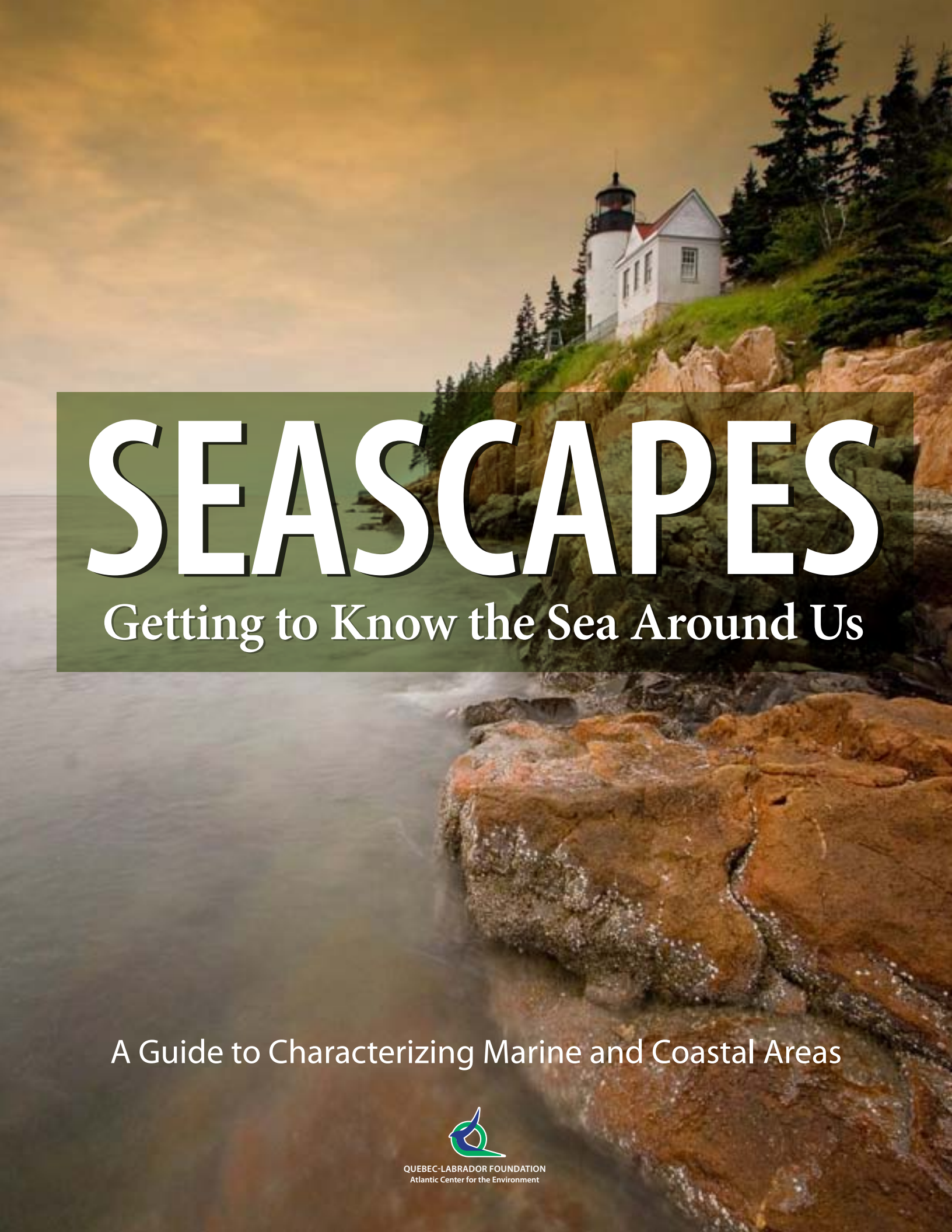

SEASCAPES

Getting to Know the Sea Around Us

A Guide to Characterizing Marine and Coastal Areas

QUEBEC-LABRADOR FOUNDATION
Atlantic Center for the Environment

SEASCAPES: Getting to Know the Sea Around Us

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Acknowledgments

Project Manager	Jennifer Atkinson, Quebec-Labrador Foundation/Atlantic Center for the Environment
Working Group Coordinator	Tracy Hart, Maine Sea Grant
Project Working Group	William Ambrose, Heather Deese, Michele Dionne, Molly Docherty, Lee Doggett, Stewart Fefer, Jill Fegley, Edward Hawes, Anne Hayden, Elizabeth Hertz, Carol Janzen, John Lichter, Linda Mercer, Slade Moore, Joe Payne, Neal Pettigrew, Linda Rowe, John Sowles, Andrew Thomas, Sean Todd, Barbara Vickery, Richard Wahle, Huijie Xue, Steve Zeeman
Text Reviewers	Barbara Arter, Jay Astle, Seth Barker, Deborah Chapman, Charles Curtin, Heather Deese, Michele Dionne, Tracy Hart, Edward Hawes, Anne Hayden, Kathleen Leyden, Linda Mercer, Slade Moore, Joe Payne, Craig Pendleton, Kristen Puryear, Laura Singer, Barbara Vickery, Steve Walker
Writer	Peter H. Taylor, Waterview Consulting
Designer	Kathlyn Tenga-González, Maine Sea Grant
Research Assistant	Elizabeth Stephenson
Cover Photo	Michael Rickard, Shutterstock

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Foreword

I once heard Maine described as the most "local" state in the nation. The vitality of the citizen conservation and resource management movement really underscores that sentiment. We have a wealth of small land trusts, watershed groups, lake associations, and conservation committees. In recent years, there also seem to be more and more saltwater friends groups, alliances, and resource centers focusing on coastal and ocean waters. For many reasons, people are increasingly interested in the harbors, bays, and sounds along our coast.

A group that decides to focus its energy on a particular place—whether marine or terrestrial—usually decides at some point that they need to describe it from both an ecological and a human-use perspective. In fact, I suspect that is why many of you reading this page are sitting down with *Seascapes*.

If your place is terrestrial, there is a small army of people and resources available to assist and support you. There are professionals who conduct ecological inventories, as well as a range of acceptable protocols and standards for these studies. There are government agencies and non-government organizations that track important habitats and species. Other ones monitor and report on uses and use trends. Maine has a number of GIS service centers with well-developed mapping capacities. There are larger institutions that can act as partners and help to leverage extra expertise and resources. We are also fortunate in New England to have private donors, government programs, and charitable foundations, which target their giving to support terrestrial inventories and the collection, storage, and communication of information necessary to produce them.

If your place is salty and wet, however, you are starting from scratch. Or you were, until the development of this guide. Although *Seascapes* doesn't provide area-specific, ready-made information, maps, or datasets, it does provide readers with a better understanding about what it is they need to know and where they can look for it.

Before this guide, groups couldn't make much progress in characterizing a marine area unless they hooked up with a larger institutional partner who could guide and direct the study, provide resources, and help secure funding. Not all areas of the coastal sea, however, command the same level of attention or interest of these bigger players. Some areas, although of tremendous interest and concern to those living in them, aren't often on the radar screen of experts addressing state, regional, or national issues. Without a major partner, even finding authoritative information about what a marine area characterization is can pose a formidable obstacle.

Seascapes hopes to ease this challenge by providing a reliable and accessible overview of what constitutes a comprehensive characterization, as well as ideas for finding, developing, and communicating data from these projects. The ideas presented here are based on the experiences of experts who come from many of the state's leading marine and coastal institutions, including federal and state agencies, universities and colleges, and non-government organizations. Over 20 representatives from these groups came together over a year-long series of workshops to develop the recommendations in this guide. They had no model or road map for what had to be in it. What is found in these pages is based on their combined knowledge, experience, and judgment, as well as information about a variety of characterization-related projects that have taken place in recent years in the Gulf of Maine and beyond. Although their recommendations apply well beyond this one state, the appendix of sources was developed with just Maine projects in mind. Additional appendices could be created, however, to extend the guide's benefits to other states and provinces.

As a bi-national conservation and community service organization, QLF/Atlantic Center for the Environment would welcome the transfer of this resource to other areas in its programming region. For readers unfamiliar with QLF, it may be surprising to hear that it is a 50-year-old organization. With small headquarters in Ipswich, Massachusetts and Montreal, Quebec, QLF programs take place all over New England and eastern Canada in response to the needs of rural, resource-dependent communities. Our Marine Program,

which began in 2002, advances community-based management of marine resources and areas through technical assistance, capacity-building, policy development, and education. QLF also has a robust suite of international programs which facilitate peer-to-peer learning between natural and cultural heritage professionals in our home region and in Central and Eastern Europe, the Middle East, Latin America, and the Caribbean. To learn more about QLF, visit our Web site at *www.qlf.org*.

For QLF's Marine Program here in Maine, *Seascapes* is a start, as well as an experiment. In offering this resource, we join all those who helped produce it in acknowledging that there is still much to be learned about marine characterization studies and how to provide useful guidance about them. We recognize that even with this introduction to the work, your real challenge is the one ahead—planning, preparing for, and implementing a study in your marine area.

And to that list we have one more task to add. Please consider helping us improve this guide in the future. Its real value will only be revealed when it is put to the test. So when you get the time and inspiration, send us your comments, ideas, new sources, or any other information you think would improve the utility of *Seascapes*. We will do our best to incorporate your suggestions as soon as we can.

Jennifer Atkinson, Director
Marine Program
October, 2007

QLF/Atlantic Center for the Environment
28 Martin Point Rd.
Friendship, ME 04547
jatkinson@qlf.org

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Overview

In recent years, people have sought to bring together information about the ocean and coast in a way that fosters more holistic understanding of the ecosystem and improved management of human activities. Collectively, these information-gathering and -sharing efforts can be referred to as marine area characterizations. In the past, the people who did the projects may have called them something else—maybe research, monitoring, assessments, or simply studies—but they are part of a growing trend. The need and desire for information about the sea and shore has never been greater.

Perhaps a particular local issue has gotten you interested in learning about the bay near your home. Perhaps you work at a government or non-government organization involved in ocean and coastal management, and you need to make decisions based on comprehensive information about a particular geographic area. Perhaps you have some other reason for wanting this type of information. Regardless, you may have found that valuable, pertinent information about your geographic area is widely scattered and no one has put it together into a useful form—a marine area characterization.

The purpose of this guide is to enable people to learn more about the ocean and coast through the process of conducting a marine area characterization. Generally, the goals of a marine area characterization are (1) to gather and integrate information about a marine area, (2) to communicate the information, and (3) to use the information to guide resource management decisions.

How does one go about characterizing a marine area in a meaningful way? What information is needed? How should the information be obtained and organized? How can the findings be communicated so they are useful? This guide answers those questions.

In many places, the information needed for effective ocean and coastal management is lacking. Many people are knowledgeable about ways to learn about and understand land areas, but few have similar experience for marine areas. At the same time, people increasingly seek to understand the nature and human uses of the ocean to address environmental and resource management issues.


Keri Lindberg

The marine area characterization process described in this document can be used to produce a well-rounded, comprehensive, and reliable compendium of information that will be invaluable for countless purposes.

About This Guide

Section 1 describes what marine area characterizations are, why they are done, and who is involved. **Section 2** outlines the process of doing a marine area characterization. **Section 3** details the types of information that comprise a marine area characterization. **Appendix A** provides a detailed list of information sources for Maine.

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Section 1 Introduction

Background

People who live and work along the ocean often acquire keen knowledge of local waters and surrounding lands. Commercial and recreational fishermen know where and when to find fish and shellfish. Boaters understand the winds and tidal currents. Birdwatchers keep an eye on the feathered residents. Scuba divers know the seabed's contours and inhabitants. Homebuilders and real estate brokers have a sense of the area's demographics and changes in land use. Longtime residents may remember salt marshes that were filled and built on, factories that once released pollutants into the bay, upswings and downturns in the fishing fleet, and other local history. Every person along the coast, even if he or she just occasionally walks a dog on the beach, has a unique perspective on the natural and human rhythms of the sea and shore.

In a more formal way, many scientists and other professionals focus their work on understanding the ocean and coast. Ecologists study interactions among animals, plants, and the environment—from the habitat requirements of microscopic marine creatures to the enormous web of biology, chemistry, and physics that connects land and sea. Oceanographers investigate ocean circulation and help unravel the complex workings of the marine ecosystem. Geologists map sediments and rocks, and they describe the processes that shaped the seabed. Historians uncover the human and environmental background of a place, while economists analyze past trends and forecast changes in the coastal economy.

Rarely is all this knowledge brought together to form a more complete understanding of an area. The fragments of knowledge tend to stay dispersed among many people or in narrowly focused academic publications, rather than being stitched together to tell the story of an ocean area. Key elements of the story might even be awaiting discovery. As an example, people long believed that Penobscot Bay, Maine, was defined by the vast flow of freshwater from the mighty Penobscot River. But in the 1990s, an unusual set of oceanographic studies revealed that an even mightier "river" of ocean water flows along the coast from the northeast and enters the bay. This influx of salt water overwhelms the influence of the Penobscot River and shapes the ecology of the bay. This "ocean river" is critical for the area's renowned lobster fishery—but nobody knew about it until oceanographic studies detected it. Likewise, few people would ever have guessed that large corals inhabit the cold waters of the Gulf of Maine—until fishermen and scientists began to document the existence of these astoundingly beautiful life forms in the deep waters of the Gulf.

Similar mysteries linger in every area of the ocean, even the most urbanized bay and the smallest cove. Consider, for example, a typical nautical chart of the coast. Scattered around the chart are numbers indicating water depths at individual points, usually based on soundings taken decades or even more than a century ago. This is the best depth information available for most ocean areas, yet it only begins to describe the actual contours of the seabed. The surface of the moon has been mapped in greater detail than the seabed of the Gulf of Maine. People have lived, fished, and boated here for millennia, but the underwater landscape remains a frontier.

The contrast between our understanding of land and sea could hardly be sharper. At your town and county offices, you may find detailed maps of the landscape: terrestrial vegetation, soil types, habitats, topography, infrastructure, land use, and zoning. You might even have access to them on the Web, along with detailed aerial photos that let you zoom in on your backyard. From readily accessible sources, you could quickly put together a reasonably good historical

Slade Moore

and present-day description of the landscape. Indeed, government agencies, environmental consultants, and land-conservation groups routinely compile historical, environmental, and land-use information for environmental impact statements, planning residential and industrial growth, and land conservation and management priorities.

Not so for seascapes. Most places along the coast have no detailed maps of marine habitats or seabed topography, little information about where and when human activities such as scallop dredging take place, and few data on changes in fish populations. Even if the sea has been a town's lifeblood for generations, much of this information simply does not exist or has not been compiled and made available.

Many people still consider the ocean largely unknown and unknowable. We typically accept that we can look across a landscape to see the plants, animals, and terrain but that our ability to see essentially ends at the ocean's edge. A waterfront landowner might know his or her property intimately but little about the adjacent terrain below the low-tide line. Management agencies typically have access to copious information about terrestrial habitats and land-dwelling species, but often they must make decisions affecting coastal waters with little or no information about marine habitats and species.

Dr. Les Watling/NOAA Office of Ocean Exploration

The dearth of marine information is beginning to change. In recent decades, technology has vastly improved our capacity for exploring and understanding the ocean. Scuba diving and submersibles have opened the underwater world. Recreational boats carry depth sounders and electronic navigation equipment of extraordinary precision. Anyone can log onto the Web at *www.gomoos.org* to see hourly water temperature data at depths of more than 800 feet, transmitted from buoys in the Gulf of Maine. Scientists use sophisticated sonar to map seabed contours and geology. Specialized radar stations enable oceanographers to monitor ocean currents in real-time over hundreds of square miles.

State, federal, and academic programs conduct increasingly comprehensive research and monitoring to detect changes in the ocean ecosystem. Ordinary citizens are demanding to know more about their local marine areas and are becoming active in data collection. These efforts have dramatically increased the amount of information available and have at times served as a first alert to changing conditions.

The list of reasons to learn about the ocean and share the information is ever expanding. Growth of the human population and development of coastal land are resulting in greater stresses on coastal waters. Relatively new uses of the ocean and seabed, such as wind farms, tidal power generation, aquaculture, mining, and underwater pipelines, bring additional complexity to marine management. Climate change is altering the ocean in fundamental ways with unknown consequences. These forces are putting increased pressure on the sea. People are calling for better planning and management to reduce harmful impacts on the ecosystem and conflicts among uses. The capacity to plan for and adaptively manage human activities on the ocean and along the coast depends heavily on the availability and accessibility of information about the ocean and on the engagement of local people. Scientific data on water quality, biodiversity, habitat conditions, and other characteristics are essential for detecting human impacts on the ocean and for adaptive management to reduce the impacts.


Natalie Springuel

This document is intended to guide you in bringing together information that exists about a marine area and in filling gaps in that knowledge. It is designed to help you:

- compile sources of scientific, historical, and socio-economic information;
- capture the unique and valuable local knowledge carried by those who live and work in the area;
- collect new data to fill in the missing pieces; and
- communicate your findings so they can be used by others.

Following the process described in this guide can result in a better understanding of a marine area's character, its history, how the ecosystem functions, human activities and impacts, and the questions that still need to be answered.


Slade Moore

What Is a Marine Area Characterization?

Conducting a marine area characterization involves finding, compiling, synthesizing, and presenting information about an area of the ocean. The purpose of a marine area characterization is to tell the natural and human story of a place by describing its historical and present-day character—including biology, ecology, geology, oceanography, chemistry, economy, and human uses. Products of a marine area characterization might include booklets, technical reports, databases, maps, photograph albums, oral presentations, and Web sites.

The area to be characterized can be as small as a cove or harbor, or as large as the Gulf of Maine. The characterized area can be entirely ocean—ranging from shallow, coastal waters to the deep, open ocean—or it can include rivers and coastal lands. The boundaries of a characterized area can be natural features, such as capes and headlands, or political borders, such as towns or states. From a scientific perspective, it is usually advantageous to use natural boundaries, particularly watersheds.

Information of many types can be included in a marine area characterization. It may focus only on present conditions or describe historical conditions, too. The characterization might describe the species, habitats, water circulation patterns, sediments, rock types, and human activities in the place, as well as short- and long-term changes. Such scientific information often is compiled from existing publications and studies, and it also may be obtained through new data collection and analysis. Along with ecological information, a marine area characterization may encompass human dimensions, such as economics, demographics, and fishing.

Section 3 describes the types of information that make up a comprehensive marine area characterization. However, many characterization projects do not attempt to include all of the components because the project goals are limited or funding is insufficient. Some characterization efforts happen in a series of stages, examining different aspects of the area at different times as resources allow.


Natalie Springuel

Who Performs a Marine Area Characterization?

A marine area characterization can be initiated and led by anyone. In some cases, individual citizens interested in their local harbor or bay take the lead. In others, government agencies and non-government organizations are the driving force.

A comprehensive characterization requires people with many different skills and areas of expertise. Depending on a study's goals and the intended application of the results, participants can include scientists, fishermen, mapping experts, historians, writers, community volunteers, database programmers, and many others. The skills of volunteers within a community group or ad hoc characterization group can vary widely—at times including Ph.D. scientists willing and able to conduct scientific field research, at other times including grant writers, artists, mariners, or environmental planners. Or the team may consist of people new to marine issues but with time to contribute.

Applications of Characterization Information

- Local comprehensive planning and ordinance development
- Comprehensive planning at watershed, state, and regional levels
- Ecosystem-based management
- Education tool for legislation, resource management, the public, and schools
- Baseline assessment of an area, region, or ecosystem
- Understanding how human activities affect the area
- Context for addressing particular threats (existing or future) to the area
- Encouragement of citizen stewardship
- Fostering discussion and collaboration among individuals, government agencies, and non-government organizations
- Stimulate scientific research

All of these types of groups have important roles in marine characterizations. This guide will help you to match your group's particular skills with appropriate tasks, roles, and objectives.

Citizens do not need to conduct their own scientific fieldwork to be involved in a characterization. There are many roles for citizen participation, and hired expertise may be needed only for specific tasks. The skills encompassed within a citizen group can dictate the roles that the group is able to take on directly. If group members do not have the expertise for some elements of the characterization process, they can serve as coordinators or fundraisers to help the process happen. For example, a marine area characterization project may be organized as a grassroots partnership led by volunteers in a community group, who search for information, participate in fieldwork, obtain grants, ask experts for guidance, and hire consultants to carry out some tasks.

Why Conduct a Marine Area Characterization?

Marine area characterizations are done for many different reasons. The findings can be used to address a host of information needs related to industry, governance, scientific research, and environmental issues.

Some characterizations are done by people who simply have an interest in gathering information and telling the story of a particular place or by groups of volunteers as a community-building activity that creates a foundation of information about the place where they live.

Some are conducted to make existing and new information more available to resource managers and thereby improve their capacity to make informed decisions.

Marine area characterizations can help support scientific research. They can identify gaps in information about the marine area and therefore help in prioritizing research needs; allow scientists to compare conditions within the site to the findings of other studies that are conducted in the area or at other sites; provide a more complete understanding of the area to provide context for findings from specific studies; and create the foundation of information that is often necessary to attract additional research interest and funding.

Bill Silliker

Results from a marine area characterization provide a snapshot of the area's conditions at one point in time. This snapshot can be useful for developing an assessment of the area's status, such as a "state of the bay report," and it can help identify the best variables for long-term monitoring of the area's condition over time. Characterization results can be used in future studies to identify key changes that have taken place and to determine the natural variability of conditions in the area.

Many values of marine area characterizations lie beyond the realm of science. The projects can focus citizen attention on a marine area, fostering local stewardship and responsibility for the site. Characterizations provide information that can be used to resolve conflicts among human activities or management goals for the area.

Examples of Marine Area Characterization Projects

Many government and non-government organizations have worked to characterize marine areas. As examples, three projects are described in this section. This guide evolved partly in response to these projects, as well as more limited efforts by other groups. They demonstrated the increasing need for, and broad utility of, characterizing marine areas. Although these projects were not comprehensive characterizations and may have used different methods than those described in this guide, they give a sense of what is involved in a marine area characterization. People who worked on these three projects were involved in producing the *Seascapes* guide, and their experience and expertise is reflected throughout the guide.

Example 1: Taunton Bay, Maine

Site-specific ecological studies to address local concerns and develop long-term collaborative management strategies.

Where: Taunton Bay is 10 miles north of Acadia National Park in eastern Maine. The 3,800-acre, estuarine bay is surrounded by the towns of Franklin, Hancock, and Sullivan.

Who: Maine Department of Marine Resources, Friends of Taunton Bay, Maine Maritime Academy, University of Maine, Maine Sea Grant, commercial mussel harvesters.

Why: In 1999, a new bridge across the Taunton River enabled larger boats to pass into the bay, including fishing vessels that would drag for mussels. A local conservation group known as Friends of Taunton Bay raised concerns about the ecological effects of mussel dragging. In response, the state signed a law in 2000 that temporarily closed Taunton Bay to fishing by vessels that use bottom-tending mobile gear. The law required the Maine Department of Marine Resources (DMR) to study the impacts of dragging on Taunton Bay and to recommend by February 2004 whether the ban should become permanent.


Steve Perrin

What: Several projects have helped to characterize Taunton Bay. Prior to the DMR study, Friends of Taunton Bay produced a bibliography about the bay and described the bay's physical, geological, and biological attributes. Maine Sea Grant conducted an opinion survey of residents concerning marine and coastal issues. DMR conducted fieldwork, mapping, and data analysis to provide the information that was needed for management decisions. The DMR study was intended to:

- develop a baseline characterization of the Taunton Bay estuary,
- provide information for decisions regarding the moratorium on mussel dragging in the bay,
- respond to the legislative mandate, and
- develop a framework for responding to similar concerns.

Following the DMR assessment, Friends of Taunton Bay conducted additional research, monitoring, economic assessment, outreach, and mapping with funding from the Maine State Planning Office.

How :

- Developed a general physical description of the bay.
- Performed an inventory of seabed invertebrates.
- Interviewed fishermen to describe the bay's dragging history.
- Measured benthic (seabed) community changes in response to mussel dragging.
- Collected water-quality data.
- Identified the types and amounts of species harvestable by dragging.
- Mapped seabed with sonar and aerial imagery and tracked the loss of eelgrass over time using aerial imagery.
- Conducted winter waterbird surveys.
- Quantified fish diversity and abundance to determine importance of eelgrass to fish communities.
- Tracked horseshoe crabs with sonic telemetry to identify vulnerability to dragging and other human activities.

Selected Products:

- Arter, B.S. 2007. ***Taunton Bay Mudflat Management Plan: A Case Study in Mudflat Fisheries Management Using Ecosystem-Based Principles.*** Friends of Taunton Bay: Hancock, Maine.
- Maine Department of Marine Resources. 2007. ***Report to the Joint Standing Committee on Marine Resources of the 123rd Maine Legislature on a Comprehensive Resource Management Plan for Taunton Bay, Maine.*** Maine Department of Marine Resources: Augusta, Maine.
- Friends of Taunton Bay. 2006. ***The Taunton Bay Study, A Pilot Project in Collaborative Bay Management: Final Report.*** Friends of Taunton Bay: Hancock, Maine.
- Moore, S. 2004. ***The Taunton Bay Assessment: A Report to the Maine Legislature Marine Resources Committee for Consideration of the 2000-2005 Dragging Prohibition***. Maine Department of Marine Resources: Augusta, Maine.
- Hart, T. 2003. ***Needs and Issues in the Taunton Bay Region: A Survey of Residents in Franklin, Hancock, and Sullivan, Maine***. Maine Sea Grant Program: Orono, Maine.
- Friends of Taunton Bay. 1991. ***Inventory of the Taunton Bay Region in Franklin, Hancock, Sullivan***. Revised, Second Edition. Friends of Taunton Bay: Hancock, Maine.

These products are available on the Web sites of Friends of Taunton Bay (*http://ellsworthme.org/tauntonbay*), Maine Department of Marine Resources (*www.maine.gov/dmr/baystudy/baystudy.htm*), and Maine State Planning Office (*www.maine.gov/spo/mcp/baymanagementreport.php*).

Example 2: Cobscook Bay, Maine

Conducting basic science to help inform conservation and management.

Where: Cobscook Bay is an estuary in eastern Maine, along the Canadian border. Towns on its shores include Eastport and Lubec, Maine.

Who: The Nature Conservancy – Maine Chapter, Bigelow Laboratory of Ocean Sciences, Texas A&M University, University of Maine, Cobscook Bay Resource Center, Suffolk University, Cornell University, Maine Sea Grant, local high school.

Why: Provide baseline information about the bay and understanding of key environmental parameters that influence it. Gather information to enable greater use of science in decision-making that affects the bay and to encourage more research centered on the bay. Contribute to conservation of biological diversity and sustaining the region's commercial productivity.

What: In 1995, Cobscook Bay became the focus of extensive field sampling to collect physical, chemical, and biological data. A major goal was to develop the first components of an ecosystem model for Cobscook Bay—the levels and sources of primary productivity. The studies took a broad, ecosystem approach to understanding ocean currents, habitats, nutrients, and growth of seaweeds and phytoplankton.

