (University of Maine)

SODAR – Sonic Detection and Ranging
SPO – (Maine) State Planning Office (also written as MESPO for Maine SPO)
spp – Species
SPUE – sightings per unit effort
STE – Short Term Emergency Rating
T & D Systems – Transmission and Distribution Systems
TAC – total allowable catch
TEDEC – Tidal Energy Device Evaluation Center (Maine Maritime Academy)
TNC – The Nature Conservancy
TSDF – Hazardous Waste Treatment, Storage, and Disposal Facilities
TWC – Time Warner Cable
U.S.C. – United States Code
UMaine – University of Maine at Orono (other documents may also refer to UMO)
UNE – University of New England
UNESCO – United Nations Educational, Scientific and Cultural Organization
UNH – University of New Hampshire
USACE – United States Army Corps of Engineers
USCG – United States Coast Guard (division of DHS)
USDA – United States Department of Agriculture
USDOC – United States Department of Commerce
USDOE – United States Department of Energy (also written as DOE)
USDOI – United States Department of the Interior (also written as DOI)
USDOT – United States Department of Transportation (also written as DOT)
USEPA – United States Environmental Protection Agency (also written as EPA)
USFWS – United States Fish and Wildlife Service
USGS – United States Geological Survey
USMM – United States Merchant Marines
UTM – Universal Transverse Mercator (Maine – Zone 19N)
UXO – unexploded ordnance
VMS – Vessel Monitoring System
VTS – Vessel Traffic Services
WEA – wind energy areas (BOEMRE)
WGS 84 – World Geodetic System 1984 (common unit used on handheld GPS units)
WHSC – Woods Hole Coastal and Marine Science Center
WHSRN – Western Hemisphere Shorebird Reserve Network
WVS – World Vector Shoreline
XLPE – cross linked polyethylene (insulation)

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