How:

- Compiled a historical checklist of macroinvertebrates seen in bay during last 160 years.
- Studied circulation patterns using drifters tracked by satellite.
- Created three-dimensional numerical model of circulation.
- Mapped and measured intertidal habitats using aerial photos and Landsat data.
- Identified sources and distributions of nutrients.
- Mapped bottom sediments with sidescan sonar.
- Estimated biomass and productivity of rockweeds and microalgae.
- Modeled the influences of tides, wind, nutrients, and solar radiation on biological productivity.
- Created ecosystem model using satellite images, aerial photography, and on-the-ground and in-the-water sampling compiled into GIS layers.

Bill Silliker


Louis Torrieri

Selected Products:

- *Ecosystem Modeling in Cobscook Bay, Maine: A Boreal, Macrotidal Estuary*. *Northeastern Naturalist*, Volume 11, Special Issue 2, 2004. This special issue of Northeastern Naturalist contains 17 articles describing the results of cooperative research in Cobscook Bay organized by The Nature Conservancy. Topics include hydrodynamic modeling of tidal circulation, distribution of nutrients, productivity, and geological context, among others.
- Larsen, P. F. and R.V. Webb. 1997. ***Cobscook Bay: An Environmental Bibliography***. Bigelow Laboratory Technical Report #100. Maine Chapter of the Nature Conservancy: Brunswick, Maine.

These products are available on the Cobscook Bay Resource Center's Web site at *www.cobscook.org/reference.htm*.

Example 3: Penobscot Bay, Maine

Exploring new ways to use scientific information in managing the lobster fishery.

Where: Penobscot Bay is Maine's largest bay. It is located midway along the state's coast. Camden, Belfast, and Castine are a few of the towns on Penobscot Bay.

Who: Members of the Penobscot Bay Network, Island Institute, University of Maine, Bigelow Laboratory for Ocean Sciences, Maine Department of Marine Resources, NOAA Coastal Services Center, Maine State Planning Office, commercial lobstermen.

Why: Several efforts have focused on characterizing Penobscot Bay, beginning with a series of conferences in the 1990s which was followed by the formation of the Penobscot Bay Network. Through the 1990s, the Network produced publications on the bay, organized more conferences, and sought National Estuary Program status for Penobscot Bay. This work helped to set the stage for the development of the Penobscot Bay Marine Resource Collaborative. Its initial purpose was to "create a Project GIS containing layers of information essential to describing the ecological character of Penobscot Bay." This work was part of a five-year, federally funded demonstration project to "determine whether environmental satellite data could be practically and cost effectively used at the state level to support coastal marine resources management." Interest in the study of Penobscot Bay arose from questions about the effects of port development plans for Sears Island and dams on the Penobscot River. Broad interest grew in understanding the oceanography and ecology of the bay. As the project progressed, however, the project narrowed its focus to environmental issues relevant to management of the bay's lobster fishery.

What: This collaborative effort collected information that is valuable for management of Penobscot Bay's lobster fishery. Lobsters are persistently abundant in the bay despite intense harvesting. The goal was to enable predictions of changes in the lobster population based on oceanographic and ecological factors.

How:

- Monitored abundance and distribution of lobsters.
- Characterized and classified habitats in the bay.
- Collected oceanographic data on water circulation.
- Created numerical model that described circulation patterns.
- Mapped geology of the seafloor.
- Identified plankton species and measured productivity.
- Analyzed satellite data for seasonal average of water temperatures.
- Built GIS map layers using biological, tidal, geological, and nutrient data.

Selected Products:

- Platt, D.D. (Ed.) 1996. ***Penobscot: The Forest, River and Bay***. Island Institute: Rockland, Maine.
- Conkling, P. and A. Hayden. 2002. ***Lobsters Great and Small***. Down East Books: Camden, Maine.


Deb Bouchard


Deb Bouchard

Other Examples

Many other places in the United States and Canada have been the focus of marine area characterization efforts. This list provides a few examples and where to obtain more information about them.

Kachemak Bay, Alaska *http://www.habitat.adfg.state.ak.us/geninfo/kbrr/coolkbayinfo/kbec.html*

Damariscotta River Estuary, Maine. McAlice, Bernard J. 1993. Environmental Characteristics of the Damariscotta River Estuary, Maine. Darling Marine Center: South Bristol, Maine. Available from the University of Maine Library, *http://www.library.umaine.edu/*

New Meadows River, Maine *http://www.bowdoin.edu/new_meadows/*

Gloucester Harbor, Massachusetts *http://www.mass.gov/czm/glouc_harb_rpt_toc.htm*

Plum Island Sound, Massachusetts *http://www.mass.gov/czm/marineresourcepreb.htm*

Salem Sound, Massachusetts *http://www.mass.gov/dfwele/dmf/publications/salem_sound_report_tr6.pdf*

Stellwagen Bank National Marine Sanctuary, Massachusetts Bay
http://stellwagen.noaa.gov/science/sitecharacterization/toc.html

Musquash Estuary, New Brunswick *http://www.musquashmpa.ca/*

Gilbert Bay, Newfoundland *http://www.gilbertbay.com/science.htm*

The Gully, Nova Scotia *http://www.mar.dfo-mpo.gc.ca/oceans/e/essim/gully/gully-documents-e.html*

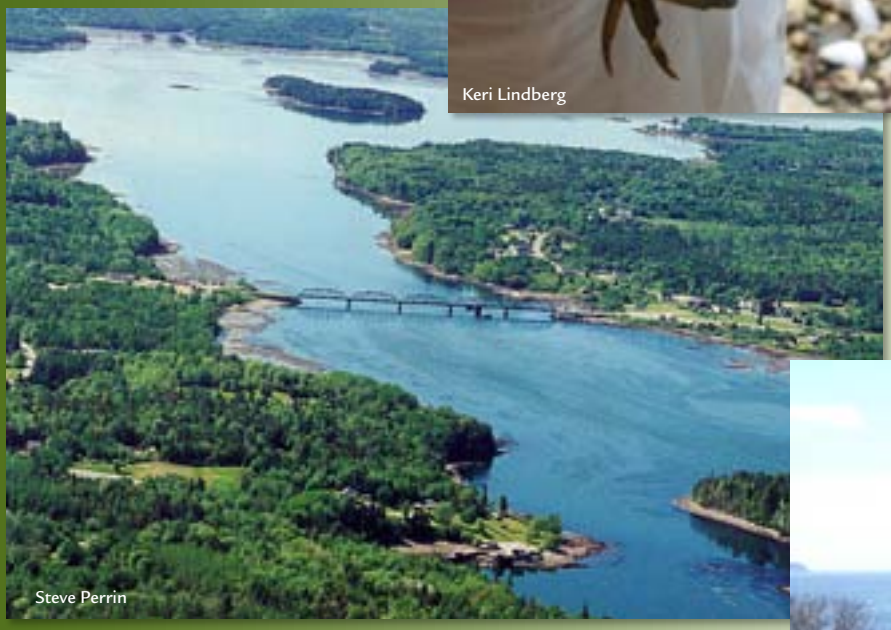
ACE Basin, South Carolina *http://www.dnr.sc.gov/marine/mrri/acechar/index.html*


Natalie Springuel


Natalie Springuel


Keri Lindberg


Slade Moore


Steve Perrin


Natalie Springuel


Deb Bouchard

Section 2 A Course of Action for Marine Area Characterization

Overview

Every marine area characterization is different. Each has a unique combination of goals, funding, interests, skills, information sources, and geographic focus. Because of the endless variety, it is impossible to prescribe a process for how to do a marine area characterization. However, this section describes common steps that may be included in the course of action for planning and conducting a marine area characterization. Following these recommendations can help to ensure that the characterization is successful.

Steps in Marine Area Characterization

Planning

Step 1: Identify the Reasons for Doing the Characterization
Step 2: Involve Key People
Step 3: Clarify Themes for the Project
Step 4: Create a Strategy for Sharing the Findings

Developing Tools and Acquiring Resources

Step 5: Decide Types of Information to Gather
Step 6: Set Up a System to Store Information
Step 7: Consider Seeking Funds

Conducting the Characterization

Step 8: Find and Compile Existing Information
Step 9: Conduct Original Research
- Step 9a: Identify Gaps in Knowledge
- Step 9b: Determine How to Fill Gaps
- Step 9c: Marshal Resources
- Step 9d: Conduct Research and Monitoring

Producing and Sharing Findings

Step 10: Analyze Data and Produce Findings
Step 11: Review Findings
Step 12: Share Findings

Planning

Step 1: Identify the Reasons for Doing the Characterization

Why is the characterization being conducted? What are the goals, and what are the desired outcomes? Is there a particular management issue or human impact that requires attention in the area? Is the project aimed broadly at strengthening community ties and improving the overall understanding of the area, rather than solving a particular environmental problem? A clear, shared understanding among the project participants is needed to ensure that goals are achieved successfully and efficiently.

A marine area characterization project needs clear goals that are put into writing. Decide the goals early in the project and use them as a touchstone for maintaining focus throughout each stage. Over time, the project might expand beyond the original purpose because of unforeseen needs, questions, and opportunities, as was the case for characterization work in Penobscot Bay (see page 17). But the written goals serve as a guide for all subsequent steps—from engaging other people to gathering information to sharing findings.

To begin developing the goals statement, pull project partners and advisors together to discuss their areas of interest, motivation, and intended outcomes for the marine area characterization. Why are you conducting a marine area characterization? What needs will the project address? What questions is it intended to answer? What is the project's geographic scope? The answers to these questions provide fodder for the goals statement, which provides a framework for specific objectives and tasks.

The process of developing the goals statement is just as important as the statement itself. It can build support among people who might not otherwise feel part of the characterization effort. It can also prevent conflicts later in the characterization process by reducing misunderstandings of the project's goals.

The goals statement can facilitate prioritizing of project tasks and budgets. After the characterization information has been gathered, the goals statement can be used to determine the best way to share the findings. Finally, a clearly written goals statement makes it possible to evaluate the success of the project after it is completed.

Outputs: Concise written record of the project's goals. Map identifying project area.

Step 2: Involve Key People

A marine area characterization requires participants with a range of perspectives, skills, and knowledge to guide, manage, and carry out the project and to apply its results. Early in the process, it is vital to involve as many people and organizations as possible who have relevant skills or who may be affected by outcomes resulting from the characterization. When people are involved early, their knowledge and perspectives can guide the project, and they are likely to be more interested in its findings. For example, scientists and resource managers can provide valuable input on how to collect data that are scientifically defensible and useful in a management context. Fishermen and others knowledgeable about the local environment can provide important information about the area and how it is used. Not everyone needs to become an active participant in the project, but seeking their advice, incorporating their knowledge, and making them aware of the project will build credibility and buy-in. Ultimately, the project's success and impact depend on the support it receives from people outside the project's core participants. In addition, early engagement with a range of people will help the project organizers to clarify the project's scope and goals and to evaluate the requirements for personnel and funding.

Outputs: List of participants, advisors, and consultants. List of participants' areas of expertise. List of other expertise needed. A name for the group conducting the characterization or for the project.

What Area Are We Characterizing?

Some marine area characterizations focus on a town's harbor, while others cover thousands of square miles of ocean. Whatever the geographic scale, it is important to define exactly what area is being characterized, so the project keeps its focus. If the area is along the coast, how far offshore will be characterized? Will the characterization go inland into the watershed or stop at the high-tide line? For example, if the project is a local community activity for a town, then the town's borders might serve by default as the project's boundaries. However, if the goal is to provide information for ecosystem-based management, then it is usually advantageous to choose natural boundaries such as watersheds, bays, and/or the edge of the coastal shelf, rather than political boundaries.

Choosing boundaries is by necessity an arbitrary process. Once a boundary is chosen, those factors that do not conform to the boundaries ought to be noted. For example, ocean currents probably go across the boundaries. Fish are likely to move into and out of the study area. Perhaps the area is important for shorebirds, but only as a stop along their migration. Essentially, any study area is nested within a hierarchy of larger, smaller, and overlapping areas. Recognizing these connections is important for understanding the study area.

Examples of Possible Boundaries

Natural boundaries. Coastal features (harbors, coves, bays, gulfs, sounds, estuaries, islands, capes, headlands, and peninsulas); watersheds; oceanographic features such as currents (e.g., Eastern Maine Coastal Current, Gulf Stream); seafloor features (banks, channels, basins, ledges, shoals, reefs, continental shelf or slope); rivers and river mouths; salinity or tidal gradients; geographic range limits of animal and plant species; edges of biogeographic regions.

Political boundaries. Town, county, state, provincial, and national borders; resource management areas (e.g., lobster zones, urchin harvesting zones); jurisdictions, such as state or federal waters; areas of influence for relevant government agencies (e.g., marine resource management, environmental protection).

Cultural, organizational, or use-related boundaries. Areas used for particular industries (e.g., shipping, dredging, aquaculture, energy, communications); area of concern for the organization conducting the characterization; area defined by previous scientific studies or conservation efforts; areas of historic use such as shipbuilding, canneries, farming.

Other boundaries. Latitude/longitude; specific depth or distance offshore/inland; limits imposed by sampling devices or technology used for characterization, such as mooring arrays or high-frequency radar.

Who Might Participate?

- Volunteers and community groups. Dedicated volunteers can be invaluable participants and leaders. Residents may contribute valuable time and local knowledge to the project, and some volunteers may bring skills, such as database design, birding, and boat operation. Volunteers may be able to do substantial parts of the work involved in a marine area characterization, given adequate training and guidance or their existing career skills. For example, skilled recreational boaters with GPS and depth sounders could be organized to map the underwater topography of a bay. Coastal landowners could set up and maintain basic meteorological stations to collect data on wind and other parameters. Sometimes volunteers even have specialized skills that would normally require hiring consultants.
- Scientists and/or their graduate students with relevant expertise. Scientists are essential to engage in any marine area characterization. They may come from academic institutions, government agencies, industry, consulting firms, or non-government organizations. They may be based locally or elsewhere in the state, region, or country. They may include marine biologists, ecologists, oceanographers (biological, physical, chemical, geological), zoologists, botanists, geologists, environmental chemists, geographers, and hydrologists. They may have conducted previous studies in the geographic area of interest or similar studies elsewhere. Scientists may provide guidance to volunteers and assist with data analysis and synthesis.
- Resource users who know the area through frequent use and observation. Commercial and recreational fishermen, aquaculturists, hunters, farmers, boaters, mariners, land surveyors, loggers, naturalists, birders, divers, and others may live locally or commute to the area for their work. Years of direct contact with the area and its resources give these people an invaluable breadth and depth of knowledge about the area.
- Municipal officials. The local mayor, port authority, planning board, conservation commission, code enforcement officer, shellfish warden, harbormaster, and other officials may contribute information and ultimately use the characterization's findings.
- Staff members from government agencies. State agencies (e.g., coastal zone management program, marine resources, fish and wildlife, environmental protection, state planning office) and federal agencies (e.g., National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Environmental Protection Agency, U.S. Geological Survey) have resource managers, scientists, planners, GIS specialists, enforcement officers, policy specialists, and educators.
- Business people and commercial interests. Tourist-oriented companies, aquatic businesses, professional associations, and industrial and trade associations may participate by providing information, funding, and perspectives on how to make a marine area characterization useful.
- Staff members and volunteers from non-government organizations. Cultural (ethnic, art, music), educational, and outdoors (birding, kayaking, boating) organizations, as well as land trusts, conservation groups, and historical societies may be interested in participating in the characterization process and using the results.
- Writers, editors, graphic designers, illustrators, photographers, mapping (GIS) technicians, and Web designers. People with these skills can help identify needs for particular types of information, plan how to address those needs, and develop compelling ways to communicate findings of a marine area characterization.


Louis Torrieri

Step 3: Clarify Themes for the Project

The information collected during a marine area characterization needs to be organized and communicated effectively. Without well-defined themes, the information collected during the characterization could remain difficult to use and therefore underutilized. From the beginning of the project, identify the project's focal themes.

Themes are related to project goals, but they serve a more narrow function. Project goals are the grand targets that the organizers ultimately want to accomplish. Project themes provide a framework for collecting, organizing, and communicating data and information throughout the characterization process, and help the characterization project to generate a targeted body of information. Project themes might relate to habitats and species in the area; historical and recent changes in environmental quality and human activity in the area; economic resources and value of the area; and current health of the ecosystem.

Of course, the findings will be unknown until after the information is collected and analyzed during the characterization process. However, project participants can decide on the project themes. The themes may or may not be explicitly stated in the project's end products, but they should be identified clearly in the early planning stages of the characterization.

Variations on a Theme

A marine area characterization might:

- explore interconnections between land and sea *or* focus on the sea.
- delve into economics of commercial activities *or* orient toward non-economic information.
- focus on contaminants and water quality *or* seek to understand the effects of fishing, study a few types of animals, *or* look holistically at habitats and the entire ecosystem.

These themes guide the people responsible for gathering existing information. They are crucial for planning and creating end products, such as booklets, Web pages, and maps.

Output: Description of project themes.

Step 4: Create a Strategy for Sharing the Findings

Generally, the overarching goals of a marine area characterization are to (1) gather and integrate information about a marine area, (2) communicate the information, and (3) use the information to guide resource management decisions.

At first, it might seem advantageous to approach these goals sequentially—first compiling the information and then focusing on disseminating and using it—but the goals are highly interdependent and are best pursued together. For example, creating a strategy for sharing the findings early in the project helps to define what information resources are needed. Then the project team knows in advance the planned communication products of the characterization and can obtain the information efficiently. In addition, it is usually valuable to communicate with the intended audience during the project, instead of only at the end, by producing fact sheets, press releases, and presentations about upcoming or recent activities.

Who will use the information? Whom do you wish to reach? Examples of potential audiences and users include state and federal resource managers, policy makers, conservation commissions, planners, municipal officials, academic scientists, fishermen, community groups, journalists, non-government organizations, interested local citizens, students and teachers, and marine-oriented business people. Each of these audiences has different information needs. They may want different types of information from a marine area characterization or some may respond better to a particular mode of delivery than others.

Identifying the intended audience is essential because it enables the project organizers to decide what information should be included in the characterization, how information should be organized and portrayed, and which stakeholders should be involved. For example, a characterization project could generate one set of products for resource managers and another set for students and teachers.

The goals, themes, and target audiences for the project are the key considerations when deciding how you will communicate the information that you find. These factors determine the amount, complexity, subject matter, and format of information that needs to be collected. The communications strategy identifies the products that will come out of the characterization and how they will be developed. It also determines ways to build support for the project and interest in its results. For example, people conducting a marine area characterization might decide to share the information through an eye-catching, colorful booklet for a general audience, online maps for coastal landowners, workshops for resource managers and municipal officials, a technical report for scientists, or public displays for children.

The strategy for sharing information is critical. It makes the difference between a marine area characterization that reaches, engages, and is used by the target audience versus one that sits on the shelf. The strategy requires careful thought during the early planning phase of a marine characterization. Products from other marine area characterizations (see examples on pages 14, 16, 17) can provide ideas and inspiration.

Consider hiring independent contractors who specialize in marine science communications to non-scientific audiences. If they are engaged early in the project, such experts can facilitate the process to ensure that the marine area characterization accomplishes its goals. They can help create the communications strategy, envision the end products, and eventually produce them.

Outputs: Description of target audience. Strategy for sharing findings.


Keri Lindberg

Developing tools and acquiring resources

Step 5: Decide the Types of Information to Gather

Section 3 of this guide discusses the types of information developed and recommended by a group of specialists as the elements of a comprehensive marine area characterization. A characterization that includes all of the recommended information will provide a comprehensive description of a marine area. In reality, however, marine area characterizations typically are constrained by budget, time, and expertise, and they cannot include the full suite of information. The list of components in Section 3 can be reviewed and whittled down to those that are critical to the project's goals and can be accomplished with available resources. If more resources become available or the project's goals expand, then more components can be added later for a more complete characterization.

Output: List of information components to be included in the project.

Step 6: Set Up a System to Store Information

Producing a marine area characterization can involve large amounts of data and information. The project may compile stacks of scientific articles, books, technical reports, historical documents, data sets, images, maps, and other resources. Some of them may be hard copies, while others are in electronic format. All of the information needs to be kept organized and accessible during and after the characterization process. For the characterization process to be efficient and effective, a system needs to be set up for storing data and information. The system may be as simple as a set of folders in a file cabinet or as sophisticated as a Web site with databases and interactive maps. Some important aspects of information storage include:

- Who stores the information? Is it a single person, a lead organization, or several organizations?
- How do participants gain access to the information? Is it loaned out? Are summaries sent to all participants?
- How are participants notified of additions to the information to prevent duplicative efforts?

Output: System for organizing and storing data and information.

Step 7: Consider Seeking Funds

People and financial support are the major resources needed to carry out a marine area characterization. Funding is required not only to conduct research but to synthesize findings, produce reports and other communications products, and disseminate results. Determine which components of the characterization will be performed by volunteers, independent contractors, or staff, based on the skills and time required for the work. Funding may come in the form of grants or in-kind contributions from sources such as government agencies, foundations, and corporations. It might also be raised from individual donors or local businesses with a keen interest in the area, as well as through fundraising events. Many different funding sources exist, but tracking them down and acquiring funds can be a challenge. There are many strategies and important lessons to successful fundraising, which vary depending on the source of the income. Securing funding may absorb a large amount of time during the characterization process. Once funds are obtained, they must also be tracked, managed and, in some instances, reported on. However, after initial funding is obtained, it often becomes easier to find and obtain additional funding. Having well-defined goals, themes, and target audiences will help greatly in building support and momentum for the project, as will an effective strategy for communicating the project's goals, expected impacts, and likely products. Financial support early in the characterization process could allow the group to hire people with necessary expertise and to provide training for volunteers.

Output: Funding for the project.

Conducting the characterization

Step 8: Find and Compile Existing Information

There is tremendous value in finding and integrating information that already exists about a marine area's biology, ecology, oceanography, human activities, and socioeconomics. For some marine areas, considerable information is available, but typically it is scattered among many books, articles, historical documents, maps, Web sites, and people's memories. It usually has not been gathered and made available in a useful,

compelling way to tell a complete story about the place. Some marine area characterizations involve original scientific research or monitoring.

Finding existing information might involve a combination of Web searches, library research, telephone calls, and in-person discussions. There are many places to look for existing information. The search is also a very effective way to involve people in the project and to increase people's interest in it. Some sources of information are obvious and easy to access, while others are obscure and require a bit of digging. Appendix A provides details on where to find key types of information.

The search should focus on the types of information identified in Step 5 as priorities. But it is worth staying alert for easy opportunities to get other information without much additional effort. Maps, photographs, charts, and graphs—along with written documents and data sets—are all fair game and ought to be gathered.

Output: Annotated bibliography and collection of information resources, including lists of organizations and individuals knowledgeable about the area.

Step 9: Conduct Original Research (optional)

Some marine area characterizations include original research. The need to develop new information depends largely on the project's goals, the group's capacity, and the kinds of information gaps that need filling. Steps 9a–9d provide an overview of the process, if you are thinking about conducting original research or hiring someone to do it.

Step 9a: Identify Gaps in Knowledge

Use the information uncovered in Step 8 to figure out what is not known about your area. What vital questions have not yet been answered? Which information components cannot be addressed with existing information? What necessary research, monitoring, analysis, or synthesis has not occurred in your area? Consider why such research and synthesis has not been undertaken before. Is it simply because of lack of previous funding or interest, or are there logistical or technical challenges that you should take into account for your own work?

A Few Ways to Find What You Need

- Conduct a literature search to uncover articles and books about the marine area. Obtain the sources on the Web; through interlibrary loan; at major libraries; and in special collections of museums, research stations, town halls, and historical societies.
- Contact government agencies and non-government organizations for relevant data that they have collected.
- Interview local people who have knowledge of the area

Step 9b: Plan Research to Fill Gaps

Research to collect new information about an area can take many forms. Many people think first of scientific experiments. But collecting new and previously unavailable information can also involve monitoring programs, weather or temperature readings, mapping efforts, conducting surveys, and interviewing people. Some of these methods might be done by the characterization team. Others might require the services of professional, outside researchers. Consider what information you wish to collect and what skills and level of expertise will be needed. When working with outside professionals or institutions, also determine who owns the data developed for the project and how it will be used or shared. Then clarify this mutual understanding through a written agreement before the research begins.

Section 3 of this guide describes the types of information that are needed for a complete characterization and some ways of obtaining the information. More than one method may be available for collecting a particular type of data. The methods may range widely in their expense, accuracy, ease of use, value for scientific analysis, and comparability of results with other studies. For example, trained volunteers can provide good data using a simple tool called a Secchi disk to measure water clarity, while professional researchers might use sophisticated instruments to provide more exact information. Another consideration is the frequency of data collection, which might occur monthly at a single location or daily at a dozen locations. Generally QA/QC data, or data that are quality assured and controlled, will have more value beyond the project's purposes than less rigorous data.

Depending on the purpose of the research, however, an inexpensive and easy option might be perfectly acceptable, or there might be important reasons to use a more costly, complicated method. The benefits of the different options should be weighed to determine which fits best with the purpose, funding, and expertise available for the project. Choose the research methods in consultation with scientific experts, because faulty decisions about the research plan could later

undermine the scientific validity of the findings, reducing their value for resource management and other purposes. Integrating the characterization with existing research efforts by government agencies or university scientists can help to reduce the costs to the characterization project itself.

After the research methodologies are chosen, a detailed research plan must be developed. The research plan outlines when, where, and how sampling will be conducted. Some types of information might only be collected once, such as water-depth soundings for mapping bathymetry (seafloor topography). Other variables must be measured repeatedly in order to characterize them accurately, such as water temperature throughout a year or bird abundance before, during, and after migration. Likewise, some types of data may need to be collected only at one site, whereas other types may need to be measured at many sites. The research plan makes it possible to estimate the necessary personnel, equipment, supplies, and funding.

Output: Research plan that describes any methods that will be used for assuring and controlling data quality.

Step 9c: Marshal Research Resources

Some research and monitoring methods are practical for citizen groups and volunteers to perform. For example, many volunteer groups conduct water-quality monitoring, and these programs or similar volunteer-based efforts might be incorporated into a marine area characterization. Likewise, many amateur birders are skilled at observing and identifying coastal bird species, and they could play a valuable role as volunteers in a marine area characterization. Recreational boaters and commercial fishermen often have the equipment—depth sounders and GPS units—needed to map the contours of the seabed, with guidance from scientists. Measurements of wind and temperature are another type of data collection that volunteers can perform successfully with advice from scientific experts.

One important challenge is to develop ways to attract volunteers and to involve them in meaningful tasks that meet data needs while fulfilling their expectations. Volunteers also can be integral outside the data collection phase—to enter data into a database, for example. Methods to assess and control the quality of the data are important. Sometimes retired scientists or other highly skilled people can be recruited as volunteers to oversee the training and quality control.

Just as important, recognize which aspects of the project require a greater level of expertise than what is available from project participants. Consider hiring or developing partnerships with consultants, academic scientists, and government agencies to conduct volunteer training, data quality control, and fieldwork.

Output: Trained volunteers and other partners or contractors to conduct research.


Natalie Springuel

Step 9d: Conduct Research and Monitoring

The research plan (Step 9b) describes the research and monitoring activities that will be conducted and when they will occur. Experts should help guide the planning and implementation of data collection to ensure that the data are scientifically defensible. For example, an expert might notice odd patterns in the data or see values far outside the expected range, indicating a potential problem with data collection. It is prudent to check the data being gathered early in the project to identify any problems in the method and/or documentation and then correct them. If you wait until the end of the data-gathering phase of the project, you may find that you cannot use some of the data due to incorrect methods or poor recordkeeping.

Output: Data


Keri Lindberg

Producing and sharing findings

Step 10: Analyze Data and Produce Findings

The overall goal of data analysis is to uncover the story contained in the data and other pieces of raw or primary information. What do the data reveal, confirm, or call into question? New data should be considered in light of what was previously known—and unknown—about the area. What stories can be told using the data? What new questions does the new information raise?

Individual pieces of data often mean little. They typically need to be organized into larger groups and analyzed to identify meaningful trends and patterns. Analytical techniques can vary greatly depending upon the subject matter. Statistical analysis is a common tool for natural scientists. For example, if two water samples are measured at two places in a bay, one place might have a higher concentration of pollutants, seemingly showing that it is more polluted than the other place. But if multiple samples were taken at both places, statistical analysis might demonstrate that no true difference exists—the initial difference arose due to chance and does not represent an actual difference between the two areas. Conversely, such an analysis might show conclusively that a real difference does exist.

Statistical analysis can reveal patterns that may not be apparent just by looking at raw data. For example, raw data on the abundance of plants in two neighboring salt marshes might look like a hodgepodge of numbers, but statistical analysis might reveal meaningful patterns in where the plants live, such as an increase in brackish-water plants in one salt marsh.

For a marine area characterization, a useful method for synthesizing a wide range of data is to produce maps with geographic information systems (GIS). GIS enables different types of data to be plotted on maps of the area (see page 29). Displaying data on maps often reveals patterns and suggests relationships. GIS software also has the capability to do analysis, as well as visualization of data. Skilled technicians, such as GIS experts, may be essential for data synthesis during a marine area characterization.

For the most part, data analysis and synthesis should be done by professional scientists who are trained in the intricacies of statistics.

Outputs: Data summaries, maps, and other illustrations that describe findings.

Step 11: Evaluate Findings

After data analysis and synthesis are complete, contact outside experts who were not involved in the project to review the results and make sure the findings are scientifically sound. The reviewers must have relevant expertise and be able to provide impartial criticism of the scientific methods and findings. Although careful planning and evaluation of the characterization methods and data should have occurred throughout the characterization process, this final review is essential to catch any previously unrecognized shortcomings in the research methods or errors in interpretation of the results. This practice, called peer review, is a standard procedure in scientific research to help ensure that the conclusions drawn from a study are accurate. Peer review can also help to identify new or lingering questions that could be answered through additional research.

Output: Recommendations for strengthening the study. Suggestions for further research.

Step 12: Share Findings

Step 4 focused on developing a strategy for sharing findings. After the research has been done and the data analyzed, it is time to implement the strategy. Publications, Web pages, and other products are likely to be important elements of implementing the strategy.

These products tell the story of the marine area as revealed through the information gathering, data collection, and analysis. If the characterization project included all—or even most—of the types of information discussed in Section 3, the result could be a very thorough examination of the marine area based on scientifically sound research.

Focus the communications products on the project themes identified in Step 3. Develop clear messages to convey findings in a way that relates them to the

to convey findings in a way that relates them to the themes. Producing effective communications products is just as critical—and challenging—as the earlier steps in the characterization process. Without effective communications products, the value of a marine area characterization is greatly diminished.

Frequently people dedicate considerable time to creating documents but give scant attention to distributing them. In the communications strategy for a marine area characterization, clearly identify how the products will be distributed. Compile postal and e-mail lists for the target audience and identify other opportunities for distributing the products, such as newspaper inserts and press releases. Findings can be shared through public talks, presentations at workshops and conferences, personal meetings with coastal decision-makers, scientific journal articles, and public displays. When implementing the communications strategy, accommodate unanticipated opportunities, changes in funding, and unexpected findings that might be useful to other audiences.

Outputs: Booklets, reports, Web sites, and other products that share findings with target audience. Distribution lists and methods.

Tips for Sharing Findings

- Talk to members of your target audience early in the project to find out what information they will need and how they will use it. Carefully hone communications products to meet these needs.
- People often like levels of information that allow them to quickly get a sense of the findings and then explore deeper.
  - Concise, easy-to-read, jargon-free summaries of key findings are a good starting level for most people. A short, well-written, and nicely illustrated introductory piece has more impact than a dense 200-page tome.
  - Longer reports focused on the project themes can provide deeper levels of information. Many people seek out a longer report after reading an introductory piece.
- Consider using a combination of print and Web to provide maximum exposure for your results. Some types of information, such as lengthy pieces of text, might best be presented in printed documents, while other information might work best on the Web, such as interactive maps or online databases. Printed documents are easy to mail and hand out to the target audience. Web pages can be less expensive to produce and offer on-demand access to anyone. Documents that are available as downloadable files combine benefits of print and electronic distribution.
- Eye-catching images and graphic design are essential. They grab people's attention and draw them into the deeper information levels. In addition, a well-designed map, graph, or illustration conveys much information quickly. For example, maps produced with geographic information systems (GIS) can be quite useful for presenting information from marine area characterization projects (see page 29).
- Avoid dense, text-heavy publications in favor of graphics-rich, attractively designed documents. Style isn't more important than substance, but style gets people to notice the substance.
- Be clear about who owns the project data. Resolve concerns early in the project by developing a data ownership and sharing agreement signed by project participants. This agreement can influence how data are collected and presented.


Natalie Springuel

Looking Ahead: Update with New Data and Findings

A marine area characterization is a snapshot that eventually can be updated to reflect changes in the marine area. Moreover, any characterization project is likely to raise as many questions as it answers. The original characterization, however, can create a solid foundation for future research and monitoring projects that reveal new insights and explore new questions about the marine area.

The Basics: An Introduction to Geographic Information

By Stephen Engle *Director, Center for Community GIS*

What is geotechnology?

Over the last 30 years, developments in geotechnology have created new opportunities for organizations to integrate, visualize, and analyze environmental information. Currently available digital mapping tools—ranging from free, Internet-driven programs like Google Earth to high-end Geographic Information Systems (GIS) software—make it possible for users to customize maps, investigate patterns and trends, and prepare for future events. Today, the range of geotechnology users includes not only scientists, natural resource managers, and professional planners but local conservation groups, police departments, real estate brokers, schools, and 4-H Clubs.

What is GIS?

Using GIS, one can integrate layers of geographic information according to their shared geography, regardless of the data source. Layers that are commonly overlaid in a GIS include elevation, hydrological features, roads, land use and land cover, aerial photographs, and satellite imagery. Once the data are entered, GIS users can manipulate all data layers to generate customized maps for a region, look for patterns in mapped features, or create new information by processing one or more of the existing layers. In the marine environment, GIS is being used to produce and distribute detailed nautical charts, track sightings of threatened and endangered species, assess the potential impacts of sea-level rise, describe the locations of habitats, and determine the most suitable locations for marine reserves.

Where can I find GIS data?

GIS has become a widely used medium for gathering, storing, and exchanging environmental information. Data stored within one GIS database can be shared easily with other GIS users. In the United States, a wide variety of GIS-ready data sets can be accessed from national, state, and regional organizations at no or low cost. Many government agencies (e.g., NOAA, USGS, U.S. Census Bureau) have dedicated GIS departments that are tasked with developing, maintaining, and sharing essential data layers. The number of municipalities using GIS is growing every day, creating new opportunities for GIS users to obtain highly detailed city- and town-scale data sets, such as property parcels. Many of these data providers can also supply maps of their data sets in file formats (e.g., PDF, JPEG) that can be viewed by people without GIS.

How can I create my own GIS data layers?

In spite of the growing body of GIS data sets, it is not uncommon to find that certain data layers do not exist in digital form or do not possess a suitable level of detail. For local analyses, in-field data gathering has been facilitated by the increased diffusion and affordability of Global Positioning Systems (GPS). GPS data can be integrated easily into GIS to deepen our understanding of the local environment. Data layers can also be created by tracing features from aerial photographs or scanned paper maps. Sketch mapping on charts and maps is another approach for gathering specialized information from locally knowledgeable people, such as fishermen, harbor masters, tourism operators, and long-time residents.

How can I start mapping marine issues of importance to me?

Like many information technologies, GIS has become easier to use and more affordable over time. Developing effective GIS capacity, however, remains a significant investment, especially for groups that only use the technology occasionally. For basic mapping needs, a variety of Web tools allow users to generate basic maps of areas featuring transportation networks, political boundaries, demographic information and, in some places, aerial images. Some mapping Web sites and freely available programs allow users to add their own information, such as GPS waypoints or tracks, to the map. Groups requiring more-specialized GIS services can get support from a growing network of dedicated GIS service providers.

Where can I find some mapping tools and data?

A Internet mapping sites (capable of generating base maps)

Google Maps: *http://maps.google.com*

Microsoft Virtual Earth: *http://maps.live.com*

MapQuest: *http://www.mapquest.com*

B Internet mapping sites (content specific)

USGS National Map: *http://nationalmap.gov*

U.S. Census: *http://factfinder.census.gov*

Gulf of Maine Council on the Marine Environment: *http://www.gulfofmaine.org*

Gulf of Maine Ocean Observing System: *http://www.gomoos.org*

Systems (GIS)

An Example of GIS for Marine Area Characterization: Muscongus Bay, Maine

Where Muscongus Bay is located at the midpoint of Maine's coastline, just west of Penobscot Bay. St. George, Friendship, and Bristol are three of its nine mainland towns.

Who Quebec-Labrador Foundation, Inc., and the Muscongus Bay Project Steering Committee.

Why The Muscongus Bay Project formed in 2003 in response to concerns about the future of the bay's fisheries and the impacts of changing land use and ownership. A review of scientific papers revealed major information gaps about the bay. To help fill these holes, the group began using GIS mapping in 2005, as part of a state-funded bay management pilot study. The group found that GIS was an effective tool for compiling diverse data about the bay and for making custom maps to communicate information about the bay's environment and human uses.

How Working with a GIS service center with marine expertise—The Center for Community GIS in Farmington, Maine—the Muscongus Bay Project was able to bring together a vast amount of information in a comprehensive geo-library. The Center for Community GIS and QLF built this master GIS database by:

- downloading existing digital data from online GIS catalogs maintained by organizations, such as the Maine Office of GIS;
- requesting data from organizations that use GIS, including land trusts, universities, and government agencies;
- gathering geographic information that needed to be digitized and imported into GIS (e.g., sites described by latitude and longitude, copies of printed maps);
- collecting new data with GPS;
- facilitating participatory mapping activities with local people to document information that previously had never been mapped (e.g., fishermen's descriptions of fishing grounds, important areas used for water-based recreation); and
- engaging local people in the review and revision of draft GIS maps.

A major product of these efforts is the Muscongus Bay Atlas, a collection of 23 annotated maps built from more than 150 layers of data. The atlas is available at *ww.qlf.org* or *www.community-gis.org*. The Muscongus Bay Project now has its own library of digital data (stored and managed by the Center for Community GIS) that it can use, share, or augment to create new maps and update existing ones. The group plans to use the customized maps to understand how the bay's ecosystem functions and to support a baywide outreach program to help revive a shared regional identity among the bay's communities and residents.

C Virtual globes

Google Earth: *http://earth.google.com*

NASA World Wind: *http://worldwind.arc.nasa.gov*

Microsoft Virtual Earth 3-D: *http://maps.live.com*

D Free GIS programs

ArcGIS Explorer: *http://www.esri.com/software/arcgis/explorer/index.html*

Geographic Resources Analysis Support System (GRASS): *http://grass.itc.it*

TatukGIS: *http://www.tatukgis.com*

E Online GIS data providers

Geography Network: *http://www.geographynetwork.com*

GIS Data Depot: *http://data.geocomm.com*

Maine Office of GIS: *http://apollo.ogis.state.me.us*

F Nonprofit GIS service providers

Center for Community GIS: *www.qlf.org* or *http://www.community-gis.org*

GreenInfo Network: *http://www.greeninfo.org*

Sheepscot Valley Conservation Association: *http://www.sheepscot.org/gis_page.html*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Deb Bouchard


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Section 3 Components of a Marine Area Characterization

Overview

A marine area characterization is all about information. But exactly what information is needed to characterize a marine area? How should it be obtained?

During production of this guide, numerous specialists—biologists, ecologists, oceanographers, historians, social scientists, resource managers, and others (see page 2) — worked together to develop and hone recommendations through a series of workshops, group discussions and follow-up interviews. Few full-scale marine area characterizations have been conducted as of this writing, so precedents and best practices have not been established. In addition, scientists usually focus their research to answer specific questions about aspects of the marine ecosystem, not to broadly "characterize" a place. Therefore, the experts who developed the recommendations below started out by discussing what it means to characterize a marine area. Based on their own expertise and reports from existing characterizations, they considered and debated the kinds of information that would be needed for a thorough study. Ultimately, the experts' conclusions evolved into the types of information described in this section. They identified three broad categories of information needed to characterize a marine area: oceanographic/physiographic, biological, and human dimensions.

This section explains each component of a marine area characterization, why it is valuable, and how to get and use the information. Compiling these components for a particular bay, harbor, or other marine area can generate a body of scientifically meaningful information that facilitates resource management and future research.

This guide presents some methods for getting the information that are considered good and reliable, but they are not the only ones. More or less sophisticated methods might work just as well for the purposes of a particular characterization project. Some components and information-gathering methods need to be done

Oceanographic and Physiographic Components

- O1 Marine Area Boundaries, Major Geographic Features, and Habitats
- O2 Substrate Types
- O3 Seafloor Depth, Slope, Topography (Bathymetry)
- O4 Circulation and Currents
- O5 Tides, Tidal Currents
- O6 Winds
- O7 Sea Level
- O8 Vertical Profiles of Temperature, Salinity, and Density

Biological Components

- B1 Historical Perspective on Ecological Changes
- B2 Habitats
- B3 Plants and Animals
  - B3.1 Phytoplankton
  - B3.2 Macrophytes
  - B3.3 Invertebrates
  - B3.4 Fish
  - B3.5 Marine Birds
  - B3.6 Marine Mammals
  - B3.7 Sea Turtles

Human Dimensions Components

- H1 Human Population
- H2 Community Economic Profile
- H3 Land Ownership
- H4 Land Use and Land Cover
- H5 Fisheries and Fishing Industries (Commercial, Recreational, Aquaculture)
- H6 Maritime Transport and Navigation
- H7 Marine Research and Education Sites
- H8 Transportation Infrastructure
- H9 Manufacturing Sites
- H10 Natural Resource Use
- H11 Residential Development
- H12 Recreation (Individual, Commercial)
- H13 Public and Private Waterfront Use and Access
- H14 Protected/Conserved/High-value Natural Areas
- H15 Filled Areas and Reclaimed Land
- H16 Tidal Restrictions and Barriers to Fish Passage
- H17 Riparian Buffers
- H18 Habitat Restoration Project Sites
- H19 Significant Cultural Sites (Prehistoric, Historical, Current)
- H20 Point Source Pollution (Known or Potential)
- H21 Resource Management Framework for Shore and Water
- H22 Regulatory Framework for Shore and Water

by trained professionals, such as academic scientists or environmental consultants, while others are appropriate for non-experts such as community volunteers.

The information described in this section might seem daunting, but it represents the ideal for a thorough characterization. Many characterizations do not include all the components due to budgets, schedules, skills, and interests of the groups conducting the characterization. The comprehensive list presented here enables people to understand the framework for a full characterization and to make educated choices about which components they will pursue. A complete characterization could be pursued all at once or in phases over many years, as circumstances allow. Regardless, the framework outlined in this guide helps to ensure that the characterization will withstand scientific scrutiny and provide value for resource management.

Information Provided in This Section about Each Component

Why: Why is the component important? What can it tell you?
What: What information, data, maps, or other materials may be produced?
Sources of information: Where can one look for existing information?
Research and monitoring recommendations: What scientific fieldwork can be done to provide the information?
Community involvement: How can community volunteers and other non-experts go about collecting the information?

OCEANOGRAPHIC AND PHYSIOGRAPHIC COMPONENTS

O1 Marine Area Boundaries, Major Geographic Features, and Habitats

Why: The boundaries specify exactly the area under consideration, where data are needed during the characterization process, and where the findings apply when the characterization is complete. A description of the area's major geographic features and habitats provides context for all findings of the characterization. It offers a glimpse into what might be expected for the area in terms of ecological, physiographic, oceanographic, and human characteristics.

What: Boundaries of the marine area may be defined using many types of natural and political features, such as watersheds, headlands, or town borders (see Section 2). A description of major geographic features and habitats may address such questions as:

- Is the area along the coast? Does it include offshore waters? Or both?
- Are the waters estuarine, marine, or some of each?
- Does the area include only subtidal areas or intertidal acreage as well?
- Are intertidal areas rocky coast, sandy beach, or mudflat?
- Is the coastline relatively straight, or does it have bays, coves, or islands?
- If the area is coastal, how big is the adjoining watershed?
- Are cities, small towns, or rural areas along the coast?

Sources of information: See Appendix A, page 47.

Research and monitoring recommendations: New research or monitoring usually is not necessary because the information can be obtained from maps and other sources.

Community involvement: Community members can gather information. With some training, they can categorize the major habitats, if this work has not been done already in the past.

O2 Substrate Types (see also B2 Habitats)

Why: The types of sediment or rocks on the shoreline and seabed help determine the animals and plants that can live there. "Substrates" is a general term for sediments and rocks. Knowing the types of substrates and where they are located is important for classifying habitats. Information about substrates can be highly relevant for commercial activities and resource management. For example, young lobsters and urchins often hide in cobble-covered areas of seabed, and some commercially important fish species often are associated with particular substrates. Substrates influence where pipelines, cables, and other marine structures are installed. In addition, substrates differ in their vulnerability to human activities.


Natalie Springuel

What: Mud, sand, cobble, boulder, and other loose substrates are classified primarily based on grain size. Solid rock substrates can be characterized based on rock type, surface roughness, slope, orientation, and relief.

Sources of information: See Appendix A, page 47.

Research and monitoring recommendations: Analyze sediments for grain size, using grab samples, sieves, or other widely available methods. Underwater video, remotely operated vehicles, and sidescan or multibeam sonar can be used to identify and map substrate types and other geological characteristics of the seabed.

Community involvement: With training, community members can assist in this work.

O3 Seafloor Depth, Slope, Topography (Bathymetry)

Why: The depth and shape of the seabed strongly influence the way that water circulates. For example, water tends to circulate differently in a shallow, long bay than in a deep, broad bay. Accurate depth data are essential for oceanographic models of water circulation. In most coastal areas, existing depth data may be adequate for navigational charts, but not for modeling circulation. For example, a team of oceanographers at the University of Maine once created a circulation model based on chart data. When they later measured the depths themselves from boats, they found places where the chart was off by 30 meters (98 feet), rendering the oceanographic model extremely inaccurate. Depth is a factor in the presence, absence, and growth of kelp and other seaweeds because the amount of available sunlight decreases with depth. Pressure, temperature, and concentrations of dissolved oxygen, carbon dioxide, and particulate organic carbon also vary with depth. Areas of seabed that are smooth (low relief) have less variety of habitats than areas of underwater hills, mountains, cliffs, and crevices (high relief). Sediments are more likely to move on steeply sloped areas of the seabed than on flat areas. "Bathymetry" is the scientific term for seafloor topography, or the shape of the ocean bottom.

What: Oceanographers need accurate, high-resolution data on water depths to model the circulation of water. Measurements of the surface area and approximate volume of water in a bay are important parameters for oceanographic modeling. Depth data provide information about seabed relief and slope.

Sources of information: See Appendix A, page 49.

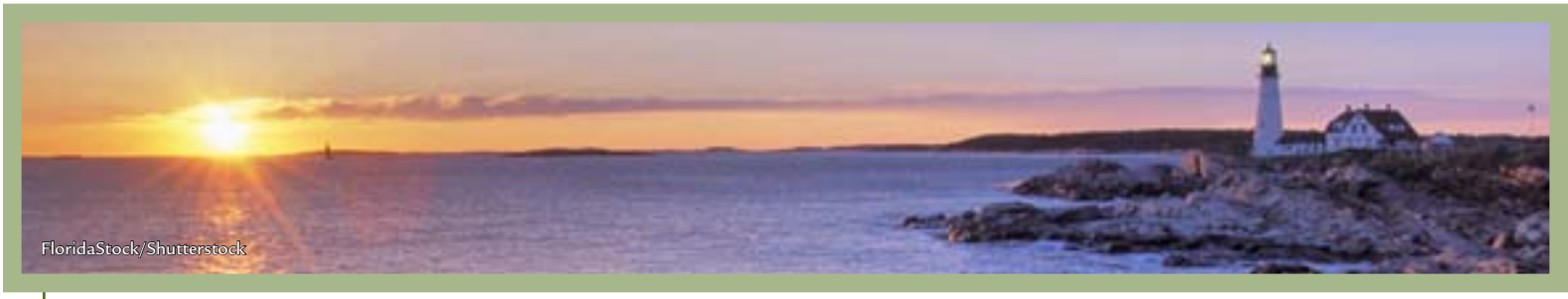
Research and monitoring recommendations: For many places, existing data on water depths is insufficient, and new bathymetric surveys will be needed as part of a complete marine area characterization. Ways of collecting the data range from old-fashioned soundings to electronic depth sounders to sophisticated sonar equipment.

Community involvement: Boaters with GPS and depth sounders can do a high-quality job of measuring water depths, if they plan and carry out their surveys carefully with advice from oceanographers or other scientists with relevant expertise. In Maine, a local, all-volunteer group did a hydrographic survey of a section of the Georges River estuary using this method, with a professional study design from a hired consultant.

O4 Circulation and Currents

Why: Circulation is the geography of the ocean. Just as mountains, rivers, and plains define a landscape, circulation patterns, such as currents, fronts, and upwelling of nutrient-rich water, define a marine area. Understanding circulation is critical because it influences nearly every aspect of a marine area. The movements of water affect temperature, species living there, nutrient levels, red tide, number of young lobsters and other animals joining their adult populations, and more. Without understanding circulation, it is impossible to understand a marine area.

What: An ideal outcome would be an accurate diagram—perhaps even an animated video—showing how water circulates in the marine area. It would show both the horizontal and vertical movements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of water, and changes that occur over the tidal cycle and seasons. Because the data or funding may not be available, however, a rough sketch or brief description might be the best practical outcome.

Sources of information: See Appendix A, page 49.

Research and monitoring recommendations: Because it is very complex, circulation can be very difficult and expensive to measure accurately. Oceanographers use tools such as drifters, moored sensors, satellite imagery, and mathematical models to understand circulation. Well-qualified physical oceanographers should be engaged in the characterization of circulation patterns to ensure accurate results.

Community involvement: Fishermen can help scientists deploy drifters and other oceanographic gear. Community members can conduct informal studies with less sophisticated gear—such as tracking oranges as they drift. While the results are not likely to be very accurate or useful in a scientific sense, they might provide some interesting clues and raise people's interest in the marine area.

Ocean Circulation

Most people who live and work along the coast know that seawater moves due to the tides, which rise and fall twice daily in the Gulf of Maine. They may not know that tidal flow is just one factor in ocean circulation. Some other factors that drive the strength and direction of circulation are (1) winds blowing across the ocean surface, (2) differences in density of water masses due to water temperature and salinity, and (3) shape of the seabed and coast. The combined effect is that ocean water moves in complex ways both horizontally and vertically offshore and along the coast. While tidal currents are often the most familiar and visible, other factors may have at least as big an effect on determining where and how fast ocean water moves. Oceanographers create complex computer models that show the movements of ocean circulation in a given area.

O5 Tides, Tidal Currents

Why: Tides are a major influence on circulation and biology along the coast. They are less important offshore. Tides help determine where species can live because low tides expose areas of the shoreline and seabed; animals and plants living there must tolerate extremes in temperatures and dryness. Tides affect the salinity and temperature of coastal waters, which in turn affect species living there.

What: Tidal range (height difference between high and low tide). Measurements and maps of tidal currents. Maps and/or aerial photography showing area at high and low tides.

Sources of information: See Appendix A, page 51.

Research and monitoring recommendations: Use tide gauges to measure tidal heights and current meters to measure tidal current speeds. Measure for a minimum of 28 days to cover a complete monthly cycle.

Community involvement: With training, community members could assist with tide measurements.

O6 Winds

Why: Wind is a driving force behind ocean circulation and surface waves. Winds blowing across the water cause horizontal and vertical water movement. Wind and the resulting waves can mix the water and can affect the seafloor, causing sand waves or scouring an area of sediment. Oceanographers need local measurements of wind speed and direction to create models of circulation. Along the coast, winds can vary greatly because of blockage or funneling of wind by hills and other land features. Although wind data is available from sources such as airports and the National Weather Service, those data are not localized enough to be useful for circulation models (unless the airport or weather station is located at the marine area).

What: Measurements of wind speed and direction.

Sources of information: See Appendix A, page 52.

Research and monitoring recommendations: Wind measurements are some of the easiest data to collect. Automated wind sensors should be placed in multiple locations within the marine area. They should be located on docks or buoys, not on land, because the goal is to measure the winds blowing across the water surface. They should not be located on shore next to hills, valleys, or other features that block or funnel the winds hitting the sensor. Characterize the orientation of the bay or other marine area in relation to wind directions.

Community involvement: Community members, such as coastal property owners with docks, could set up and maintain wind sensors.


Natalie Springuel

O7 Sea Level

Why: Although people generally think of sea level as being constant from place to place, it actually varies due to factors such as wind forcing and circulation patterns. For example, sea level can vary imperceptibly even between one end of a bay and the other or between inside and outside the bay. These tiny differences in sea level provide major clues to oceanographers about circulation patterns. Sea level is also expected to rise significantly over the next century. Taking measurements now provides a baseline for observing the change.

What: Measurements of sea level at multiple places in the marine area.

Sources of information: See Appendix A, page 52. Local data are not likely to be available unless the area has been studied by meteorologists or physical oceanographers.

Research and monitoring recommendations: Qualified scientists should measure sea level at multiple places in the marine area. If the area is a bay or other coastal indent, measurements should be taken in the main channel and at the head of the bay, not along the shore or in small coves.

Community involvement: Because fine-scale sea-level measurements are technically challenging and require specialized equipment, community members are not generally able to perform them.

O8 Vertical Profiles of Temperature, Salinity, and Density

Why: Measurements of temperature, salinity, and density of seawater are critical parameters for understanding the oceanography and biology of a marine area. At any given place in the ocean, these parameters vary with depth, and they vary horizontally from place to place. The variations may seem extremely slight on the scale of a bay or gulf, but they are important to marine life and actually help to drive the movement of ocean circulation. Temperature and salinity affect the density of seawater, such that cold, saline water is denser than warmer, less saline water, and it naturally wants to sink beneath it. This explains why scuba divers often notice that the water suddenly gets colder at a particular depth; the warmer, less dense water is on top of the colder, denser water. Similarly, freshwater flowing out of a river mouth often "floats" on top of saltier water in an estuary because it is less dense.

What: Measurements of water temperature, salinity, and density at multiple depths at multiple sites within the study area.

Sources of information: See Appendix A, page 52. Local data are not likely to be available unless the area has been studied by physical oceanographers.

Research and monitoring recommendations: Taking measurements from boats along the same transects at regular time periods is preferable to sampling at random sites and times. Consistency of sampling locations and time of day is one of the most important considerations.

Community involvement: With guidance and a sampling plan provided by qualified scientists, volunteer boaters can assist with taking the measurements. Volunteers can also sample temperature from docks, preferably at a designated time of day.

BIOLOGICAL COMPONENTS

B1 Historical Perspective on Ecological Changes

Why: An overview of past conditions and changes can provide insight into present-day circumstances. Having a timeline also provides context for the "snapshot" provided by new biological surveys. Many ecological changes occur over hours, days, months, years, or centuries. Although historical conditions could be described for each component, an integrated overview of all components may provide a better sense of a place's history and factors that shape its ecology.

What: Key elements of an area's ecological history are losses or declines of species (such as urchins, salmon, puffins); frequency of harmful algal blooms (red tide); habitat changes and degradation, such as loss of salt marsh and eelgrass beds; invasions by non-native species; and eutrophication events (large algal blooms leading to severe declines in dissolved oxygen in the water).

Sources of information: See Appendix A, page 53. Integrate historical information obtained for other biological components.

Research and monitoring recommendations: Interviews with local residents or others with firsthand knowledge about the area can provide useful anecdotes about past conditions. It is best to interview more than one person about the same event and then, where possible, to collect additional information from written accounts, documents, photos, maps, or other illustrations. In this way the key elements of the event become evident.

Community involvement: Citizens can find specimen collections, documents, images, maps, and data at government agencies, universities, libraries, and research field stations.

B2 Habitats

Why: Information about habitats is essential for characterizing a marine area because habitats help to determine which species and ecological processes occur in the area. On a practical level, understanding the types, extent, and locations of habitats can help to guide many other aspects of a characterization project. For example, habitat maps can indicate which methods for counting animal and plant species would be most appropriate and how much effort will be needed for sampling different ecological communities. Habitat maps also make it possible to identify changes over time, such as shifts in the size and locations of seagrass beds, when compared to earlier or subsequent maps.

What: Ideally, the product should be a map of habitats on the seabed and shoreline of the marine area. The habitat types should be defined as sandy, muddy, and rocky, and finer distinctions can be made based on sediment grain size or rock type (e.g., gravel, cobble, boulder, outcrop). In addition, the habitat maps should show the size and density of seagrass, kelp, rockweed, mussel, and oyster beds and salt marshes because these features provide habitat for many fish and other species. Another key habitat factor, especially along the shoreline, is exposure or shelter from waves because this determines the plants and animals that can live at the site. For example, sheltered rocky shores often host huge beds of rockweed, but mussels dominate on exposed rocky shores. Along with categorizing seabed and shoreline habitats, areas of water can be categorized into different habitats based on salinity, temperature, nutrients, depth, and other factors that affect sea life.

Sources of information: See Appendix A, page 55.

Research and monitoring recommendations: To map shoreline (intertidal) habitats, researchers use rapid surveys, spot checks, and aerial imagery. For seabed (subtidal) habitats, they lower devices from boats to grab samples of sediment from the seabed or to bring up sediment cores, much like using an apple corer. When they take the samples, they mark the site using a global positioning system (GPS) so that they can later show on a map what sediment types can be found at each collection site. Placed together on a map, these samples provide a picture of the sea bottom's composition. Researchers also use aerial photographs (primarily in shallow water) and equipment using sound waves (acoustic technologies such as multibeam, sidescan, and single-beam sonar) to produce visual images showing where different substrates or habitat types are located. Scuba diving, underwater video, and sediment samples are used with these photographic and acoustic techniques to "ground-truth" the images. These techniques enable researchers to identify, classify, and map the habitat types.

Community involvement: Citizens can acquire data from NOAA or state agencies. They can also participate in field research under the guidance of scientists.

Examples of Habitat Types in the Gulf of Maine

Salt marsh
Seagrass bed
Kelp and rockweed bed
Shellfish bed
Muddy bottom
Sandy bottom
Rocky bottom
Water column

Consult the *Gulf of Maine Marine Habitat Primer*, published by the Gulf of Maine Council on the Marine Environment *(www.gulfofmaine.org/habitatprimer)*, for more information.

B3 Plants and Animals

This information component is made up of seven subcomponents.

B3.1 Phytoplankton Microscopic organisms that drift in the water and live off photosynthesis.

B3.2 Macrophytes Includes seaweeds (e.g., kelp, rockweed, Irish moss) and aquatic flowering plants (e.g., seagrasses, salt marsh grasses).

B3.3 Invertebrates Includes a wide range of species from crabs, lobsters, clams, urchins, and mussels to tiny zooplankton and jellies that drift in the water.

B3.4 Fish

B3.5 Marine birds

B3.6 Marine mammals

B3.7 Sea turtles

Baseline Information

For each subcomponent of B3 Plants and Animals, the following baseline information should be collected.

- How many species are there and what are they (*species composition*)?
- How many animals or plants are there of each species? This can be expressed as the number of individuals of each species (*species abundance*). However, often it is more useful to express it as the number of individuals in a given area (*species density*), such as clams per square meter. For species that live attached to rocks or sediment but are difficult to count because they are so numerous, such as barnacles, mussels, seaweeds, and salt marsh plants, scientists often measure abundance as *percent cover*, instead of counting individuals. For example, mussels might cover 15 percent of a rocky shore, barnacles 20 percent, and rockweed 40 percent.
- What is the relative abundance of each species compared to other species (*species proportional abundance*)?
- Are *indicator species* present? These are particular species that reflect noteworthy ecological conditions. For example, if certain plants are present in a salt marsh, it indicates that the site is transforming to a freshwater marsh, perhaps due to restricted tidal flooding from undersized culverts under road crossings.

Identifying the species of some plants and animals is extraordinarily difficult, especially for groups of species that look very similar. If lack of expertise, time, or resources makes species identification impractical, an alternative is to identify the plants and animals to the lowest taxonomic level that is reasonable such as class, order, or genus.

At first, getting a handle on species abundance might seem relatively easy—just go out and count the birds, plants, or shellfish. However, animals and plants can vary greatly in their numbers over time and space. One month, barnacles might be scarce on the rocky shore; then a huge influx of young barnacles might settle on the rocks; and a few months later half of the young barnacles might have been eaten by whelks. Similarly, one rocky headland might be totally covered in barnacles, while a nearby cove has few barnacles. For fish, birds, lobsters, and other mobile creatures, numbers can vary in a given place with their daily travels or seasonal migrations. As any birdwatcher knows, the number and species of birds at a salt marsh varies tremendously with time of day, tides, seasons, weather, and other factors.

For all of these reasons, accurately determining the abundance of any species in a marine area is more complicated than it might seem, even if the goal is just to get a baseline snapshot and not long-term trends. As a result, the sampling program should be designed by trained scientists and followed carefully, if the goal is to produce scientifically defensible, meaningful estimates of species abundance. A good sampling program will take into account the variability over time and space in order to produce a good count of individuals.

Are crabs becoming more or less abundant? Is the diversity of seaweeds changing? Is an invasive plant or invertebrate gradually taking over the seabed—or is it staying at harmless levels? Understanding long-term trends like these is even more challenging than getting a snapshot in time. One or two years of data collection is not enough to understand such trends. A marine area characterization project is likely to be a relatively short-term effort, spanning months or a couple of years, making it appropriate for getting a snapshot

but not for characterizing long-term trends. However, comparison with historical data (if available) or re-sampling periodically after the initial characterization can help to identify trends.

B3.1 Phytoplankton

Why: Phytoplankton are microscopic organisms that drift in the water and live off photosynthesis. They are eaten by many animals and form the basis of the marine food web. Abundance of this important food source helps to determine the number of fish, shellfish, and other animals. Because phytoplankton have short life spans, they can serve as a useful indicator of shifts in the ecosystem. "Red tide" and other harmful algal blooms are caused by toxic species of phytoplankton, making phytoplankton an important consideration for human health. Phytoplankton can become overwhelmingly abundant in waters that suffer from over-productivity, or eutrophication, due to excessive nutrients from such sources as sewage effluent, lawn fertilizers, manure washed from fields, and other land-based sources. Decomposition of the abundant phytoplankton can lead to shortages of dissolved oxygen in the water, leading to fish kills and dead zones.

What: In addition to the baseline information listed above under B3 Plants and Animals, characterization studies should consider the following topics for phytoplankton.

1. *Pigment measurements.* The amount of chlorophyll *a* or certain other pigments in seawater provides a measure of how much phytoplankton is present. Repeated, ongoing monitoring can show how the amount changes between sites, seasons, and oceanographic conditions.

2. *Eutrophication events.* How often does eutrophication occur in the marine area? What are the ecological impacts of those events?

3. *Harmful algal blooms.* Is the area a hotspot for red tide? Are cysts of *Alexandrium* phytoplankton, which cause red tide, present on the seabed?

Sources of information: See Appendix A, page 59.

Research and monitoring recommendations: The following are some recommended methods for collecting new data.

- Measuring the amount of chlorophyll *a* in water samples provides information on total density of phytoplankton.
- Phytoplankton can be collected with fine nets and then identified and counted. The size of the net's mesh and the number of samples taken over time must be determined based on what scientific questions are being asked and the person's expertise.
- Plankton tows can reveal where phytoplankton species live in relation to different habitats. The surveys must be designed appropriately to take into account ocean currents, temperature gradients, and water masses.

Community involvement: Some government programs, such as the Maine Phytoplankton Monitoring Program, offer training for people who want to collect phytoplankton samples. Analysis of the samples needs to be done by experts. Citizens can gather historical data and information on phytoplankton in the marine area.

B3.2 Macrophytes

Why: Kelp, eelgrass, rockweed, and salt marsh grasses are examples of macrophytes, which translates roughly as "large plants" and includes all ocean-dwelling plants and algae larger than phytoplankton. Macrophytes live primarily in coastal waters that are shallow enough to allow sunlight to reach them on the seabed. The plants and algae may live entirely underwater, like kelp, or partially exposed, like salt marsh grasses at low tide. Certain species, such as Irish moss and rockweed, are harvested commercially. Because they are large and often grow in beds that resemble underwater forests, macrophytes form vital habitats where other animals and plants live and take cover from predators. Many animals eat macrophytes, making them an important food source. Therefore, increases or decreases in macrophytes can affect other species. Macrophytes are sensitive to environmental changes, so they can signal the overall condition of the ecosystem. For example, a big patch of *Enteromorpha* seaweed indicates that nutrient levels in the water are high. Macrophytes can

signal ecological impacts from climate shifts, pollution, coastal development, ice scouring, harvesting, and other human and natural causes. In addition, they indicate changes in the animals that are associated with macrophyte habitats. For example, when sea urchins become numerous, they often obliterate kelp beds, eating the kelp like lawn mowers. The loss of kelp causes animals dependent on kelp beds to become less numerous.

What: In addition to the baseline information listed above under B3 Plants and Animals, characterization studies should consider the following topics.

- *Invasive species.* Presence or absence of non-native, invasive macrophyte species such as *Codium fragile*. Invaders can quickly take over an area, harming native macrophytes, fish, and shellfish.
- *Changes in dominance.* Monitoring changes in macrophyte dominance can reveal important changes, such as increases in sediments that block the light or waterborne nutrients coming from land-based activities.

Sources of information: See Appendix A, page 60.

Research and monitoring recommendations:
Recommended methods for a baseline characterization include:

- analysis of aerial imagery (e.g., aerial photos of eelgrass and seaweed beds),
- on-the-ground mapping of where macrophyte species live in the marine area,
- surveys of macrophyte abundance using transects (lines across parts of the marine area) and quadrats (squares, often one square meter), and
- photographs showing changes in macrophytes over time.

Using these methods may involve scuba diving, remote sensing from satellites, underwater video, intertidal surveys, and other techniques in subtidal and intertidal areas. It may be possible to use existing protocols that have been developed and refined by the Boston Harbor Islands Intertidal Inventory, Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), and other groups.


Capt. Albert E. Theberge/NOAA Corps

B3.3 Invertebrates

Why: Lobsters, crabs, clams, urchins, and mussels often dominate in habitats of the Gulf of Maine and play key roles in the ecosystem. Some invertebrates live for many years in the same place. These qualities make them potentially useful as indicators of changes in the marine ecosystem. Declines or increases in these indicator species may reflect the overall condition of the ecological community, localized changes in climate, and habitat changes, such as warming waters or toxic contaminants. The high commercial value of species such as lobsters, crabs, and clams is another reason why they are essential to include in a marine area characterization. At the same time, non-native (or invasive) invertebrates present a grave threat because they can quickly invade and dramatically alter habitats and ecosystems. Many non-native invertebrates already are present in the Gulf of Maine, such as the European green crab, shipworms, Asian shore crab, and many tunicate species.

What: In addition to the baseline information listed above under B3 Plants and Animals, characterization studies should consider the following topic.

- *Vertical zonation.* Different species of barnacles, mussels, other invertebrates, and algae live at particular heights on rocky shores. Certain species tend to dominate at each height. The result is vertical zonation of species on the rocky shore. Although the same species live along much of the Gulf of Maine coast, the heights and widths of the species bands or zones on the rocks vary from place to place depending on tidal range, exposure to waves, and other factors. Mapping the heights where different species live on the rocky shore is useful information to collect as part of a marine area characterization.

Sources of information: See Appendix A, page 61.

Research and monitoring recommendations: For data collection, techniques differ between the intertidal (between the high and low tide marks) and subtidal (below low tide mark) zones.

Methods for the intertidal zone:

- Obtain any available information from previous research about rare species, invasive species, abundant and dominant species, and other species of management interest. Consider doing new sampling in the same locations in order to see changes that may have occurred.
- Devices called grabs and cores can be used to obtain samples of sand or mud for counting the invertebrates that live in the sediment. Sampling at several times throughout the year reveals seasonal shifts.
- On rocky shores, scientists commonly use quadrats or transects for surveying invertebrates. A quadrat is a square, often made from pieces of rigid plastic pipe, that is placed on the rocks. Scientists count the species living within the square or estimate the percentage of the square covered by each species. Transects are lines laid out along the rocks, and the scientists count species along the line. Some invertebrates, especially smaller species, may need to be collected and taken to a laboratory for identification. Quadrats and transects can be photographed and species coverage measured from the photographs.

Methods for the subtidal zone:

- Conduct surveys in shallow and deep waters. Methods will vary with depth.
- In addition to grabs and cores (see above) lowered from a boat, subtidal surveys can use video, photography, scuba diving, and remotely operated vehicles.
- For crabs, lobsters, and other small, mobile invertebrates, scientists sometimes use suction devices that suck up the animals for counting.

Methods for invertebrates living in the water:

- Tow nets to collect zooplankton.

Community involvement: Community involvement is more feasible for intertidal (shoreline) surveys than for subtidal (underwater) surveys because of the special skills needed for surveying the underwater environment. Local marine resource committees and shellfish harvesters are invaluable sources of information. With training, citizens can identify a few key species as part of a survey, although experts are needed for a complete survey.

B3.4 Fish

Why: Many people are interested in fish—fishermen, seafood lovers, naturalists, and just about anyone with an interest in the sea—and fish are widely viewed as important inhabitants of the ocean. Fish are well known and understood, and the public is more likely to be engaged in information about fish than about the many obscure creatures that live in the sea. Fish serve as indicators of water pollution, habitat loss and degradation, and climate change. Information about commercially and recreationally harvested species is important from a socioeconomic perspective, and it also provides an indicator of human impacts on the ecosystem.

What: In addition to the baseline information listed above under B3 Plants and Animals, characterization studies should consider the following topics.

- *Descriptive list.* Compile a descriptive list of fish species found in each habitat of the marine area, such as sandy, muddy, or cobble bottom. Indicate which species are full-time residents or seasonal visitors. Highlight rare species, any species that are commercially or recreationally harvested, diadromous species (salmon, eels, smelt), and species that serve as important forage fish for other species (such as menhaden, alewives, herring).
- *Fish abundance.* Use towed nets, seines, hook and line, and other methods to determine abundance of fish. Scientists often discuss fish abundance in terms of how many fish were caught using a particular method during a given period of time, which is called catch per unit effort. Record length, weight, and age class of the fish, along with general health such as presence of lesions or malformities that could indicate water pollution. Keep track of which habitat the fish were in.


Chris Bartlett

Repeat fish sampling at various times during the year to see seasonal shifts.

- *Nurseries and spawning areas.* Some fish species tend to spend their early lives in particular habitats, such as eelgrass beds, and adult fish may congregate year after year in certain places to mate. Identify and map any nursery habitats and spawning areas in the marine area that is being characterized.

Sources of information: See Appendix A, page 63.

Research and monitoring recommendations: Sampling throughout the seasons can provide key information about fish species and abundance.

Methods:

- Snorkeling or scuba diving, trapping, and hook and line are used to survey intertidal and subtidal habitats ranging from mud and sand to cobble and rocky outcrop.
- At beaches and marshes, seines can be useful.
- For subtidal surveys, beam trawls, otter trawls, gill nets, video, and remotely operated vehicles are other possible methods.
- In intertidal and shallow subtidal areas, fish sampling typically begins in late April or May and continues through November, although year-round sampling may be possible. Deeper, ice-free areas can be surveyed in the colder months.

Community involvement: With training, it may be possible for community members to participate in fish surveys under the supervision of a professional scientist. Fishermen routinely contribute to and participate in fisheries research conducted by state and federal agencies, universities, and private research organizations, such as the Gulf of Maine Research Institute.

B3.5 Marine Birds

Why: Some marine and estuarine areas provide critical habitat for birds. Salt marshes and mudflats along shorebird migration routes can serve as vital feeding and resting places for long-distance migrants. Imperiled species such as piping plovers may feed along beaches or other habitats in the marine area being characterized. Some birds can have a big impact on the ecology of a marine area by feeding on mudflat invertebrates or other creatures, which makes it important to document the birds' presence and abundance. Marine birds can serve as indicators of ecosystem health by signaling changes in prey availability, levels of environmental toxins, and other habitat impacts.

What: In addition to the baseline information listed above under B3 Plants and Animals, characterization studies should consider the following topics.

- *Breeding birds.* Note presence or absence.
- *Migratory birds.* Note usage as a feeding or resting stop for migratory birds.
- *Rare species.* Presence or absence. Existing information is often available.
- *Restored populations.* Were birds such as puffins brought back to the site after disappearing in the past?
- *Critical bird habitats.* Do birds use the area for feeding, nesting, aggregation, or rookeries?
- *Toxin levels.* Measuring toxin levels in bird tissues can indicate the presence of contaminants in the environment. Because some birds are predators at the top of the food web, they tend to accumulate toxins.

Sources of information: Much information is readily available. See Appendix A, page 65.

Research and monitoring recommendations: Scientists use many different methods to count birds in estuarine and marine habitats. Using standardized methods allows accurate comparisons over time and among different places. For example, they may count the birds seen in a given area of salt marsh in a half-hour period. They sometimes use nets to capture and count groups of shorebirds, which then are released. They use call-and-response methods to count hard-to-see species,

such as rails and bitterns. For offshore birds, scientists conduct surveys from boats.

Schedule bird counts to occur at seasonal times of the greatest numbers of birds and best visibility. The seasonal timing depends on whether the birds are breeding, migrating, or wintering in the habitat.

Community involvement: Many amateur birdwatchers are highly skilled at identifying coastal and marine birds. When trained in scientific survey methods, they can play a major role in surveying bird populations as part of a marine area characterization.

B3.6 Marine Mammals

Why: Marine mammals in the Gulf of Maine include seals, whales, dolphins, and porpoises. Some species have favorite places for feeding, breeding, or resting. They can strongly affect the abundance of their prey. At large geographic scales, marine mammals can serve as indicators of ecosystem health by signaling changes in prey availability, levels of environmental toxins, and other habitat impacts in the ocean.

What: In addition to the baseline information listed above under B3 Plants and Animals, characterization studies should consider the following topics.

- Seasonal presence and absence of species.
- Important habitats such as seal haul-outs, feeding, and breeding areas.

Sources of information: Much information is readily available. See Appendix A, page 66.

Research and monitoring recommendations: Scientists conduct marine mammal surveys from aircraft and boats. They also count seals at rookery sites.

Community involvement: Community members can provide information about seal haul-outs and rookeries. With training, they can participate in surveys under the direction of professional scientists by counting, monitoring, and identifying species.

B3.7 Sea Turtles

Why: Sea turtles are not common in the Gulf of Maine, but many laypeople and scientists are interested in them. They are long-lived, poorly understood, and charismatic animals. Regular use of an area by sea turtles would be especially noteworthy.

What: Presence/absence over time, including when and where animals have been seen, their species, size, and other identifying features.

Sources of information: See Appendix A, page 66.

Research and monitoring recommendations: Because sea turtles are so rare in the Gulf of Maine, it is not recommended that sea turtle research be conducted as part of a marine area characterization. Existing information about sightings should be used instead.

Community involvement: Community members could gather existing information about sea turtle sightings, such as by talking with local fishermen and contacting sea turtle rescue organizations.

HUMAN DIMENSIONS COMPONENTS

Why: The components in this section describe human uses and activities. Together, the components characterize the types, extent, and degree of impact people may be having on a marine area. The components also highlight the ways in which resource managers try to limit negative effects of human use. These components provide insight into the causes of certain past, present, and even future environmental conditions.

Much of the information about these components is easily obtained, but the question of how the information should be used to characterize a marine area is an active area of research. Increasingly, it is being realized that social sciences should play a bigger role in coastal and marine management. Experts at the National Oceanic and Atmospheric Administration (NOAA), other state and federal agencies, non-government organizations, and academic institutions are working to identify ways of using socioeconomic data and other information from the social sciences to understand the human dimensions of the ocean and coast. This field is relatively new, the practices for characterizing human dimensions are evolving rapidly, and the methods of analysis are not yet firmly established like the methods for characterizing biological and oceanographic components. Therefore, this guide presents only a brief listing of human dimensions components that specialists


Michael Gaffney /iStock

recommended should be considered as part of a marine area characterization. This guide does not attempt to define specific methods for studying these components. Future editions of the guide will seek to provide updated and more extensive information about how to characterize human dimensions of a marine area, including the latest recommendations from specialists in the field.

Some of the human dimensions, such as fishing and boating, are associated directly with the marine environment. Other components, such as residential development and land conservation, are not directly associated but are important because of the many linkages between land and sea. For example, freshwater that flows from land into the sea may contain contaminants. The amount of contamination is affected by land development and agriculture in the watershed. Fertilizers, pesticides, petroleum products, industrial waste, and other contaminants are common in developed areas. These substances are carried into the ocean by runoff of fresh water from the land. The amount of runoff increases in paved, developed, and disturbed areas of land.

Not all of the human dimensions listed in this section are relevant to every marine area. A particular human use or activity, such as port facilities or seabed mining, may not occur in the study area. A characterization of a deep, offshore area would not include the components related to land-based human activities.

What: Information for these components might be presented best as a set of maps, descriptions, illustrations, and data tables. Collecting information for Human Dimensions tends to be more straightforward than for Biological Components or Oceanographic and Physiographic Components, requiring little or no scientific expertise. For example, knowing how many birds live in a given salt marsh requires a field study using scientifically valid methods. But knowing how many people live in the adjacent town only requires looking at a government census, which is readily available. Similarly, mapping the topography and habitats of the seabed is usually a scientific and technical challenge, but one can obtain information about roads, fish landings, aquaculture leases, and other human dimensions without conducting any scientific studies. Accurate or defensible interpretation of the data, however, requires input from various experts—economists, historians, anthropologists, sociologists, community development professionals, and others.

Sources of information: Appendix A provides sources of information for each component. Most of the information for Human Dimensions can be obtained from existing sources.

Community involvement: Often laypeople can obtain this information readily. Experts should be consulted about appropriate use and interpretation of the information. For example, correlations that one discovers between human activities and changes observed in the marine environment do not necessarily mean that the human activities caused the marine changes.

H1 Human Population

Describe the number of people living along the coast next to the marine area, the people per square mile or town, demographics, and notable trends in population and demographics over time (seasonal and long-term).

H2 Community Economic Profile

Describe the types of businesses, industries, incomes, and occupations present in the area. Note relative composition, as well as current or anticipated changes.

H3 Land Ownership

Describe who owns or controls land parcels on the mainland and islands around the marine area. Include publicly owned lands, as well as private residential, commercial, nonproft, or industrial ownership.

H4 Land Use and Land Cover

Describe how land around the marine area is used. What kinds of vegetated or unvegetated areas cover the landscape and in what patterns or proportions, e.g., urban areas, residential or commercial development, working forests, blueberry barrens, hayfields, pavement.

H5 Fisheries and Fishing Industries (Commercial, Recreational, Aquaculture)

Describe the species harvested from the area, the amount caught and/or landed in the area, the location and type of fish buyers, dealers, services, and suppliers. What harbors are most active and which have transitioned

away from fishing? Where are the major fishing grounds for different species and what gear is used to catch fish in these areas? What offshore grounds do local fishermen frequent? How have the local fisheries declined or grown over the years? Are there closures that prevent fishing in certain areas? How are shellfish harvests affected by pollution closures? Where are the aquaculture lease sites, and which are temporary and which are longstanding? Where are the passages or harvest stations for migratory fishes? Have some fisheries been lost or abandoned due to changes in practices, significant events, or regulations?

H6 Maritime Transport and Navigation

Describe the types and locations of facilities, routes, and activities that support travel by sea. What port facilities, channels, navigational aids, ferry terminals, shipbuilding and servicing operations, dredging, ferry, or deep-draft vessel routes exist in the marine area?

H7 Marine Research and Education Sites

Describe the scientific and educational activities that occur in the area. Are there ongoing or longterm studies, periodic surveys, monitoring stations, laboratories, or other notable sites? Are there summer camps, outdoor expedition routes, nature interpretation centers? What features or functions of the marine area are being studied or used in learning, e.g., lobsters, fishes, seabirds, tide pools, beaches, horseshoe crabs, coastal forests, red tide, phytoplankton, water quality, urchins, climate, island use.

H8 Transportation Infrastructure

Describe the features that support travel across land in the coastal portion of the marine area. Include features such as roads, railways, airstrips, commuter lots, bridges, causeways, dams, dredged channels, culverts, and catch basins.

H9 Manufacturing Sites

Describe the location and type of facilities currently or historically engaged in the manufacturing of raw or processed goods, such as metalworking, furniture, textiles, toys, paper, paint, shoes, electronics, food processors, fish processing plants, and boatbuilding.

H10 Natural Resource Use

Describe the location, intensity, and types of commercial and/or recreational resource use, other than fishing (see H5 on page 45) that occur on land, on the water, or on the seabed in the marine area. Include activities such as hunting, trapping, snowmobiling, logging, agriculture (plant and/or animal), mining, hydropower dams, cell towers, wind farms (on shore or offshore), cables and pipelines (on land or seabed).

H11 Residential Development

In addition to land cover, describe in greater detail the type of development, acreage, distribution, and percentage of land covered with pavement and other impervious surfaces associated with residential life in the marine area. (Determining impervious surface requires expert analysis.) Describe trends in and patterns of development in the area or specific portions of it.

H12 Recreation (Individual, Commercial)

Describe locations commonly used for, or which support, leisurely pursuits such as swimming, sailing, kayaking, canoeing, nature watching, hiking, and swimming. Include areas for individual recreation, as well as those used for organized or commercial activities, such as whale watches, boat cruises, historic tours, and races.


Jeff Schultes/Shutterstock

H13 Public and Private Waterfront Use and Access

Describe the location, use, and ownership of sites and facilities that enable residents and visitors to access the water for recreational and commercial pursuits. Include public and privately owned, commercial, and noncommercial boat launches, ramps, landings, footpaths, moorings, docks, landings, piers, breakwaters, wharves, and marinas. Note limitations in use due to ownership, parking restrictions, tides, safety, and fees.

H14 Protected/Conserved/High-value Natural Areas

Describe the location and nature of marine and terrestrial places which are legally protected from certain types of human use or development. Include local, state or federal parks, reserves, and sanctuaries, as well as lands under conservation easements. Note their level of protection and management, as well as which areas are available for public use and which are not.

H15 Filled Areas and Reclaimed Land

Describe the location and nature of any places in the marine area which have been converted to enable new kinds of uses, such as former salt marsh areas converted to upland, land areas created by filling shallow coastal waters, dredged channels, and armored beaches.

H16 Tidal Restrictions and Barriers to Fish Passage

Describe the location, size, type, and impact (if known) of any man-made or natural structures that impede the natural flow of water or the migration of fishes between marine and freshwater areas. Include features such as road culverts, dams, bridges, berms, causeways, and dikes.

H17 Riparian Buffers

Describe the locations, species composition, and widths of vegetated areas along the shore or the marine area and its estuaries.

H18 Habitat Restoration Project Sites

Describe and locate areas that are the subject of habitat restoration efforts, such as removal of dams and tidal restrictions, replanting of eelgrass beds and salt marshes, removal of fill, and planting or enhancement of riparian buffers.

H19 Significant Cultural Sites (Prehistoric, Historical, Current)

Describe and locate known sites used by Native Americans, early European settlers, recent immigrants, or other distinct populations. Include sites listed on the National Register of Historic Places, local cemeteries, distinct neighborhoods or villages, state historic parks, and other recognized or managed cultural sites. Also include museums, historic societies, granges, lodges, community clubs, and other gathering places. Note churches, schools, and government buildings central to daily life.

H20 Point Source Pollution (Known or Potential)

Describe and locate sites and sources of toxic spills, threats, remediation sites, storage tanks, air emission facilities, thermal discharges, water discharges, sewage treatment facilities, overboard discharge sites, and pump-out stations.

H21 Resource Management Framework for Shore and Water

Other than protected areas (H14), describe the ways and locate the places where local, state, and federal authorities manage human uses. Include techniques and approaches applied on land or water such as zoning, closed areas, input or output controls, gear or equipment restrictions, harvest limits, closed seasons, and wildlife designations.

H22 Regulatory Framework for Shore and Water

Describe the specific federal, state, and local laws, rules, executive orders, ordinances, and regulations that govern human use of the natural environment in the study area. Note the government bodies responsible for administering the laws and rules.

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Appendix A Maine Information Sources

This Appendix lists some of the many useful Web sites, documents, maps, GIS layers, and other references. Not listed here are all the local, state, county, and federal agencies, universities, businesses, and nonprofit organizations that are rich sources of information on these topics. More information sources may be found on their Web sites, along with contact information for individuals who may be able to help with specific questions.

Oceanographic and Physiographic Components

O1 Marine Area Boundaries, Major Geographic Features, and Habitats

Watersheds

Maine Office of GIS map layer for wetlands, lakes, rivers and streams (WTRSHD).

Go to: *apollo.ogis.state.me.us/catalog/*

Surf Your Watershed. Environmental Protection Agency.

Go to: *cfpub.epa.gov/surf/state.cfm?statepostal=ME*

Watershed Profiles, Maine Rivers.

Go to: *www.mainerivers.org/water_profiles.html*

Description: This site provides a map of Maine's watersheds. Click on the desired watershed to find out facts about the watershed, including the rivers it contains and the organizations that are working to protect that watershed.

Wetlands

Maine Office of GIS interactive wetlands mapping site.

Go to: *megisims.state.me.us/Website/spowetc/viewer.htm*

Description: "The Maine Wetlands Characterization is designed as a planning tool to use when looking at wetlands in a landscape context. The Characterization sorts wetlands based upon their capacity to provide six specific functions at a significant level. As you zoom in on this map, more data will become visible. Once the wetlands appear color coded for the characterization functions they provide, you can turn on the wetland label layer which will assign a number to each wetland. This number will also appear in the table that corresponds with the Wetlands Characterization."

Reports and references on Maine's wetlands, U.S. Fish and Wildlife Service.

Go to: *northeast.fws.gov/wetlands/*

Description: Click on Maine under the My State menu.

Wetland Mapper, National Wetlands Inventory.

Go to: *wetlandsfws.er.usgs.gov/wtlnds/launch.html*

Geologic Features

Online maps, digital data, and geological bibliography, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/mgs.htm*

Description: Among the maps and data available are beach and dune geology (aerial photos), bedrock geology maps, bedrock groundwater resources maps, bluff maps, coastal landslide hazards maps, earthquakes, lakes, significant sand and gravel aquifers maps, surficial geology maps, surficial geology of the Maine inner continental shelf maps, and surficial materials maps.

O2 Substrate types (see also B2 Habitats)

Beach and dune geology aerial photographs, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/pubs/series/descrip-dunes.htm*

Description: "These color photos provide detailed information about Maine's largest beaches and dune systems. The photos show frontal dunes, back dunes, and other geologic environments conforming to the Department of Environmental Protection's 2004 Coastal Sand Dune Rules."

Coastal bluff maps, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/pubs/online/bluffs/bluffs.htm*

Description: "Coastal Bluffs Maps show the shoreline type and relative stability of bluffs along the Maine coast. The slope, shape, and amount of vegetation covering a coastal bluff and the adjacent shoreline are directly related to the susceptibility of the bluff face to ongoing erosion. These maps can help identify shorelines with increased risk of coastal erosion. Bluff erosion can result in a landward shift

of the top edge of the bluff. This shoreline change is a natural process that, by itself, is not a coastal hazard. Only when erosion threatens something of value, such as a building near the bluff edge, does bluff retreat become a hazard. Understanding local erosion rates can help determine the severity, and perhaps longevity, of coastal development along a bluff edge."

Coastal marine geologic environments maps, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/pubs/series/descrip-cmge.htm*

Description: "These maps show regional characteristics of the Maine coast. They illustrate which areas are rocky, muddy, sandy, etc. along the shoreline between the high- and low-tide lines. These maps include sand and gravel beaches and dunes in areas of the state where MGS has not published detailed Sand Dune Photos for use in the Department of Environmental Protection permitting process. These maps illustrate the location of salt marshes and other tidal wetlands for evaluation of coastal habitats, impact of dredging, and siting of coastal facilities."

Dynamic Atlas of the Gulf of Maine, Census of Marine Life.

Go to: *research.usm.maine.edu/gulfofmaine-census/data-mapping/*

Description: Access to data used throughout the Census program, either directly from the Data and Mapping Portal, or from the list of data providers and links.

Maine Office of GIS coverage of intertidal habitat (BATHY30).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "BATHY30 is a raster data set of bathymetry and intertidal cover types for the Gulf of Maine developed by the U.S. Fish & Wildlife Service Gulf of Maine Program. Sounding data was used in deeper areas to generate a relatively coarse resolution bathymetry grid. Finer spatial resolution around inshore features were achieved by use of tidal exposure classifications described from aerial photography (e.g., "regularly flooded, irregularly exposed, irregularly flooded") in the USFWS National Wetland Inventory data sets, channels and tidal flats mapped from photography in Maine's Coastal Marine Geologic Environments (CMGE) and Massachusetts orthophoto wetlands maps. These classes were not translated into absolute elevations, but instead were coded as to position within the intertidal zone, and the general cover type (e.g., high marsh, lower intertidal flats, etc.), which may convey useful ecological information."

Kelley, J.T. et al. 2005. *The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf.* Augusta, ME: Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/explore/marine/seafloor/contents.htm*

Description: "During the past ten years we have conducted many exploratory surveys of the seafloor of the western Gulf of Maine. Recently we compiled that information, along with previously published data, using a geographic information system (GIS) to produce a series of maps of the seafloor of the inner continental shelf of the western Gulf of Maine. The data compiled for this map series were originally collected for a variety of research projects, contracts, and graduate student theses. For this reason there are varying degrees of geophysical data and bottom-sample coverage from place-to-place along the coast. More detailed information regarding specific locations and original field descriptions exists in Maine Geological Survey open-file reports. This report is written to accompany the map series and to explain the field techniques used to collect data. The nature of the seafloor, as well as the late Quaternary geologic history of the area, is also described."

Surficial geology maps of the Maine Inner Continental Shelf, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/pubs/online/ics/ics.htm*

Description: "The maps in this series provide a broad overview of the seafloor along the coast of Maine. They illustrate the complex characteristics of bathymetry and bottom types for a variety of marine uses. Information on these maps can be of value in identifying seabed habitats, sand for beach nourishment, dredged material disposal sites, unstable sites with subsurface biogenic gas deposits, shipwreck sites, potential cable or pipeline routes, and sites for offshore wind farms or aquaculture. The maps are not intended for navigational use, but they can supplement other information in selecting anchorages. This map series shows the surficial geology of the Maine inner continental shelf. Color map units showing seafloor type were determined using

side-scan sonar surveys, seismic reflection profiles, grab samples, cores, and video images. Bathymetry is shown with 10 meter (33 ft.) contour intervals from National Ocean Service provisional bathymetric and fishing maps. An explanatory text describes the regional geologic setting, scientific methods used, description of seafloor types, geologic history, summary of seafloor types, and sources of additional information."

O3 Bathymetry

Dynamic Atlas of the Gulf of Maine, Census of Marine Life.

Go to: *research.usm.maine.edu/gulfofmaine-census/data-mapping/*

Kelley, J.T. et al. 2005. The Seafloor Revealed: The Geology of the Northwestern Gulf of Maine Inner Continental Shelf. Augusta, ME: Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/explore/marine/seafloor/contents.htm*

Maine Office of GIS map layer (BATHYM100).

Go to: *megisims.state.me.us/metadata/bathym100.htm*

Description: "BATHYM100 contains bathymetry lines for the Gulf of Maine at a scale of 1:100,000 showing depth in 10-meter intervals. This coverage was developed by the Maine Geological Survey using USGS 30 X 60 minute series topographic-bathymetric maps. Bathymetric contours are coded with depth in feet (10 meter interval -mean lower low water datum). Spatial topology varies from good to poor."

Marine geology maps, NOAA National Geophysical Data Center.

Go to: *www.ngdc.noaa.gov/mgg/mggd.html*

Description: Among the maps available are bathymetric maps (topographic maps of the sea floor). "Through the use of detailed depth contours and full use of bathymetric data, the size, shape and distribution of underwater features are vividly portrayed. No other map or chart gives this descriptive picture of the ocean bottom terrain. The bathymetric map serves as the basic tool for performing scientific, engineering, marine geophysical and environmental studies, that are required in the development of energy and marine resources. Also, detailed multipurpose maps show both the NOS bathymetry (ocean bottom topography) and the US Geological Survey (USGS) land topographic information. These maps are cooperatively produced by National Ocean Service and USGS to support the Coastal Zone Management and Energy Impact Programs and the offshore oil and gas program. They may also be used by land-use planners, conservationists, oceanographers, marine geologists, and other having an interest in the coastal zone and the Outer Continental Shelf's (OCS) physical environment."

Surficial geology maps of the Maine Inner Continental Shelf, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/pubs/online/ics/ics.htm*

Description: See listing under 02 Substrate types

O4 Circulation and Currents

General

Gulf of Maine Ocean Observing System (GoMOOS).

Go to: *www.gomoos.org*

Description: GoMOOS brings hourly oceanographic data from the Gulf of Maine via buoys, radar, and satellites. Historical, "real-time," and forecast data are available.

Introductory information about ocean circulation in the Gulf of Maine.

Go to: *www.gomoos.org/datatypes/CURRENTS.html*

Description: Provides an overview of Gulf of Maine circulation along with diagrams.

Xue, H., F. Chai, and N.R. Pettigrew. 2000. **A model study of seasonal circulation in the Gulf of Maine.** *Journal of Physical Oceanography* 30:1111-1135.

Go to: *rocky.umeoce.maine.edu/publication.htm* (publications page of the University of Maine's Ocean Modeling Group). Scroll down to the year 2000 and click Download next to the listing of this publication.

Abstract: "The Princeton Ocean Model is used to study the circulation in the Gulf of Maine and its seasonal transition in response to wind, surface heat flux, river discharge, and the M_2 tide. The model has an orthogonal-curvature linear grid in the horizontal with variable spacing from 3 km nearshore to 7 km offshore and 19 levels in the vertical. It is initialized and forced at the open boundary with model results

from the East Coast Forecast System. The first experiment is forced by monthly climatological wind and heat flux from the Comprehensive Ocean Atmosphere Data Set; discharges from the Saint John, Penobscot, Kennebec, and Merrimack Rivers are added in the second experiment; the semidiurnal lunar tide (M_2) is included as part of the open boundary forcing in the third experiment. It is found that the surface heat flux plays an important role in regulating the annual cycle of the circulation in the Gulf of Maine. The spinup of the cyclonic circulation between April and June is likely caused by the differential heating between the interior gulf and the exterior shelf/slope region. From June to December, the cyclonic circulation continues to strengthen, but gradually shrinks in size. When winter cooling erodes the stratification, the cyclonic circulation penetrates deeper into the water column. The circulation quickly spins down from December to February as most of the energy is consumed by bottom friction. While inclusion of river discharge changes details of the circulation pattern, the annual evolution of the circulation is largely unaffected. On the other hand, inclusion of the tide results in not only the anticyclonic circulation on Georges Bank but also modifications to the seasonal circulation."

Casco Bay

Janzen, C.D., J. Churchill, and N. Pettigrew. 2005. **Observations of exchange between eastern Casco Bay and the western Gulf of Maine.** *Deep Sea Research Part II* 52:2411-2429.

Abstract: "Exchange of water between eastern Casco Bay and the adjacent Gulf of Maine shelf is examined to assess the circulation processes that impact the distribution and occurrence of a toxic dinoflagellate, *Alexandrium fundyense*, in eastern Casco Bay. Over the inner shelf adjacent to the bay, tidal variance is weak, and the across-shelf current is highly coherent and in phase with the along-shelf wind stress. Although tidal current variance increases as one advances into the bay, non-tidal currents account for 30–40% of the across-shelf current variance at the bay entrance. Between the shelf and the bay interior is a transition region, where the circulation response to wind forcing changes as the wind adjusts to the changing orientation of the shoreline. Far from shore, the overall large-scale coastline orientation dominates the wind-driven response, but within a few internal Rossby radii, the local coastline clearly dominates the flow patterns and across-shelf wind becomes locally shore-parallel inside the bay. Within the bay interior, the across-shelf wind is highly coherent and in phase with the near-surface subtidal across-shelf current. The Kennebec River north of the study area supplies freshwater to eastern Casco Bay in all seasons. A pool of low-density, relatively fresh water at the entrance to the bay sets up an across-shelf density gradient that is reversed from a typical estuary, and likely contributes to the mean surface on-shelf transport in this region. Surface-drifter trajectories observed over the course of the study suggest that both the across-shelf wind and the across-shelf density gradient are important in driving surface up-bay transport and in the retention of surface-dwelling organisms in eastern Casco Bay."

Understanding Casco Bay: A Circulation Study, Casco Bay Estuary Partnership.

Go to: *www.cascobay.usm.maine.edu/publications.html*

Description: An eight-page illustrated pamphlet summarizing what is known about circulation in the bay.

Cobscook Bay

Brooks, D.A., M.W. Baca, and Y.-T. Lo. 1999. **Tidal circulation and residence time in a macrotidal estuary: Cobscook Bay, Maine.** *Estuarine, Coastal and Shelf Science* 49:647-665.

Abstract: "Cobscook Bay is a macrotidal estuary situated near the entrance to the Bay of Fundy, where the mean semi-diurnal tidal range is 5.7 m. Vigorous tidal currents in the bay maintain cold water temperatures year-round and effectively exchange nutrients and other dissolved matter with offshore waters. Partly because of the cold water and tidal exchange, a net-pen salmon aquaculture industry has rapidly expanded in the last decade, raising questions about sustainable levels of production in the environmentally pristine bay. The present study addresses the question of dispersion and flushing of materials in the bay, using a three-dimensional numerical model to simulate the circulation driven by the semi-diurnal tide and runoff from principal rivers. With initialization based on May 1995 cruise data, the results show that the tidal-mean flushing times for neutral surface particles vary from less than one day in the main channel near the entrance to more than a week in the extremities of the inner arms of the bay. A bay-wide average flushing time is about two days, or four tidal cycles, but the detailed distribution is strongly influenced by a pair

of counter-rotating eddies that forms in the central bay during each flooding tide. The eddy pattern preferentially directs the initial flood into a southern arm of the bay, where particles and dissolved materials are sequestered. The effective horizontal mixing coefficient in the main channel of the central bay is 300–400 $m^2 s^{-1}$, leading to rapid dispersal of particles and pollutants in the along-channel direction and into the shallow inner arms of the bay where they tend to accumulate. A map of tidal-mean residence time indicates that most current aquaculture sites are located in reasonably well flushed regions."

Cobscook Bay Resource Center Drift Study.

Go to: *www.cobscook.org/resourceCenter/studentDriftStudy.htm* Scroll down and select a date to view a map of results from the drift study showing currents in Cobscook Bay.

Description: "Cobscook Bay is well known for its dramatic tidal range and strong currents. During the Nature Conservancy's Cobscook Bay Ecosystem Study, a computer model was designed by David Brooks of Texas A&M University and others to simulate the three-dimensional circulation in the bay. The predictions made by this model have not been extensively confirmed in the field. The Drift Study was conceived and designed to allow for groundtruthing of the model while involving high school students in a meaningful scientific project. Students at Shead High School designed and built the drifters and continue to participate in all aspects of the study from data collection to data analysis. For each trial, drifters were dropped between Gove Point, Lubec and Birch Point, Perry at the start of flood tide and tracked for about six hours (one-half a tidal cycle) using skiffs and hand-held Global Positioning System (GPS) units. The data collected were brought into ArcView software and used to create maps. Click on the links to view maps of each drifter trial."

Penobscot Bay

Pettigrew, N. 2000. **Circulation Patterns and Processes in Penobscot Bay: Preliminary Interpretation of Data. A Final Report for Year 4 of the Penobscot Bay Experiment.**

Go to: *www.islandinstitute.org/penbay/pettigrew.htm* Click on the pdf report from 1999 or from 2000.

Description: "The principal objectives of the third year of the circulation experiment were to expand the seasonal circulation study into the previously unmeasured inner Bay, to study the circulation linkages between the inner and outer Bays and the Eastern Maine Coastal Current (EMCC), and to monitor the here-to-fore unmeasured currents in the near-surface layer (2m). These objectives were achieved by deploying five buoys in the experiment (two in the inner Bay, two in the outer Bay, and one in the EMCC), adding acoustic current meters at 2 m depth on each of the four Bay buoys, and maintaining this coastal ocean observing system for a period of approximately 12 months."

Xue, H. et al. 2000. **Modeling the Circulation in Penobscot Bay, Maine.** In: Estuarine and Coastal Modeling Louisiana, November 3-5, 1999.

Go to: *rocky.umeoce.maine.edu/publication.htm* Scroll down to the year 2000 and click Download next to the listing of this publication.

Abstract: "Penobscot Bay, with approximate dimensions 50 x 100 km, is the largest estuarine embayment along the Maine coast. It can be characterized by two deep channels on its eastern and western sides, which are separated by several islands and a shoal region in the middle of the Bay. Subtidal circulation in Penobscot Bay is influenced by winds, fresh water discharge from the Penobscot River, and the southwestward Maine Coastal Current flowing past the mouth of the Bay. The Princeton Ocean Model was adapted to Penobscot Bay to simulate the circulation for the spring and summer of 1998. Observed winds at nearby Matinicus Rock and realistic river discharge rates were used to force the model. Open boundary conditions were specified using the results from a Gulf of Maine climatological model. Simulations were somewhat sensitive to the mixing coefficient in the model. When a background viscosity of $5x10^{-6}$ m^2/s was used, the model reproduced the observed three-layer structure in the outer western bay with outflows near the surface and the bottom and inflows in the middle of the water column. In contrast, a two-layer estuarine like circulation was found in the outer eastern bay with outflows in the upper water column and inflows in the lower water column."

O5 Tides, Tidal Currents

Tidal Range

NOAA Tidal Predictions.

Go to: *co-ops.nos.noaa.gov/tide_pred.html*

Description: Tidal data for many locations in Maine.

Tidal Currents—General

NOAA Tidal Current Predictions.

Go to: *co-ops.nos.noaa.gov/curr_pred.html*

Description: "Unlike tide stations, which are normally located along the shoreline, most tidal current stations are located offshore in channels, rivers, and bays. Tidal current stations are often named for the channel, river, or bay in which they are located or for a nearby navigational reference point. A map or some personal knowledge of the area may be necessary to help identify stations in the area you are interested in."

The Maine Coast Guide.

Go to: *www.coastguides.com/intro/tides.html*

Description: General narrative information about tidal currents in Maine.

Cobscook Bay

Brooks, D.A., M.W. Baca, and Y.-T. Lo. 1999. **Tidal circulation and residence time in a macrotidal estuary: Cobscook Bay, Maine.** *Estuarine, Coastal and Shelf Science* 49:647-665.

Brooks, D.A. 2004. **Modeling Tidal Circulation and Exchange in Cobscook Bay, Maine.** *Northeastern Naturalist* 11(Spec. Issue 2):23-50.

Description: This paper summarizes a Cobscook Bay circulation study by Brooks et al. (1999) and presents some new results to improve understanding of the tidal circulation and potential exchange pathways linking the bays.

O6 Winds

Wind data from buoys and island stations, GoMOOS.

Go to: *www.gomoos.org*

Gulf of Maine Wind Vector Images.

Go to: *wavy.umeoce.maine.edu/frames_qs.html*

Description: The images are based on data collected by a satellite passing over the Gulf of Maine (one ascending and one descending orbit per day). Wind speed is reported in meters per second.

O7 Sea Level

Barnhardt, W.A., and J.T. Kelley. 1995. **Carbonate accumulation on the inner continental shelf of Maine: a modern consequence of late Quaternary glaciation and sea-level change.** *Journal of Sedimentary Research* A65:195-207.

Barnhardt, W.A., W.R. Gehrels, D.F. Belknap, and J.T. Kelley. 1995. **Late Quaternary relative sea-level change in the Western Gulf of Maine: evidence for a migrating glacial forebulge.** Geology *23: 317-320*.

Kelley, J.T., S.M. Dickson, D.F. Belknap, and R. Stuckenrath. 1992. **Sea level change and the introduction of late Quaternary sediment to the southern Maine inner continental shelf, pp. 23-34 in** *Quaternary Coasts of the United States* (J. Wehmiller and C. Fletcher, eds.) Special Paper 48, Society of Economic Paleontologists and Mineralogists.

Maine's history of sea-level changes, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/explore/marine/facts/sealevel.htm*

Description: Fact sheet on history, effects, and potential for future sea-level change.

Sea level trends for stations in Maine, NOAA.

Go to: *co-ops.nos.noaa.gov/sltrends/sltrends_states.shtml?region=me*

Description: Water-level records combine data on ocean fluctuations and vertical motion of the land at the station. The sea-level variations determined by these records include the linear trend, the average seasonal cycle, and the interannual variability at each station. Monthly data through the end of 1999 were used in the calculation, and all stations had data spanning a period of 25 years or more.

O8 Vertical Profiles of Temperature, Salinity, and Density

Temperature, salinity, and density measurements, GoMOOS buoys.

Go to: *www.gomoos.org*

Sea surface temperature from University of Maine Satellite Oceanography Data Lab.

Go to: *wavy.umeoce.maine.edu/sat_ims.htm*

Description: A Web site which presents the research activities carried out in the UMaine Satellite Oceanography Data Lab and makes available some of the data products they produce including real-time and archived satellite imagery for several geographic regions (special focus on the Gulf of Maine).

Biological Components

B1 Historical Perspective on Ecological Changes

Frequency of harmful algal blooms (red tide)

Biotoxin Monitoring Program, Maine Department of Marine Resources.

Go to: *www.maine.gov/dmr/rm/public_health/biotoxinmonitoring.htm*

Description: Extensive history of red tide for some sites going back almost 30 years. Data available by request.

Eutrophication

Mayer, L., et al. 1996. ***The Kennebec, Sheepscot, and Damariscotta River Estuaries: Seasonal Oceanographic Data.*** Technical Report No. 9601, Department of Oceanography. Orono, ME: University of Maine.

Nutrient data from Marine Resources Volunteer Coordinator, Maine Department of Marine Resources.

Go to: *www.umaine.edu/umext/ssteward*

Description: Data collected by volunteers in the Shore Stewards water-quality monitoring program.

Changes in wetlands and eelgrass coverage

Effects of commercial fishing on eelgrass in New England: Characterization of impacts and measurements of regrowth, results of high altitude photography [Maquoit Bay]. Report from Maine Department of Marine Resources to USGS Eastern Regional Office State Partnership Project.

Go to: *www.maine.gov/dmr/rm/ecologydivision.html*

Description: "As part of a multi-agency USGS State Partnership Program funded study of eelgrass regrowth in Maquoit Bay, Brunswick, Maine, Maine Department of Marine Resources (MDMR) documented small (1:12,000) and medium (1:2,400) scale distribution of eelgrass throughout the bay. This work was initiated in response to reports of the destruction of eelgrass beds by commercial mussel harvesting activities in the bay... Maquoit Bay has offered an excellent opportunity to study re-growth of eelgrass after meadows had been disrupted by a number of commercial harvesting methods. It was apparent from aerial photography taken in 1999 and from field observations that in recent years fairly extensive portions of Maquoit Bay had been impacted by mussel harvesting activities. It was also clear that eelgrass beds in Maquoit Bay had expanded since they were mapped in 1993 and that there was evidence of marine worm and soft clam harvesting activities that continued to take place in eelgrass. In addition, other uses of the Bay such as boating may have had impacts on eelgrass."

Maine Office of GIS map layer of eelgrass beds (MEGRASS).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "MEGRASS is a REGIONS dataset of Maine's eelgrass meadows, which form an important aquatic habitat for the state. These meadows provide shelter for juvenile fish, and invertebrates. In certain locations they also help stabilize unconsolidated sediments and shorelines. As a continuing project, sections of the coast have been flown and photographed using Kodak 2448 film at a scale of 1:12000. This photography has been supplemented in the Penobscot Bay region by 1992 flights using Kodak 2445 film. The Penobscot Bay flights were contracted by the Maine Department of Transportation and interpreted by Dr. Fred Short of University of New Hampshire." Contact: GIS specialist, Maine Department of Marine Resources, (207) 633-9500.

Regional wetland status and trend reports, U.S. Fish and Wildlife Service.

Go to: *northeast.fws.gov/wetlands/* and for ordering instructions go to *northeast.fws.gov/wetlands/docs/publication.pdf*

Description: In the mid-1970s, the National Wetlands Inventory program was established to inventory the nation's wetlands and report on their status. The program produces wetland maps and periodically updates these maps and accompanying digital data. The program also evaluates and reports on changes in wetland status (wetland trends) to inform the Ameri-

can public on how wetlands are changing in response to natural processes (e.g., sea level rise, fire, and mudslides) and to human development (e.g., agriculture, urban and suburban development, impoundment, dredging, channelization and ditching).

Habitat changes/degradation

Historical aerial photographs, USGS Earth Resources Observation Systems Data Center.

Go to: *edc.usgs.gov/products/aerial.html*

Description: Aerial photographs dating back to the 1940s can be ordered for a fee from this site. Search the site for availability of photographs from Maine.

Recent aerial photographs, Maine Department of Marine Resources.

Go to: *www.state.me.us/dmr/aerialphotos/index.html*

Description: "The photographs for Maine were from a coast-wide eelgrass mapping project and represent scanned images for the years 1992 to 1997. Photographs are organized by region."

Maine Office of GIS map layer for impervious surfaces (IMPERV).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "IMPERV is a raster data set of impervious areas, derived from 5 meter SPOT imagery collected in the summer of 2004 over the State of Maine. Areas of imperviousness are characterized by anthropogenic features such as buildings, roads, parking lots, etc. Pixel values of 0 (zero) indicate an impervious land cover, while pixel values of 1 (one) indicate pervious land cover features."

Maine Office of GIS map layer for land cover (MELCD).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "MELCD is a land cover map for Maine primarily derived from Landsat Thematic Mapper 5 and 7 imagery, from the years 1999-2001. This imagery constitutes the basis for the National Land Cover Dataset (NLCD 2001) and the NOAA Coastal Change Analysis Program (C-CAP). This land cover map was refined to the State of Maine requirements using SPOT 5 panchromatic imagery from 2004. The Landsat imagery used was for three seasons: early spring (leaf-off), summer, and early fall (senescence) and was collected with a spatial resolution of 30 m. The SPOT 5 panchromatic imagery was collected at a spatial resolution of 5 m during the spring and summer months of 2004. The map was developed in two distinct stages, the first stage was the development of a state wide land cover data set consistent with the NOAAC-CAP land cover map. The second stage was: a) the update to 2004 conditions, b) a refinement of the classification system to Maine specific classes and, c) a refinement of the spatial boundaries to create a polygon map based on 5 m imagery."

Maine Office of GIS high-resolution coastal photographs.

Go to: *apollo.ogis.state.me.us/ Note: These can also be found in Google Earth along with some other industry sources, earth.google.com/*

Maine Land Cover Change Reports, NOAA Coastal Services Center.

Go to: *www.csc.noaa.gov/crs/lca/maine.html*

Description: "This project studied the estuarine drainage areas of the Gulf of Maine, including the surrounding areas of Great Bay in New Hampshire and the St. Croix Estuary at the Maine/Canada border. This project mapped terrestrial land cover in coastal watershed environments and identified changes in these areas that occurred between 1985 and 1995. The project relied on satellite multispectral imagery as the primary information source. These data were used to distinguish major land cover classes, and previous images were studied to locate areas that changed over time. For this project, the data were acquired according to the Center's Coastal Change Analysis Program (C-CAP) methods."

Invasive species

Berman, J., L. Harris, W. Lambert, M. Buttrick, and M. Dufresne. 1992. **Recent invasions of the Gulf of Maine: three contrasting ecological histories.** *Conservation Biology* 6:435-441.

Abstract: "Introduced species are common members of estuarine communities where their role as competitors and predators is of concern. This paper examines the invasion of Gulf of Maine benthic habitats by the ecologically similar alien invertebrates *Styela clava, Botrylloides diegensis*, and *Membranipora membranacea*. *Styela clava* increased slowly in abundance at study sites in Beverly, Massachusetts and Portsmouth, New Hampshire. We found no evidence of competitive dominance by *S. clava*, even though it is the competitive dominant in similar habitats elsewhere. *Botrylloides diegensis* rapidly became a dominant species after its arrival in the Great Bay Es-

tuary, but this dominance was short-lived. *B. diegensis* persists in the estuary as an early colonist of primary space and as an epibiont on secondary substrates in established communities. *Membranipora membranacea* became the dominant epiphyte on laminarian kelps within two years. Although *M. membranacea* overgrew the native epiphytes *Obelia geniculata* and *Electra pilosa* in the overwhelming majority of encounters these native species are more common on other algal hosts. Therefore, competitive dominance is not likely a factor in the successful invasion of the Gulf of Maine by *M. membranacea*. These species provide evidence for opposing views of the role of competition in mediating community invasion. We show that ecological similarity among species is not an accurate criterion to predict either the mechanism of invasion or the means of persistence. In addition, these data indicate that biological invasions must be examined on broad spatial and temporal scales; short-term or narrowly focused studies can lead to incorrect conclusions.

Carlton, J.T. 2004 (unpublished). **A Preliminary Checklist of the Introduced Marine and Estuarine Organisms on the Coast of Maine, U.S.A**. Mystic, CT: Williams College-Mystic Seaport.

Go to: *www.seagrant.umaine.edu/documents/pdf/invchk.pdf*

Description: "This regional list for the coast of Maine is derived from a larger work (commenced in 1975) monographing the introduced and cryptogenic marine organisms from Nova Scotia to Long Island Sound. Many colleagues and students have been involved in this work over the past 29 years. August 2003 surveys of selected sites along the Maine coast (led by Dr. Judith Pederson and colleagues; personal communications) added several new taxa to this working list. These sites included South Portland (Port Harbor Marine floats and retaining walls), Portland (Portland Yacht Services floats), and South Freeport (Brewer South Freeport floats)."

Maine's Marine Invasion: A Forum on the Impact of Non-native and Other Invasive Species on Maine's Coastal Ecosystems. Presentation and documents from a workshop on May 5, 2004.

Go to: *www.cascobay.usm.maine.edu/oldsite/invasforum.html*

Description: "At this forum, scientists and managers working on marine invasive species issues throughout New England addressed questions related to the issue of marine invasions in Maine. Presentations included the results of an August 2003 survey fvor marine invasives species in Casco Bay and ports south of Casco Bay in New England; information about specific bio-invaders; potential pathways for their introduction; and a case study from Massachusetts on how to manage what's here and keep potential new invasions out."

Maine's Marine Invasion, Maine Sea Grant.

Go to: *www.seagrant.umaine.edu/documents/pdf/MMI05.pdf*

Description: Provides general information and resources on marine invasions in Maine.

Marine Invaders in the Northeast: Rapid assessment survey of non-native and native marine species on floating dock communities.

Go to: *www.mass.gov/envir/massbays/pdf/ras2003.pdf*

Description: "A rapid assessment survey (RAS) approach was used to identify native, introduced, and cryptogenic species present as fouling communities on floating docks and associated structures (ropes, buoys, chains, hulls, and other floating materials) for selected coastal locations along the northeastern U.S. coast from Portland, Maine through New York City and Staten Island, New York. The Northeast RAS was similar to surveys conducted in Puget Sound, Washington, San Francisco Bay, California, and Southern California (Cohen et al. 1998; Cohen et al. 2001; H. Berry pers. comm.; C. Mills pers. comm.) and in Massachusetts and Rhode Island (Cute 2001; Pederson et al. 2001) and relies on taxonomic experts who are familiar with native, introduced, and cryptogenic species for taxonomic identifications."

B2 Habitats

Mapping and image data documenting coastal marine habitats

Aerial photography index of the Maine coast, Maine Department of Marine Resources.

Go to: *www.state.me.us/dmr/aerialphotos/index.html*

Description: See Habitat Change listings under B1Historical Perspective on Ecological Changes.

Beginning with Habitat maps and GIS data.

Go to: *www.beginningwithhabitat.org/the_maps/index.html*

Description: "Three primary maps, Water Resources & Riparian Habitats, High Value Plant & Animal Habitats, and Undeveloped Habitat Blocks, form the core of the Beginning with Habitat information."

Brown, B. 1993. **A Classification System of Marine and Estuarine Habitats in Maine: An Ecosystem Approach to Habitats. Part 1: Benthic Habitats, Maine Natural Areas Program.**

Go to: *www.mainenaturalareas.org/docs/publications/*

Description: This document describes a preliminary classification system for Maine's benthic marine and estuarine habitats. It uses an ecosystem approach and classifies habitats based on both biotic and abiotic features.

GIS maps of eelgrass beds, Maine Department of Marine Resources.

Go to: *www.maine.gov/dmr/rm/eelgrass/index.htm*

Description: "In the period 1992-1997, eelgrass bed locations were compiled on stable-base manuscripts containing the coastline and other basemap features from the 1:24,000 scale USGS topographic maps. Polygons delineating stands of eelgrass were digitized and coded using a four category scale of percent cover. In the 2001 to 2005 time period polygons were screen digitized. Verification has been carried out by boat, on foot, and by plane. Though dense patches of eelgrass approximately 6 meters in diameter and less can be identified under good conditions and in some cases were mapped, a conservative estimate of the minimum mapping unit is 150 square meters. This represents a stand of approximately 14 meters in diameter." Digital eelgrass data are also available from Maine Office of GIS.

GIS data for Essential Wildlife Habitats and Significant Wildlife Habitats as well as habitat of endangered, threatened or special concern species, Maine Department of Inland Fisheries and Wildlife.

Go to: *www.maine.gov/ifw/wildlife/habitat_data/index.htm*

Description: "MDIFW provides digital copies of its wildlife habitat data upon written request. All data are provided as Geographic Information System (GIS) shapefiles." Habitat for some species are also available as statewide datasets from Maine Office of GIS.

Maine Office of GIS map layer of commercially harvested worm habitat (WORM).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "WORM provides a generalized representation at 1:24,000 scale of commercially harvested marine worm habitat in Maine, based on Maine Department of Marine Resources data from 1970s. Original maps were created by MDMR and published by USF&WS as part of the Ecological Characteristics of Coastal Maine. According to a MDMR staff member in 2007, there is new information available that has been incorporated into DEP EVI maps but not yet published by the Maine Office of GIS."

GIS identification of important habitats in the lower Casco Bay (Maine) watershed.

Go to: *gulfofmaine.org/library/casco/casco.htm*

Description: "The U.S. Fish and Wildlife Service Gulf of Maine Project has identified important habitats for a variety of plants, invertebrates, fishes and birds, in the lower Casco Bay watershed of Southern Maine. Habitat identification was based on species occurrences and also was projected from environmental parameters favorable to those species, such as suitable vegetation, water depth, or presence of food resources. Numerical scores were assigned to each habitat, reflecting level of use and apparent environmental quality for the evaluation species. Scores were adjusted according to the relative abundance of each habitat within the study area, and the relative ranking of the evaluation species on the Gulf of Maine Council regional listing. Habitat maps for the individual species were aggregated into a final map highlighting areas important to one or several species. This information is being used in an analysis of threats to important habitats from development activities, performed in cooperation with the Casco Bay Estuary Project. The digital data described in this report are available as geo-referenced compressed binary raster files. These files may be downloaded for use in a number of GIS programs and viewers by accessing the documentation page from several places in this report."

Maine Office of GIS map layer of saltwater and estuarine habitat value (SALINE91).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "SALINE91 represents the overall habitat values, within saltwater and estuarine cover types for 91

priority trust species of the U.S. Fish Wildlife Service, in the U.S. portion of the Gulf of Maine watershed. Habitats for each species were mapped and ranked from actual sightings or by developing habitat suitability models reflecting environmental requirements for each species. Scores for each species were then added to derive the sum of scores for all species combined. The value for each cell reflects both the number of species using each cell and the relative habitat suitability for those species." For more information about the USFWS Gulf of Maine Coastal Program's Gulf of Maine Habitat Analysis, Go to: *www.fws.gov/northeast/gulfofmaine/projects/habitat_analysis.htm*

Maine Office of GIS map layer of shellfish habitat (SHELL).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "SHELL offers a generalized representation of molluscan shellfish habitat in Maine, based on a 1977 Maine Department of Marine Resources coastwide survey. Original mapping was done as a cooperative effort between the U.S. Environmental Protection Agency (USEPA) and Maine Department of Marine Resources (MDMR) staff. The coverage represents a composite of the 1:24000 scale coastline with polygons digitized from paper maps produced for the US Fish and Wildlife Service (USF&WS) Ecological Characteristics of Coastal Maine."

Gulf of Maine Watershed Habitat Analysis Important Habitat Internet Map Viewer, U.S. Fish and Wildlife Service Gulf of Maine Coastal Program.

Go to: *www.fws.gov/northeast/gulfofmaine/maps_data/map_viewer.htm*

Description: "This online mapping tool displays the results from the Gulf of Maine Watershed Habitat Analysis. It allows you to view important habitat for 91 priority trust species of the U.S. Fish and Wildlife Service as determined by analysis of field data and modeling efforts. The study area includes Maine, and the eastern portion of New Hampshire and Massachusetts that drain into the Gulf of Maine. The habitat data in the map viewer are intended to be used for proactive, voluntary habitat protection projects. This may include use in comprehensive and open space planning. It may also be used to prioritize habitat protection efforts and to support grant applications. The data are not meant to be used in a regulatory fashion and are not meant to portray U.S. Fish and Wildlife Service Critical Habitat."

Reports documenting coastal marine habitats

Beginning with Habitat Focus Areas of Ecological Significance, Maine Natural Areas Program and Maine Department of Inland Fisheries and Wildlife.

Go to: *www.mainenaturalareas.org* In the left-hand menu click on Focus Areas of Natural Significance. Click on the desired county, or scroll down to see an alphabetical listing by county of reports on profiled areas.

Description: This site includes a description of each area and its unique habitat characteristics, a table of rare species and exemplary natural communities, conservation considerations and protection status. An explanation of the ranking system can be found under Natural Communities in the main menu on the home page.

Doggett, L.F., et al. 1978. **Intertidal bedrock areas of high species diversity in Maine, and their relevance to the Critical Areas Program, Maine Critical Areas Program Planning Report No. 55.** Augusta, ME: Critical Areas Program, Natural Resource Planning Division, Maine State Planning Office. Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

Description: "Intertidal bedrock areas have a high species diversity when specific conditions are met. A relatively high energy level due to wave action and a heterogeneous substrate which contains tidepools and crevices in the lower intertidal zone are among the most important conditions determining the level of species diversity. A number of the species present in these high diversity areas are unusual and noteworthy. Brittlestars, sponges, sea spiders, and nudibranchs (shell-less gastropods) are examples of the fauna present. This report documents and describes areas of high species diversity at 18 intertidal bedrock sites. Also included (for the 12 sites which were field checked) are species lists which state the zone in which the species was found and the relative abundance of the species. General information on marine invertebrates is provided. Abiotic and biotic factors as they pertain to the species in this habitat are discussed. Descriptions of the intertidal zones and the species which were present at the sites which were checked are included. Criteria for determining significant sites are stated. It is recommended that additional sites be considered and that they be evaluated based on the criteria presented in this report.

Intertidal bedrock areas of high species diversity can be disturbed and/or destroyed by over-collecting and excessive foot traffic. Therefore, this report recommends that the 18 sites described here be evaluated for inclusion in the Register of Critical Areas."

Fefer, S.I., L.L. Thornton, P. Schettig, and R. Brami. 1978. **An Ecological Characterization of Maine's Coast North and East of Cape Elizabeth.** Boston, MA: U.S. Fish and Wildlife Service. Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

Description: This study consists of six volumes devoted to the detailed study of the ecological characteristics of Maine's coast.

Natural Resource Inventories of coastal watersheds produced by local land trusts. The Maine Land Trust Network lists most of the organizations and provides links to their Web sites.

Go to: *www.mltn.org*

The Ecology of Maine's Intertidal Habitats: A Report Prepared for the Maine State Planning Office. Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

Ward, A. 1999. **Maine's Coastal Wetlands (Vol. I and II).** Augusta, ME: Maine Department of Environmental Protection.

Go to: *www.maine.gov/dep/blwq/doceducation/general.htm*

Description: Part I serves as a reference providing biological and geological information on Maine's coastal habitats and summarizing coastal development activities during the later half of the 1990s. Part II provides functional assessment guidelines to enable consultants to meet permit application requirements in Maine's Natural Resources Protection Act.

B3 Plants and Animals

Sources about multiple types of plants and animals

Census of Marine Life Gulf of Maine Area Program.

Go to: *research.usm.maine.edu/gulfofmaine-census/biodiversity*

Description: Interactive maps and narrative descriptions about changes in fish populations and many other aspects of sea life in the Gulf of Maine.

Dynamic Atlas of the Gulf of Maine, Census of Marine Life.

Go to: *research.usm.maine.edu/gulfofmaine-census/data-mapping/*

Description: Access to data used throughout the Census program, either directly from the Data and Mapping Portal, or from the list of data providers and links.

Maine marine resource information by species, Maine Department of Marine Resources.

Go to: *www.maine.gov/dmr/rm/speciesinformation.htm*

Description: Information about many kinds of fish and invertebrates.

Maine-New Hampshire Inshore Trawl Survey, Maine Department of Marine Resources and New Hampshire Department of Fish and Game.

Go to: *www.maine.gov/dmr/rm/trawl/index.htm*

Description: "The Inshore Groundfish Trawl Survey is a fisheries independent assessment of living resources inside the coastal waters of Maine and New Hampshire. Its purpose is to fill a significant information gap that hampers efficient management of Maine's fishing industry. In fact, until this survey, Maine and New Hampshire were the only states on the east coast not conducting a near shore assessment. Quotas, closures, and other management measures are based on assessments done outside Maine waters where fishing pressure and conditions are entirely different. As a result, Maine's and New Hampshire's resources are being managed without benefit of adequate information. While the funding comes from money Congress set aside to provide some economic relief to the groundfish industry, the assessment is more than a groundfish survey. Lobsters, recreational finfish species, and non-commercial species of ecological interest are also assessed. This is truly a multispecies survey that should benefit all decision makers confronted with issues such as fish stock recovery, fishery management measures, Essential Fish Habitat designations, climate change, Marine Protected Areas and more. The coast has been broken into 5 areas based on geologic, oceanographic, geographic and biologic factors and in addition, each area has been divided into four depth layers; 5-20, 21-35, 36-55, and 55+ fathoms. Stations are located randomly to reflect representative conditions within each of the strata. We attempt

to complete 115 tows during each survey. Gear consists of a modified shrimp net with a 2 inch mesh in wings and 1/2 inch mesh liner in the cod end. Foot rope and head ropes are 57' and 70' respectively, with 6 inch rubber cookies. The gear was designed to be very light on the bottom to minimize habitat disruption. Video work conducted in February and August 2002 has confirmed that this is so."

Rare plant fact sheets, Maine Natural Areas Program.

Go to: *www.mainenaturalareas.org and click on Rare Plants in the column on the left hand side.*

Description: Fact sheets provide information on the identification, distribution, and population status of rare plants, including those found in coastal habitats.

Resource information by species, Maine Department of Inland Fisheries and Wildlife.

Go to: *www.maine.gov/ifw/wildlife/species/index.htm*

Description: Information about many kinds of game, nongame, and endangered and threatened animals including waterfowl and shorebirds. Sport fish also described at: *www.maine.gov/ifw/fishing/species/identification/index.htm*

Sears Island Dry Cargo Terminal Marine Resources Baseline Report. 1995. Prepared for Maine Department of Transportation by Normandeau Associates.

Description: "This report presents results of investigations of various marine resources in the vicinity of Sears Island, Maine in upper Penobscot Bay during 1992. These investigations were undertaken to supplement baseline information on intertidal and nearshore habitat conditions and utilization of fisheries resources as a basis for evaluating impacts of the Maine Department of Transportation's (MDOT) proposed Sears Island Dry Cargo Terminal. These investigations included studies of eelgrass (*Zostera marina*), soft-shell clams (*Mya arenaria*), marine worms (primarily baitworms *Glycera dibranchiata* and *Nereis virens*), lobsters (*Homarus americanus*), sea scallops (*Placopecten magellanicus*) and sea urchins (*Strongylocentrotus droebachiensis*). The northwest shoreline, in the area covered by the High Intensity Wildlife Survey, was encompassed in these investigations because this entire area was being reviewed for alternative port locations at the time. Information on other marine resources is recapitulated from the EIS."

The Taunton Bay Assessment, A Report to the Maine Legislature Marine Resources Committee for Consideration of the 2000-2005 Dragging Prohibition. January 30, 2004. Augusta, ME: Maine Department of Marine Resources.

Go to: *www.maine.gov/dmr/baystudy/baystudy.htm* to contact the Ecology Division of the Maine Department of Marine Resources.

Description: Seabed mapping (Maine DMR/local fishermen); Characterization of the Bay's dragging history (Maine DMR/local fishermen); Eelgrass distributional changes (Maine DMR); Intertidal community characterizations (Maine Maritime Academy); Horseshoe crab seasonal movements (Maine DMR/Friends of Taunton Bay); Shallow subtidal fish communities (Maine DMR); Mussel dragging experiment (Maine DMR/Univ. of Maine/local fishermen).

B3.1 Phytoplankton

General

Bigelow, H.B. 1926. Plankton of the Offshore Waters of the Gulf of Maine. Washington, DC: Government Printing Office. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Chlorophyll concentration data, Gulf of Maine Ocean Observing System (GoMOOS).

Go to: *www.gomoos.org/oceanbiology/*

Description: "GoMOOS measures microscopic plant life. Direct measurements include chlorophyll and sunlight. These measurements are utilized to estimate phytoplankton biomass, the occurrence of phytoplankton blooms, and primary productivity."

Field Guide to the Phytoplankton in the Gulf of Maine. University of Maine Cooperative Extension and the Maine Sea Grant Program.

Go to: *www.umaine.edu/umext/ssteward/phyto.htm*

Description: "This field guide was created for the citizen volunteers who provide a first-alert system to the Maine Department of Marine Resources by watching for the presence of potentially toxic phytoplankton along Maine's coast."

Marine Planktonic Diatoms of the Northeast U.S. Coast.

Go to: *thalassa.gso.uri.edu/flora/NElist.html*

Description: This Web site consists of a list of diatom genera. The site user can click on one of the genera to see which diatom species of that genus are found on the northeast U.S. coast.

Cobscook Bay

Cobscook Bay Phytoplankton Reports.

Go to: *www.cobscook.org/reference/publications/phytoReports.htm*

Description: "The Cobscook Bay Resource Center has monitored phytoplankton presence and abundance in the Cobscook Bay region since 1998. Data are shared with and analyzed by the Maine Department of Marine Resources (DMR). Samples are collected using two methods: net tows and "at-depth" cell counts. We sample six shore-side sites and two fish farm sites regularly. Other sites are sampled by special arrangement. We have recently completed development of a database which allows us to track changes in the phytoplankton community as they occur. In response to blooms of multiple species which occurred in 2003, the Resource Center developed an email notification system to inform fish farmers and other interested parties of phytoplankton conditions. Our partner in these efforts is the Pleasant Point Passamaquoddy Environmental Department."

Kennebec River Estuary

Wong, M.W. and D.W. Townsend. 1999. **Phytoplankton and hydrography of the Kennebec estuary, Maine (USA).** *Marine Ecology Progress Series* 178:133-144.

Abstract: "The biomass, abundance and species composition of phytoplankton in the Kennebec estuary, Maine, USA, were investigated in relation to hydrography and light regime during 7 seasonal survey cruises. The salinity distribution ranged from 32 at the mouth to between 0 and 5 at the head, depending on the magnitude of freshwater discharge at the time of each survey. Maximum vertical salinity and temperature gradients were observed at the mouth, while local tidal mixing, combined with the freshwater flow, produced a well-mixed water column at the head of the estuary. The middle portion of the estuary was stratified on flooding and ebbing tides, but was vertically well mixed at high and low tides. Phytoplankton biomass was lowest in winter (chlorophyll *a* ~= 1 $\mu g\ l^{-1}$) and highest in summer (up to 10 $\mu g\ l^{-1}$). The phytoplankton species assemblages at the seaward and the riverine ends of the estuary were made up of taxa with corresponding salinity preferences. Both cell numbers and biomass (chlorophyll *a*) exhibited a bimodal distribution along the length of the estuary in the warmer months, with the middle portions of the estuary having depressed phytoplankton standing stocks compared with the seaward and landward ends. This bimodal distribution was related to light limitation and nutrient regeneration in the middle portion of the estuary and to the production of and advective contributions of phytoplankton from both the freshwater and seaward ends."

Penobscot Bay

Reports on the characterization of phytoplankton communities, primary production, and detrital components in Penobscot Bay.

Go to: *www.islandinstitute.org/penbay/phytoplankton.htm*

Description: "Maureen Keller and Andrew Thomas studied several aspects of primary productivity, the base of the food web, in the bay. Their research sought to identify patterns of temperature, salinity, chlorophyll, light transmission, primary productivity, and dissolved and particulate organic matter in the surface waters of the Bay. In addition, the researchers identified the distribution of dominant phytoplankton species."

B3.2 Macrophytes

Lamb, M. et al. 1977. *Artificial Key to the Common Marine Algae of New England North of Cape Cod***.** Cambridge, MA: Farlow Herbarium, Harvard University.

Description: "The purpose of this field guide is to provide the reader with a convenient means to the identification of selected marine algae of the New England Coast, north of Cape Cod to adjacent Canadian waters....The majority of plants contained in the key are identifiable macroscopically or by the use of a hand lens....The majority of species descriptions are accompanied by line drawings or [black-and-white] photographs. These illustrations were prepared almost exclusively from living specimens."

GIS maps of eelgrass beds.

Go to: *www.maine.gov/dmr/rm/eelgrass/index.htm*

Description: See listing under B2 Habitats Mapping data.

South, G. R., and I. Tittley. 1986. ***A Checklist and Distributional Index of the Benthic Marine Algae of the North Atlantic Ocean.*** St. Andrews, New Brunswick: Huntsman Marine Laboratory.

Go to: *www.huntsmanmarine.ca/publications1985-1989.shtml*

Villalard-Bohnsack, M. 1995. ***Illustrated Key to the Seaweeds of New England.*** Rhode Island Natural History Survey.

Description: Black and white photos and line drawings.

Watling, L., J. Fegley, and J. Moring. 2003. ***Life Between the Tides, Marine Plants and Animals of the Northeast.*** Gardiner, ME: Tilbury House.

Go to: *www.tilburyhouse.com/Maine%20Frames/me_tide_fr.html*

Description: Includes drawings and descriptions of vascular marine plants and seaweeds.

Wippelhauser, G. 1996. ***Ecology and Management of Maine's Eelgrass, Rockweeds and Kelps.*** Augusta, ME: Maine Natural Areas Program.

Go to: *www.mainenaturalareas.org/docs/publications/*

B3.3 Invertebrates

General

Bousfield, E.L. and D.R. Laubitz. 1972. Station lists and new distributional records of littoral marine invertebrates of the Canadian Atlantic and New England regions. Biological Oceanography Publication No. 5, Canadian National Museum of Natural Sciences. Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

Description: "Station data and locality maps are provided for field investigations on the distribution and ecology of littoral marine invertebrates, mainly molluscs and crustaceans, in the following regions: St. Lawrence estuary and Gaspe coast, 1953, 1969; the southwestern Gulf of St. Lawrence, 1960, the Atlantic coast of eastern Nova Scotia, 1962; and the Gulf of Maine coast of western Nova Scotia and New England, 1963. Locality records are provided for a number of invertebrate species that are believed to set new distributional limits, or are of particular interest, zoogeographically or ecologically."

Brinkhurst, R.O., L.E. Linkletter, et al. 1976. **A preliminary guide to the littoral and sublittoral marine invertebrates of Passamaquoddy Bay.** St. Andrews, New Brunswick: Fisheries and Marine Service Biological Station. Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

Description: "This is a general, easy-to-use key to the common intertidal and subtidal invertebrates of the Passamaquoddy region."

Doggett, L. (unpublished.) ***Species Checklist for the Gulf of Maine.***

Description: This 241-page document lists a variety of species that have been sighted in Maine and gives the location in which they were found.

Gosner, K.L. 1978. Atlantic Seashore: A Peterson Field Guide. Boston, MA: Houghton Mifflin.

Go to: *Available at most bookstores and libraries.*

Description: A guide and identification key to intertidal marine invertebrates.

Marine Flora and Fauna of the Northeastern United States, NOAA Technical Report, NMFS Circular Series.

Go to: To check for the availability of a circular on a particular group of organisms, and to order copies, call the Sales Office at the National Technical Information Service at (703) 605-6900 or email *info@ntis.gov.* Ask for titles in NOAA's Marine Flora and Fauna Series. Also available from the University of Maine Library System, *www.library.umaine.edu*

Description: Each of these circulars contains information, drawings and identification keys about a different group of marine organisms.

Pollock, L.W. 1998. ***A Practical Guide to the Marine Animals of Northeastern North America.*** New Brunswick, NJ: Rutgers University Press. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Description: Species identification key.

Watling, L., J. Fegley, and J. Moring. 2003. ***Life Between the Tides, Marine Plants and Animals of the Northeast.*** Gardiner, ME: Tilbury House.

Go to: *www.tilburyhouse.com/Maine%20Frames/me_tide_fr.html*

Description: See listing under B3.2 Macrophytes.

Crustaceans

Conkling, P. and A. Hayden. 2002. ***Lobsters Great and Small.*** Camden, ME: Down East Books.

Go to: *www.islandinstitute.org/programs.asp?section=publications*

Description: A description of the basis, activities and outcomes of the Penobscot Bay Marine Resources Collaborative Project. Between 1996 and 2001 lobstermen and scientists investigated the health and future of the bay's lobster resource.

New England Lobster Settlement Index.

Go to: *www.bigelow.org/srs/lobsterset.html*

Description: "The New England lobster settlement index is a sampling program supported by Maine, Rhode Island, and Massachusetts. The goal of the program is to evaluate the strength of lobster year classes as they first arrive by larval settlement in shallow, nearshore nurseries. The information obtained from the research can then be used in stock assessment, and in forecasting trends in the fishery."

Palma, A.T., R.S. Steneck, and C. Wilson. 1999. ***Settlement-driven, multiscale demographic patterns of large benthic decapods in the Gulf of Maine.*** *Journal of Experimental Marine Biology and Ecology* 241:107-136. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Abstract: "Three decapod species in the Gulf of Maine (American lobster Homarus americanus Milne Edwards, 1837, rock crab Cancer irroratus Say, 1817, and Jonah crab Cancer borealis Stimpson, 1859) were investigated to determine how their patterns of settlement and post-settlement abundance varied at different spatial and temporal scales. Spatial scales ranged from centimeters to hundreds of kilometers. Abundances of newly settled and older (sum of several cohorts) individuals were measured at different substrata, depths, sites within and among widely spaced regions, and along estuarine gradients. Temporal scales ranged from weekly censuses of new settlers within a season to inter-annual comparisons of settlement strengths. Over the scales considered here, only lobsters and rock crabs were consistently abundant in their early post-settlement stages. Compared to rock crabs, lobsters settled at lower densities but in specific habitats and over a narrower range of conditions. The abundance and distribution of older individuals of both species were, however, similar at all scales. This is consistent with previous observations that, by virtue of high fecundity, rock crabs have high rates of settlement, but do not discriminate among habitats, and suffer high levels of post-settlement mortality relative to lobsters. At settlement, large, habitat-scale differences exist for lobsters but not for rock crabs; these are probably the result of larval settling behavior. In contrast, patterns at the largest, inter-regional, spatial scales suggest oceanographic control of larval delivery. Increased mobility and vagility with greater body size for both species reduces demographic differences among older individuals over a range of spatial scales."

Reports from Volunteer-based Juvenile Lobster Monitoring Program, Lobster Conservancy.

Go to: *www.lobsters.org* Click on Volunteers in left-hand menu. Scroll down to see reports on juvenile lobsters in Maine's intertidal zone.

Description: "The Juvenile Lobster Monitoring Program measures the health and productivity of lobster nursery habitats over space and time by measuring the abundance and distribution of juvenile lobsters and using mark/recapture techniques to investigate growth rates and survival. TLC scientists have developed a set of rigorous training tools to teach volunteers how to become 'citizen scientists' by censusing lobsters at nursery grounds in the lower intertidal zone. Harboring 'baby' lobsters under rocks, these nursery sites are accessible once a month during the lowest low tides. The census data collected by volunteers are extremely valuable as indicators of lobster fishery health because the juvenile lobsters of today represent the catches of tomorrow."

Williams, A.B. 1984. ***Shrimps, Lobsters and Crabs of the Atlantic Coast.*** Washington, D.C.: Smithsonian Institution. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Mollusks

Abbott, R.T. and P.A. Morris. 1995. ***Shells of the Atlantic and Gulf Coasts and the West Indies: A Peterson Field Guide.*** Boston, MA: Houghton Mifflin.

GIS map layer for shellfish growing areas.

Go to: Maine Department of Marine Resources Public Health Division for current GIS data.

Description: The status of shellfish growing areas is monitored for the protection of public health.

Polychaete Worms

Appy, T.D., L.E. Linkletter, and M.J. Dadswell. 1980. **A Guide to the Marine Flora and Fauna of the Bay of Fundy: Annelida: Polychaeta.** Technical Report No. 920. St. Andrews, New Brunswick: Fisheries and Marine Service Biological Station. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Description: "42 families and l88 species of polychaetes known from the Bay of Fundy are distinguished in an illustrated dichotomous key. A description and the biology and distribution records are given for each species."

Pettibone, M.H. 1983. ***Marine Polychaete Worms of the New England Region.*** Smithsonian Institute. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Description: Includes species description, drawings, and key to identification.

Sea Urchins

Green Sea Urchins in Maine: Fishery, Monitoring, and Research Information, Department of Marine Resources.

Go to: *www.maine.gov/dmr/rm/seaurchin/research.htm*

Description: Includes reports on distribution and abundance of urchins along the Maine coast based on the sea urchin survey initiated in 2001. "DMR, with the cooperation of industry, the SUZC, and scientists and students at the University of Maine, began an annual spring sea urchin dive survey, funded by the industry. It is probably the most thorough urchin survey in the world. DMR and industry divers counted and measured urchins at 135 shallow sites, working from industry vessels. A remotely deployed video camera was used to view the bottom at 90 deeper sites. Crabs, starfish, and algal (seaweed) cover were evaluated. The survey has been repeated each year since 2001. 72 of the sites visited in 2001 were recommended by harvesters to be revisited each year. The rest are picked randomly from suitable bottom types and depths."

Taylor, P.H. 2004. ***Green Gold: Scientific Findings for Management of Maine's Sea Urchin Fishery.*** Boothbay Harbor, ME: Maine Department of Marine Resources.

Go to: *www.maine.gov/dmr/rm/seaurchin/greengold.pdf*

Description: This document provides an overview of the ecology and life history of sea urchins in Maine, as well as discussion of the management and future of the sea urchin fishery.

Tunicates

Plough, H.H. 1978. ***Sea Squirts of the Atlantic Continental Shelf from Maine to Texas.*** Baltimore, MD: Johns Hopkins University Press. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

B3.4 Fish

Ames, E.P. 2004. ***Atlantic Cod Stock Structure in the Gulf of Maine.*** Fisheries 29:10-28.

Go to: *www.penobscoteast.org/ames_research.asp*

Abstract: "Atlantic cod (*Gadus morhua*) in the Gulf of Maine provide an important but depleted fishery that needs to be made sustainable. However, restoring and maintaining robust population components to achieve sustainability is made difficult when their distribution and character is unknown. This study clarifies the structure of the Gulf of Maine cod grouping by deriving the distribution, movements, and behavior of population components from 1920s data and surveys of retired fishermen. These derivations are consistent with current cod populations and with the existence of localized spawning components. Nearly half the coastal spawning grounds of 50 to 70 years ago are abandoned today and their spawning components have disappeared, suggesting depletion, undetected by system-wide assessments, may have been well advanced by the 1980s."

Collette, B. and Klein-McPhee, G., eds. 2002. ***Bigelow and Schroeder's Fishes of the Gulf of Maine.*** Washington, D.C.: Smithsonian Institution Press.

Go to: *www.gma.org/fogm*

Description: This large volume contains drawings and descriptions of the fish species found in the Gulf of Maine.

Ecology of Groundfish Along the Maine Coast, Maine Department of Marine Resources.

Go to: *www.maine.gov/dmr/rm/groundfish.html*

Description: This Web page contains information about the life history of certain groundfish species, stock decline, and enhancement. Information about whom to contact with questions is also provided.

Fish Species of the Wells National Estuarine Reserve.

Go to: *www.wellsreserve.org/research/fish-brochure.pdf*

Description: "This brochure lists the 55 fish species found during surveys done between 1989 and 2001 in the Merriland River, Branch Brook, the Little River, the Webhannet River, and Wells Bay. Biologists used fish weirs, fyke nets, seine nets, minnow traps, and electrofishing to sample adults and juveniles, and ichthyoplankton nets to sample larvae." The brochure indicates whether adults and/or larvae were found, and where the fish were found (e.g., channel, marsh, salt panne). An indication of relative abundance is also provided.

GIS map layer for anadromous and catadromous fish, U.S. Fish and Wildlife Service Gulf of Maine Program.

Go to: *www.fws.gov/northeast/gulfofmaine/maps_data/index.htm*

Maine Office of GIS map layer for Atlantic salmon habitat (ASHAB3).

Go to: *apollo.ogis.state.me.us*

Description: "This dataset is designed to be used in a variety of management and planning activities including fry stocking, developing production estimates and habitat protection efforts. ASHAB3 contains arcs representing important Atlantic salmon habitat in Maine, suitable for mapping at 1:12,000 or smaller scale. This coverage was developed from field surveys conducted on the main stem and/or selected tributaries of the Aroostook, Dennys, Ducktrap, East Machias, Kennebec, Machias, Passagassawakeag, Penobscot, Pleasant, Presumpscot, Sheepscot, St. George, Tunk and Union Rivers in Maine by staff of the Maine Atlantic Salmon Commission and U.S. Fish and Wildlife Service. These surveys were conducted to identify important Atlantic salmon habitat including spawning and rearing areas. The majority of the survey data was collected using Trimble Pro, Pro-XL and GeoExplorer3 receivers and survey files were differentially corrected to provide 2-5 meter accuracy. Surveys for some reaches were collected with minimal or no GPS control points and the attributes were overlaid on a stream centerline created using either a GPS-acquired line, a line derived from MEGIS/USGS 1:24,000 hydrography data, or a line drawn as a centerline based on MEGIS 1-meter Digital Orthophotography. The dataset includes information on habitat categories and areas, and an indication of spawning and rearing potential, as well as detailed attribute information concerning stream dimensions, substrates, vegetation, and other stream characteristics."

GIS map of historic spawning grounds for Atlantic cod and haddock based on work of Ted Ames, available on request from the Island Institute, Rockland, ME.

Go to: *www.islandinstitute.org/resources.asp?section=maps* and for information on the mapping project that developed the data go to *www.penobscoteast.org/documents/commercialfisheries.pdf*

Description: Map layers of spawning grounds carefully developed through interviews with fishermen and supplementary research.

Jury, S.H., J.D. Field, et al. 1994. **Distribution and abundance of fishes and invertebrates in North Atlantic estuaries.** NOAA NOS Strategic Environmental Assessments Division, ELMR (No. 13). Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Description: This report presents information on the spatial and temporal distribution, relative abundance, and life history characteristics of 58 species of fishes and invertebrates in 17 estuaries between Cape Cod and the Canadian border.

List of fish species targeted by recreational fishermen in the Gulf of Maine, Maine Department of Marine Resources.

Go to: *www.maine.gov/dmr/rm/speciesinformation.htm*

Description: This Web page contains general information on these fish species and indicates whether each is found inshore, offshore, or both.

Matthiessen, G.C. 2007. ***Forage Fish and the Industrialized Fishery.*** Ipswich, MA: Quebec-Labrador Foundation, Inc.

Go to: *www.qlf.org*

Description: Drawings and descriptions of principal forage fish species in the U.S. Gulf of Maine and their population status.

Watling, L., J. Fegley, and J. Moring. 2003. ***Life Between the Tides, Marine Plants and Animals of the Northeast.*** Gardiner, ME: Tilbury House.

Go to: *www.tilburyhouse.com/Maine%20Frames/me_tide_fr.html*

Description: See listing under B3.2 Macrophytes.

B3.5 Marine Birds

Birds of the Wells National Estuarine Research Reserve.

Go to: *www.wellsreserve.org/research/bird-list.pdf*

Description: "These 235 species have occurred at the Wells Reserve since recordkeeping began in the 1980s. The list follows the AOU Check-list of North American Birds." It indicates which season(s) each species is present.

Christmas Bird Count, National Audubon Society.

Go to: *www.audubon.org/bird/cbc/* Click on Current Year's Results. On the next page, fill in the query to find data by species and location. Or click on Historical Results in the menu for data from past years.

Description: "More than 50,000 observers participate each year in this all-day census of early-winter bird populations. The results of their efforts are compiled into the longest running database in ornithology, representing over a century of unbroken data on trends of early-winter bird populations across the Americas. Simply put, the Christmas Bird Count, or CBC, is citizen science in action."

Checklist of Maine's birds, Maine Audubon.

Go to: *www.maineaudubon.org/nature/checklist.shtml*

Description: This Web site presents a list of all bird species observed in Maine, including seabirds. The site also indicates whether the species is declining.

Distribution maps for marine mammals, seabirds, and sea turtles, Ocean Biogeographic Information System and Duke University.

Go to: *obis.env.duke.edu/map/main/viewer.pmap* Click on Select Animals to choose a species to view. You need to know the scientific name of the species.

Description: "As part of the Ocean Biogeographic Information System (OBIS), a group of investigators, led by Andrew Read of Duke University, will create a digital database of marine mammal, seabird, and sea turtle distribution and abundance. Partners with Duke include UC San Diego, University of Washington, College of the Atlantic, St. Andrews University, British Antarctic Survey, SAHFOS, NMFS Southeast Fisheries Center, and several industries. The Web-based system will allow the interactive display, query, and analysis of Digital Archive in conjunction with environmental data." This site is a work in progress but there is a large amount of data available currently on seals, sea turtles, whales, dolphins, and seabirds.

eBird Mapping Site, National Audubon Society and Cornell Ornithology Lab.

Go to: *www.ebird.org/content/* Click on View and Explore Data in the menu. Then click on Create Maps and Graphs to generate results on sightings of a species by date and location.

Description: "eBird, a project developed by the Cornell Lab of Ornithology and the National Audubon Society, provides a simple way for you to keep track of the birds you see anywhere in North America. You can retrieve information on your bird observations, from your backyard to your neighborhood to your favorite bird-watching locations, at any time for your personal use. You can also access the entire historical database to find out what other eBirders are reporting from across North America. In addition, the cumulative eBird database is used by birdwatchers, scientists, and conservationists who want to know more about the distributions and movement patterns of birds across the continent."

Essential habitat maps for bald eagles, piping plovers, least and roseate terns.

Go to: *megisims.state.me.us/Website/mdifweh/viewer.htm* or *www.state.me.us/ifw* Click on Essential Habitat in the left hand menu. Click on Introduction to Essential Habitat. Click on Essential Wildlife Habitat Maps. Then click on Essential Wildlife Habitat Internet Mapping Service. Use the zoom tool to focus on the desired area.

Description: This is an interactive mapping site by the Maine Department of Inland Fisheries and Wildlife that presents information on essential habitat in Maine for bald eagles, piping plovers, least terns, and roseate terns**.**

Maine Office of GIS map layer of Piping Plover and Least Tern Essential Habitat (EHPVTRN).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "EHPLVTRN contains piping plover and least tern nesting, feeding, and brood-rearing areas identified and mapped as Essential Habitat by the Maine Department of Inland Fisheries and Wildlife (MDIFW). This dataset contains both LINE and POLYGON topology, and both are needed to accurately depict Piping Plover/Least Tern Essential Habitats."

Great Backyard Bird Count, National Audubon Society and Cornell Lab of Ornithology.

Go to: *www.birdsource.org/gbbc/* Click on View Results. Click on State Tallies and then select Maine. Scroll down and select "see list of localities in Maine with reports." Click on a locality to see the information broken down by species.

Description: This Web site provides access to data taken by citizens during the Great Backyard Bird Count. Data include the number of individuals of a species that observed during the count by state, by year, and by participating towns. These data are most helpful in obtaining a list of species that occur in a given area.

List of Birds Found on the Petit Manan Wildlife Refuge (now known as Maine Coastal Islands National Wildlife Refuge).

Go to: *library.fws.gov/refuges/Petit_Manan_Birds.pdf*

Description: "This document provides a list of the over 300 bird species that have been identified on the islands of the refuge. The list also identifies whether the birds nest in the refuge, whether they are threatened or endangered, and which season(s) they are observed in the refuge. The Maine Coastal Islands National Wildlife Refuge contains 47 offshore islands and three coastal parcels, totaling more than 7,400 acres. The complex spans more than 150 miles of Maine coastline and includes five national wildlife refuges: Petit Manan, Cross Island, Franklin Island, Seal Island, and Pond Island."

Pierson, E.C., J.E. Pierson, and P.D. Vickery. 1996**.** ***Birder's Guide to Maine.*** Camden, ME: Down East Books.

Description: "A guide to where and when to see Maine's inland and coastal birds. There are maps, directions, background information about an area, and hints for observing the birds."

Project Puffin, National Audubon Society.

Go to: *www.audubon.org/bird/puffin/* Click on Seabird Research News. Scroll down on the next page to see reports from islands in the Gulf of Maine that serve as seabird habitat.

Description: The reports deal mostly with terns and puffins.

B3.6 Marine Mammals and B3.7 Sea Turtles

Clapham, P., J. Barlow, M. Bessinger, T. Cole, D.D. Mattila, R. Pace, D. Polka., J. Robbins, and R. Seton. 2003. **Abundance and demographic parameters of humpback whales from the Gulf of Maine, and stock definition relative to the Scotian Shelf.** *Journal of Cetacean Research and Management* 5:13-22.

Distribution maps for marine mammals, seabirds and sea turtles, Ocean Biogeographic Information System and Duke University.

Go to: *www.iobis.org/*

Description: See listing under B3.5 Marine Birds.

Sea Turtle Program, National Marine Fisheries Service's Northeast Regional Office.

Go to: *www.nero.noaa.gov/prot_res/seaturtles/*

Description: General information page with internet links.

Katona, S.K., V. Rough, and D.T. Richardson. 1993. ***A Field Guide to Whales, Porpoises and Seals From Cape Cod to Newfoundland.*** Washington, D.C.: Smithsonian Institution Press.

Recent Whale Sightings Interactive Map, Maine Department of Marine Resources Large Whale Take Reduction Program.

Go to: *megisims.state.me.us/WhaleSightings/*

Description: This interactive mapping page allows the user to view locations of sightings of large whale species within the Gulf of Maine. Data are categorized by species and by the time frame of the sighting (ranging from the past day to the past year). Histori-

cal data are also available. "The Voluntary Sightings Network is comprised of members of the Maine commercial fishing industry, Maine Marine Patrol (MMP), whale watch vessels, and other mariners (ship pilots, ferry captains, tugboat pilots, recreational boaters, sailors). All large whale sightings can be reported to the Maine Whale Plan Coordinator using the upgraded state-wide toll free Maine Marine Animal Reporting Hotline. Once verified, whale sightings are fed into the Web-based GIS application by staff at the Department of Marine Resources (DMR) in West Boothbay Harbor and are immediately viewable to the public on the Maine Whale sightings page."

U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments. NOAA Technical Memorandum NMFS-NE-162. U.S. Department of Commerce.

Go to: *www.nefsc.noaa.gov/nefsc/publications/tm/tm169/*

Description: "Under the 1994 amendments of the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS) were required to generate stock assessment reports (SAR) for all marine mammal stocks in waters within the U.S. Exclusive Economic Zone (EEZ)... The current (2002) report contains updated assessments for Atlantic strategic stocks and for any additional stocks which had significant new information available."

Human Dimensions

General

These general resources can be used to develop a story of change for an area, a harbor, a town, or a watershed. For example, some of the resources indicate locations and types of industries that historically were located in the area.

Podmaniczky, C., and E. Shettleworth. 1981. ***Through a Bird's Eye: Nineteenth Century Views of Maine.*** Rockland, ME: Farnsworth Museum.

Description: Available at local historical societies. Some maps have been reproduced and are available commercially (e.g., Portland, Bangor). Detailed views of cities and towns created mainly in the 1870s and 1880s that show industries, waterfronts, residential areas, and sometimes farmland and streams.

Atlas of the State of Maine 1894-1895, 9th ed. West Paris, ME: Stuart.

Description: This atlas and other county maps and state atlases are available through historical societies, county commissioners offices, and local libraries. Several of the state atlases are at the State Library in Augusta and the Fogler Archive in the library of the University of Maine. Large wall maps of many Maine counties were published in the 1850s and 1860s. State of Maine atlases were printed in the 1880s and 1890s by various publishers. Maps typically show towns or portions of towns with roads, streams, rivers, and farmhouses, and are useful to understand development in a watershed.

Cronon, W. Jr. 1983. ***Changes in the Land: Indians, Colonists and the Ecology of New England.*** New York, NY: Hill and Wang.

Historical resources, State of Maine.

Go to: *www.maine.gov/portal/facts_history/*

List of local historical societies for Maine towns.

Go to: *www.maine.gov/portal/facts_history/historicalsoc.html*

Description: Municipal history, books, artifacts, reports, images.

Maine Historic Preservation Commission.

Go to: *www.maine.gov/mhpc/archaeology/index.html*

Description: Extensive information related to Native Americans, European colonization, and prehistoric and historic archaeology.

Maine Historical Society.

Go to: *www.mainehistory.com/*

Maine Memory Network.

Go to*: www.mainememory.net/bin/Browse*

Description: Historical photographs, maps, documents, and other information resources related to fishing, agriculture, maritime activities, and other human dimensions of Maine's coast. "Developed and managed by the Maine Historical Society, the Maine Memory Network enables historical societies, libraries, and other cultural institutions across the state to upload, catalog, and manage digital copies of historic items from their collections into one centralized, Web-accessible database. Through online exhibits, outreach, interactive tools, lesson

plans, in-school demonstrations, and other resources, the Maine Memory Network strives to help communities and schools learn about, celebrate, and share their local history. Visitors to the Web site can search, browse, sort, and easily access these historic items. With a free account, you can create your own collections of albums, add your own text, collaborate with friends and colleagues, and even create online exhibits. There are currently over 12,000 historic items from over 180 Contributing Partners in the database. Examples include:

- Letters, journals, notes, manuscripts, and other hand-written materials.
- Photographs, albumen prints, glass plate negatives, paintings, and other images.
- Sketches, woodcuts, broadsides, business cards, and other graphic items.
- Architectural and mechanical drawings, maps, and other oversized documents.
- Clothing, tools, household goods, archaeological artifacts, and other museum objects.
- Audio and video files."

Managing Maine's Nearshore Coastal Resources, Final Report of Bay Management Study.

Go to: *www.maine.gov/dmr/baystudy/baystudy.htm*

Description: Appendices are useful for various specific categories below.

Muscongus Bay Atlas. 2007. Quebec-Labrador Foundation, Inc.

Go to: *www.qlf.org* or *www.community-gis.org*

Description: Maps of land cover, commercial and recreation fishing grounds, kayaking and sailing areas, educational use areas, important wildlife, transportation and navigation and other characteristics of the bay, its estuaries, nine mainland towns and one year-round island community.

Sanborn Insurance Co. maps.

Go to: A Library of Congress publication lists all that have been published nationally: Fire Insurance Maps in the Library of Congress (Washington, 1981). Bowdoin College Library and the State Library have the microfilm edition in eight reels. However, it is in black and white only and loses the color-coding for building material, height, roof form, and other features. Volumes for individual towns and cities can sometimes be found at a County Recorder of Deeds office, a town planning department, or a local historical society. The History Room at the Bangor Public Library has access in its basement storage to cataloged, bound Sanborn Insurance Co. maps for some towns.

Description: Published periodically between the 1800s and 1960s for Maine towns and cities. Color-coded footprint maps showing streets, commercial and industrial buildings, watercourses, and sometimes sewer outflows (e.g., Portland) and gasoline tanks (e.g., Bath).

Sewer maps.

Go to: Maps may be available at public works department (e.g. Portland) or engineering office (e.g., Bangor).

Description: Available for some areas (e.g., Portland) showing not only locations of sewer lines but also direction of flows. The latter reveals historic watersheds because early sewers typically were built in streams and went downhill to a body of flowing water.

State of the Bay 2005 Report maps, Casco Bay Estuary Partnership.

Go to: *www.cascobay.usm.maine.edu/maps.html*

Description: Maps of population changes, impervious surface, conserved lands, eelgrass distribution, and other characteristics of towns around Casco Bay.

Year-by-year descriptions of harbors, rivers, estuaries, and bays.

Go to: Army Corps of Engineers Annual Reports. Reports from the twentieth century were published by the U.S. Department of War and then the U.S. Department of Defense. Nineteenth-century reports were released, as were most government documents of the period, as House or Senate publications. The 1883 report is in Senate Exec. Doc. No. 44, 48th Congress, 1st Session. The 1887-88 report appeared in House Exec. Doc. No. 133, 50th Congress, 1st Session. Some nineteenth-century reports have useful charts of the rivers and harbors. Available at libraries of Bowdoin College and University of Maine.

Description: The Corps reported on every river and bay where they worked, e.g., where dredging would be done, the locations of shoals, what features were subject to blasting, and the actual work carried out. Reports are voluminous until the 1980s because

projects had to be described every year until completed and for some time after completion. By comparing reports, it is possible to determine the evolution of a harbor with its industrial and commercial uses. The lengthy reports stopped in the 1980s.

H1 Human Population

Maine Census Data Program.

Go to: *www.maine.gov/spo/economics/census/*

Description: This site is intended to facilitate public access to the services of the Maine Census Data Center Program by providing information about and electronic links to participating organizations. It also provides information about and electronic links to numerous sources of data likely to be of interest to users of Census data. In addition, the site provides answers to common information requests.

Maine census interactive Web site, University of Maine.

Go to: *www.library.umaine.edu/census/*

Description: This site allows the user to search census data from 1790 to 2000. Searches can be conducted in terms of trends or thresholds and by area (municipality, locality, etc.).

Maine state census through time, Maine Historical Society.

Go to: *www.mainehistory.com/library_search.shtml*
In the library search engine type "Maine" and "census" to see a listing of census results by date (from 1790 to 1920).

Thorndale, W., and W.D. Bountiful. 1987. ***Map guide to U.S. federal censuses: Maine 1790-1920.*** Utah: American Genealogical Lending Library. Available from the Maine Historical Society library.

H2 Community Economic Profile

Directory of local chambers of commerce.

Go to: *www.mainechamber.org/local_chambers.asp*

Description: Local chambers of commerce usually have a list of many of the businesses and industries in an area.

Maine Census Data Program.

Go to: *www.maine.gov/spo/economics/census/*

Description: This site is intended to facilitate public access to the services of the Maine Census Data Center Program by providing information about and electronic links to participating organizations. It also provides information about and electronic links to numerous sources of data likely to be of interest to users of Census data. In addition, the site provides answers to common information requests.

New England Fishing Communities, MIT Sea Grant.

Go to: *web.mit.edu/seagrant/aqua/cmss/marfin/index.html*

Description: Sections 5.8-5.11 profile 14 Maine fishing communities and eight fishing counties. "This report takes several approaches to identifying New England's fishing communities and ranking their dependency. One approach is based on a regional consideration of fisheries-related employment compared to alternative employment. Another approach focuses on fishing structure complexity and degrees of individual communities' gentrification, and finally, the third approach offers community profiles that detail individual ports' characteristics with some attention to stakeholders' views on their community, way of life, institutions, and fisheries management."

MIT Sea Grant report from Community Panels project.

Go to: *web.mit.edu/seagrant/aqua/cmss/comm%20mtgs/commmtgs.html*

Description: Two Maine communities are profiled in this study, Beals Island/Jonesport and Portland, Maine. "The Massachusetts Fishermen's Partnership's Community Panels Project, funded by the Northeast Consortium and Saltonstall-Kennedy grants, is focusing on 6 communities: Beals Island/Jonesport and Portland, Maine; Gloucester, Scituate and New Bedford, Massachusetts; and Point Judith, Rhode Island. MIT Sea Grant College Program's anthropologist, Dr. Madeleine Hall-Arber, is the project leader with Dr. Bonnie McCay of Rutgers University and David Bergeron of the MFP as co-principal investigators. The six communities in the study represent the variety of characteristics found in New England's fishing industry including inshore/offshore, large/small vessels; urban/rural communities; fish/shellfish products; mobile/fixed gear; auction/entrepreneur-dealer."

H3 Land Ownership

County Registry of Deeds.

Go to: *www.mainelandrecords.com/melr_me005/MelrApp/index.jsp* or conduct an internet search for the registry in a particular county.

Description: Research on past ownership of any particular property or special conditions of current ownership, such as a right of way, can also be found through a title search.

Local land trust listing, Maine Land Trust Network.

Go to: *www.mltn.org*

Description: Some land trusts have worked with towns to create GIS data layers of town tax maps. They might be willing to share this digital data.

Municipal tax maps.

Go to: Your local town office to view land parcel maps.

Description: Some may be in print form only while others may be available as a GIS data layer. Ownership of individual parcels may be listed on the maps or in the most recent town report. Also available are which parcels are under special tax reduction programs.

H4 Land Use and Land Cover

Maine Office of GIS map layer for land cover (MELCD).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "MELCD is a land cover map for Maine primarily derived from Landsat Thematic Mapper 5 and 7 imagery, from the years 1999-2001. This imagery constitutes the basis for the National Land Cover Dataset (NLCD 2001) and the NOAA Coastal Change Analysis Program (C-CAP). This land cover map was refined to the State of Maine requirements using SPOT 5 panchromatic imagery from 2004. The Landsat imagery used was for three seasons: early spring (leaf-off), summer, and early fall (senescence) and was collected with a spatial resolution of 30 m. The SPOT 5 panchromatic imagery was collected at a spatial resolution of 5 m during the spring and summer months of 2004. The map was developed in two distinct stages, the first stage was the development of a state wide land cover data set consistent with the NOAAC-CAP land cover map. The second stage was: a) the update to 2004 conditions, b) a refinement of the classification system to Maine specific classes and, c) a refinement of the spatial boundaries to create a polygon map based on 5 m imagery."

Land Cover Analysis, NOAA Coastal Services Center.

Go to: *www.csc.noaa.gov/crs/lca/*

Description: This Web site provides land cover mapping data, tools, and assistance to the coastal management community. The NOAA Coastal Services Center works with resource managers and mapping professionals to promote the use of land cover mapping to address coastal management issues.

H5 Fisheries and Fishing Industries

Fishing grounds by gear, MIT Sea Grant.

Go to: *web.mit.edu/seagrant/aqua/cfer/index.html or web.mit.edu/seagrant/aqua/cfer/GearMapping/GearMapping.html*

Description: MIT Sea Grant has been mapping the types of gear used on different fishing grounds.

Fishing grounds by port.

Go to: *geography.rutgers.edu/people/faculty/stmartin/research.html*

Description: Faculty in the Department of Geography at Rutgers University have mapped the relationship between fishing grounds and fishing ports to show which offshore grounds are predominantly fished by which ports.

Maine Office of GIS layer of commercially harvested worm habitat (WORM).

Go to: *apollo.ogis.state.me.us*

Description: "WORM provides a generalized representation at 1:24,000 scale of commercially harvested marine worm habitat in Maine, based on Maine Department of Marine Resources data from 1970s. Original maps were created by MDMR and published by USF&WS as part of the Ecological Characteristics of Coastal Maine."

Maine Office of GIS map layer of herring weirs (WEIR90).

Go to: *apollo.ogis.state.me.us*

Description: "WEIR90 shows point locations of herring weirs in Maine based on 1990 overflight by MDMR Marine Patrol, mapped at an approximate scale of 1:100,000. Data were screen digitized from paper maps used during the overflight."

Good, G.B. 1884. **Fisheries and Fishery Industries of the U.S. Washington, D.C.: Government Printing Office.** Available from the State Library, Bowdoin College library, and University of Maine Library System.

Go to: *www.library.umaine.edu*

Description: This publication contains a chapter on "The Coast of Maine and Its Fisheries" by R. Edward Earll.

Landings Data, National Marine Fisheries Service Fisheries Statistics Division.

Go to: *www.st.nmfs.gov/st1/index.html* Click on Commercial Fisheries or Recreational Fisheries.

Description: This Web site allows users "to query our commercial fishery data bases and summarize United States domestic commercial landings in several formats. Domestic fishery landings are those fish and shellfish that are landed and sold in the 50 states by U.S. fishermen and do not include landings made in U.S. territories or by foreign fishermen. You can summarize the pounds and dollar value of commercial landings by your choice of years, months, states and species for the years 1990 onwards. The volume and value of 1950 onwards landings can be summarized by: years, states and species; by years, states, species and fishing gears; or years, states, species, finfish or shellfish groups, and price per pound."

Lotze, H.K. and I. Milewski. 2004. **Two successive centuries of multiple human impacts and successive changes in a North Atlantic food web.** *Ecological Applications* 14(5):1428-1447.

Go to: *conservationcouncil.ca/marine/marine_quoddy_publications.html*

Abstract: "European colonization of North America severely altered terrestrial and aquatic ecosystems alike. Here, we integrate archaeological, historical, and recent data to derive the ecological history of the Quoddy Region, Bay of Fundy, Canada, an upwelling region rich in marine diversity and productivity. We document successive changes on all trophic levels from primary producers to top predators over the last centuries. Our objectives were to (1) construct a baseline of what was natural in the coastal ocean, and (2) analyze the sequence and potential interaction of multiple human impacts. Archaeological records highlight the abundance and diversity of marine species used by indigenous people over the last 2000–3000 years. Europeans colonized the area in the late 1700s and rapidly transformed the environment by multiple 'top-down' (exploitation), 'bottom-up' (nutrient loading), and 'side-in' (habitat destruction, pollution) impacts. Most large vertebrates were severely overexploited by 1900, leading to the extinction of three mammal and six bird species. Diadromous fish dramatically declined after river damming in the early 1800s, and recovery was prevented by subsequent river pollution. Over-fishing of groundfish stocks started in the late 1800s, gradually leading to a final collapse in the 1970s. In the 20th century, decline of traditional fisheries induced a shift to low trophic level harvesting and aquaculture, which increased exponentially over the past 20 years. Eutrophication caused shifts in seaweed and phytoplankton communities: Some long-lived rockweeds were replaced by annual bloom-forming algae, and diatoms were replaced by dinoflagellates. Today, the once unique Quoddy Region shows the most common signs of degradation found in highly impacted coastal areas worldwide. Multiple human influences have altered abundance and composition of every trophic level in the food web and reduced upper trophic levels by at least one order of magnitude. We highlight cumulative and indirect effects that impair the ability to predict and manage highly impacted coastal ecosystems. On the other hand, simple protection and restoration measures in the 20th century led to the recovery of some species. It is these successes that provide guidance for a more sustainable interaction of humans with their marine environment."

NOAA Fisheries Northeast Regional Office landings reports.

Go to: *www.nero.noaa.gov/fso/ Click on Weekly Quota-Landing Reports. On the next page, select the desired species.*

Description: The data are divided by state.

Rich, W. 1929. ***Fishing Grounds of the Gulf of Maine*** (reprint). Augusta, ME: Maine Department of Marine Resources.

Description: Hand-drawn maps and brief descriptions of areas fished (principally outside of bays and beyond) and the species caught in the early 1900s in the Gulf of Maine and Bay of Fundy. Originally published by the U.S. Dept. of Commerce, Bureau of Fisheries.

Status of Fishery Resources off the Northeastern United States, NOAA Northeast Fisheries Science Center.

Go to: *www.nefsc.noaa.gov/sos/spsyn/ Click on "42 species" in the text of this page to see a list of species, then navigate to the desired data.*

Description: "The synopses of information on the status of the stocks of the 42 species or groups of species presented in this section are based on commercial and recreational fishery data and on research survey data, as described in the Introduction to this report. Each synopsis briefly reviews the biology of the animals and the general nature of the fishery, summarizes recent catch statistics and stock assessment results and indicates the general status of the stock. For each stock or species a summary table of recent catches is presented, along with graphs depicting trends in landings, stock abundance, fishing mortality, age structure and other pertinent results from the most recent stock assessment. The measures of stock abundance include research vessel survey catch per tow indices and estimated stock size from age structured or biomass dynamics models."

Steneck, R.S. 1997. Fisheries-induced biological changes to the structure and function of the Gulf of Maine Ecosystem, pp. 151-165 in ***Proceedings of the Gulf of Maine Ecosystem Dynamics Scientific Symposium and Workshop*** (G.T. Wallace and E.F. Braasch, eds.) RARGOM Report 91-1. Hanover, NH: Regional Association for Research on the Gulf of Maine. Available from the University of Maine library system.

Go to: *www.library.umaine.edu*

Abstract: "Atlantic cod and other large predatory groundfish were important components of near shore marine habitats in the Gulf of Maine for over four thousand years. They were harvested over most of that time by hook and line through the 1920s. In the 1930s otter trawls and other technological improvements allowed for the efficient harvesting of spawning stocks and by the end of the 1940s groundfish stocks in coastal zones were said to be depleted. Studies conducted over the past 109 years document this rapid decline of coastal fishing grounds and changes in average body size of cod. Several decades later, harvesting caused the decline of the offshore groundfish on Georges Bank. Dominant fish predators were replaced by commercially less important species, such as sculpins, in coastal zones and dogfish and skate on Georges Bank. Today large predatory finfish are functionally absent from vast regions of the Gulf of Maine. This loss of the top trophic level for benthic systems may have fundamentally altered food webs, with lobsters, crabs and sea urchins increasing in abundance in coastal zones. Fisheries-induced changes there have continued with the sequential targeting of species at lower trophic levels. The recently developed industry for herbivorous sea urchins has resulted in increases in kelp and other macroalgae. This may increase productivity, habitat and the recruitment potential for some species in coastal zones. If true, such cascading changes to both the structure and function of the Gulf of Maine ecosystem may make predictions difficult or impossible."

H6 Maritime Transport and Commerce

Baker, W.A. 1974. ***Maine Shipbuilding, A Bibliographical Guide. Portland, ME: Maine Historical Society.*** Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

Dredged areas, U.S. Army Corps of Engineers, New England section.

Go to: *www.nae.usace.army.mil/* Digital mapping information can be found at *http://www.usace.army.mil/howdoi/where.html#Maps*

Description: For more details and help in finding the most recent information as well as historical data, the Army Corps of Engineers local office is located in Manchester, Maine.

Maine Maritime Museum Library in Bath, Maine.

Go to: *www.bathmaine.com/research/library.cfm*

Description: The Library contains information on every aspect of Maine maritime history and coastal life. There is a concentration of material related to shipbuilding, the maritime history of the Kennebec River region, and Bath history.

Maritime Maine Heritage Trail Bibliography of Resources.

Go to: *www.maritimemaine.org/biographysources.aspx*

Description: "[A] bibliography of sources on Maine maritime history. This is by no means an exhaustive work, and additions, corrections and other suggestions are welcome. For help in locating these works, contact your maritime history museum, historical society or local library."

Navigational aids, lighthouses, and deep draft vessel routes, NOAA.

Go to: *chartmaker.ncd.noaa.gov/mcd/enc/download.htm* for electronic navigational charts.

Description: "The NOAA Electronic Navigational Charts are a geo-referenced database(s) of NOAA nautical chart features and their attributes, published by NOAA in the format of the International Hydrographic Organization S-57 Standard, IHO Transfer Standard for Digital Hydrographic Data. NOAA updates the ENCs for Notice to Mariners on a weekly basis (timing of their availability is not guaranteed)."

Go to: *chartmaker.ncd.noaa.gov/mcd/Raster/Index.htm* for raster navigational charts.

Description: In the United States, all official nautical paper charts produced by NOAA's Office of Coast Survey (OCS) are available in raster format. A fundamental tool of marine navigation, NOAA's Raster Navigational Charts (NOAA RNCs™) are produced by scanning at high resolution the original color separates, which are used to print the paper charts. NOAA adds to the digital raster file such features as data describing the chart, its datum, projection, and its geo-reference. Geo-referencing enables a computer-based navigation system that is connected to a GPS to locate and display on the chart image on screen the vessel's exact position.

Stephen Phillips Memorial Library at the Penobscot Marine Museum, Searsport, Maine.

Go to: *www.penobscotmarinemuseum.org/libraryresearch.html*

Description: "The library serves as the museum's research center, providing access to books, manuscripts, photographs, nautical charts, maps, and boat plans. In addition to our strong collections in maritime history, with an emphasis on mid-coast Maine, we also have very important collections in Maine history and genealogy."

H7 Marine research and monitoring sites and facilities

Fisheries and aquaculture, aquatic habitat, climate change, coastal development, contaminants, eutrophication, Ecosystem Indicator Partnership (ESIP) Monitoring Map.

Go to: *www.gulfofmaine.org/esip/map*

Description: The Ecosystem Indicator Partnership (ESIP) is a committee of the Gulf of Maine Council on the Marine Environment. ESIP is developing indicators for the Gulf of Maine and integrating regional data for a new Web-based reporting system for marine ecosystem monitoring. Activities of ESIP initially center on convening regional practitioners in six indicator areas: coastal development, contaminants and pathogens, eutrophication, aquatic habitat, fisheries and aquaculture, and climate change.

GIS data illustrating the locations of long term monitoring or survey work can be also be obtained directly from the researchers. For example:

- **Marine biotoxin monitoring, water quality monitoring, rain gauge, and phytoplankton monitoring stations, Public Health Division of the Department of Marine Resources.**
  Go to: *www.maine.gov/dmr/healthsafety.htm*
- **Maine-New Hampshire Inshore Trawl Survey, Ecology Division at the Department of Marine Resources.**
  Go to: *www.maine.gov/dmr/rm/trawl/index.htm*
- **Green urchin survey, Biological Assessment and Monitoring Division at the Department of Marine Resources.**
  Go to: *www.maine.gov/dmr/rm/seaurchin/research.htm*
- **Recreational island usage data, Maine Island Trail Association.**
  Go to: *www.mita.org*
- **Location of juvenile lobster survey stations, The Lobster Conservancy, Friendship, ME.**
  Go to: *www.lobsters.org*
- **Seabird surveys, Maine Coastal Islands National Wildlife Refuge (formerly named Petit Manan National Wildlife Refuge) U.S. Fish & Wildlife Service.**
  Go to: *www.fws.gov/northeast/mainecoastal/*
- **Ocean observing buoys, GoMOOS.**
  Go to: *www.gomoos.org/*
- **Long-term hydrographic surveys,** University of Maine School of Marine Sciences.
  Go to: *www.umaine.edu/marine/*

National Buoy Data Center

Go to: *www.ndbc.noaa.gov/maps/Northeast.shtml*

Marine research facilities. Some of the marine laboratories, field and research stations in Maine include:

- Bigelow Laboratory for Ocean Sciences, Sheepscot River
- Center for Cooperative Aquaculture Research, Taunton Bay
- Downeast Institute for Applied Research & Education, Great Wass Island
- Gulf of Maine Research Institute, Casco Bay
- Marine Environmental Research Institute, Blue Hill Bay
- Mount Desert Island Biological Laboratory, Frenchman Bay
- Suffolk University R.S. Friedman Field Station, Cobscook Bay
- University of Maine Darling Marine Center, Damariscotta River
- University of New England, Marine Science Center, Saco Bay
- University of Southern Maine, Casco Bay
- West Quoddy Biological Research Station, Cobscook Bay

H8 Transportation infrastructure

Maine Office of GIS map layer for airports, air strips, seaplane bases (MEAIR).

Go to: *megisims.state.me.us/metadata/meair.htm*

Description: "MEAIR includes point locations of airports in Maine from USGS 1:100,000 scale DLG files. Data for this coverage were compiled by MEGIS staff in 1999. Seaplane base locations were generated from lat-long coordinates. The coverage was updated in August 1995 by MEGIS staff using the latest NOAA Airport/Facility Directory and NOAA Sectional Aeronautical Charts, and has been renamed from MEAIR100 to MEAIR. Codes were added at this time for a number of attributes including length of longest runway, runway surface, and fuel available."

Maine Office of GIS map layer for bridges (BRDGS).

Go to: *megisims.state.me.us/metadata/brdgs.htm*

Description: "BRDGS was created by Maine Department of Transportation to show locations of public bridges at 1:24,000 scale. This dataset was designed for use in applications within MEDOT. Only attribute is bridge number."

GIS map layer for culverts and catch basins, Maine Department of Transportation's Office of Transportation Reporting, Inventory and Mapping.

Go to: *www.maine.gov/mdot/systems_management/trim.php*

Maine Office of GIS map layers for railways (MERAIL24).

Go to: *megisims.state.me.us/metadata/merail24.htm*

Description: "MERAIL24 is a statewide railroad coverage for Maine at 1:24,000 scale. The data were extracted from USGS 1:24,000 DLG files by MEGIS staff in 1997, built the attribute tables and edge-matched the coverage across quadrangle boundaries. Arc attributes include railroad name, operator, track type (maineline, branch, siding, yard), status (active, inactive, abandoned) and remarks.

Maine Office of GIS layer of other transportation features (OTRANS, TRANS).

Go to: *megisims.state.me.us/metadata/otrans.htm or megisims.state.me.us/metadata/trans.htm*

Description: "OTRANS represents other transportation features - electric, pipeline, railroad, and telephone lines at 1:24,000 scale. Some New Hampshire and New Brunswick features are also included. Data for this coverage were digitized from USGS 1:24,000 scale quadrangle maps by various contractors. TRANS represents roads, trails, railroads, transmission lines, and pipelines in Maine at 1:100,000 scale. Data for this coverage were compiled from U.S. Geological Survey (USGS) 1:100,000 scale digital line graph files by J.W. Sewall Co., for the Maine Low-Level Radioactive Waste Authority in 1989."

Maine Office of GIS map layers for roads, ferry routes (E911RDS).

Go to: *megisims.state.me.us/metadata/e911rds_01062006.htm*

Description: "E911RDS contains updated road centerline and road name data for Maine at 1:24,000 scale. E911RDS digital roads were developed, and are maintained, to serve the Enhanced 911 project in Maine."

H9 Manufacturing sites

Facility compliance and enforcement records, Environmental Protection Agency.

Go to: *www.epa-echo.gov/echo/*

Description: EPA's searchable database called ECHO is where users can locate and learn about the compliance and enforcement status of facilities with state and/or federal permits.

Local records

Local comprehensive plans available at town offices (and/or on town Web sites) often list manufacturers in the municipality. Sometimes information on historical facilities is also included.

Sites with NPDES permits (industrial wastewater discharge sites), Bureau of Land and Water Quality, Maine Department of Environmental Protection.

Go to: *www.maine.gov/dep/blwq/docstand/municipal_industrial/index.htm or cfpub.epa.gov/npdes/*

Sites with air emission discharge licenses (industrial air emission sites), Bureau of Air Quality, Maine Department of Environmental Protection.

Go to: *www.maine.gov/dep/air/licensing/index.htm*

H10 Natural resource use

Managing Maine's Nearshore Coastal Resources, Maine Coastal Program.

Go to: *www.maine.gov/spo/mcp/baymanagementreport.php*

Description: Appendix B has information on current uses and anticipated trends.

Local comprehensive plans available at town offices (and/or on town Web sites) usually have a section on natural resources of the municipality.

Agriculture

Agricultural fact sheets by county, Maine Department of Agriculture.

Go to: *www.maine.gov/agriculture/mpd/farmland/mainecountymap.html*

Description: County fact sheets give information on the acreage devoted to farming along with the economic value of various crops by county.

Census of Agriculture, U.S. Department of Agriculture National Agriculture Statistics Service.

Go to: *www.nass.usda.gov/census/*

Description: These comprehensive databases and documents contain recent and historical information on the economics and demographics of farming in Maine. Data are available at the state or county level.

Day, C.A. 1954. ***A History of Maine Agriculture, 1604-1860.*** Orono, ME: University of Maine Press.

Day, C.A. 1963. ***Farming in Maine, 1860-1940.*** Orono, ME: University of Maine Press.

Maine Association of Soil and Water Conservation Districts.

Go to: *www.maineswcds.org/index.htm*

Maine Department of Agriculture.

Go to: *www.maine.gov/agriculture/index.shtml*

Natural Resources Conservation Service, U.S. Department of Agriculture.

Go to: *www.me.nrcs.usda.gov/*

Logging

Coolidge, P.T. 1963. ***History of the Maine Woods.*** Bangor, ME: Furbush-Roberts.

Maine Office of GIS map layer on woodlots (MEOWN250).

Go to: *apollo.ogis.state.me.us/catalog/*

Description: "MEOWN250 describes industrial, non-industrial, and public woodlot ownership in Maine at 1:250,000 scale. Industrial owners are those having at least one primary wood processing facility. Non-industrial owners are those with no primary wood processing facility. Public ownership includes property which is owned by either a local, state, or federal entity. Individual owners are NOT identified in this coverage. State, town, and coastline arcs in this coverage most closely match those of the 1:250,000 scale coverage METWP250. Data for this map were provided by the J.W. Sewall Co. to the Northern Forest Land Survey in 1993. Information in this coverage is NO LONGER CURRENT and should be used with caution. The dataset MECNSLND contains information on conservation lands ownership boundaries for Maine land in federal, state, and non-profit own-

ership with easements. MEOWN250 was created to identify major industrial, non-industrial, and public woodlot ownership."

Judd, R.C. 1989. ***Aroostook: A Century of Logging in Northern Maine.*** Orono, ME: University of Maine Press.

Maine Forest Service.

Go to: *www.maine.gov/doc/mfs/index.shtml*

Description: Links to publications and resources on the status of Maine's forests.

Patten Lumbermen's Museum.

Go to: *www.lumbermensmuseum.org*

Smith, D.C. 1961. ***A History of Lumbering in Maine, 1861-1960.*** Orono, ME: University of Maine Press.

The Forests of Maine, 2003, USDA Forest Service.

Go to: *www.fs.fed.us/ne/fia/states/me/ME5yr.html*

Description: "In 1999, the Maine Forest Service (MFS) and the USDA Forest Service's Forest Inventory and Analysis (FIA) program implemented a new system for inventorying and monitoring Maine's forest resources. The following is a summary of resource conditions, a prospective future outlook, and policy implications related to the principal findings of this report."

Wood, R.G. 1935. ***A History of Lumbering in Maine, 1820-1861.*** Orono, ME: University of Maine Press.

Mining/Quarrying

History of Quarrying in Maine, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/explore/mining/quarry.htm*

Mining in Maine: Past, Present, and Future, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/explore/mining/minemaine.htm.*

Virtual Tour of Maine's Mines and Quarries, Maine Geological Survey.

Go to: *www.maine.gov/doc/nrimc/mgs/explore/mining/virtual/slides.htm*

Geological publications, Maine Geological Survey.

Go to: *megisims.state.me.us/DOC_IMS/viewer.jsp?MODE=mgs_pubs*

Description: This interactive map enables searches by geography and keyword for publications on Maine mining history, maps of mineral resources, and mining reports.

King, V. 1994. ***The Mineralogy of Maine, Vol. 1 and 2.*** Augusta, ME: Maine Geological Survey.

Description: "This book is a collection of articles with emphasis on the state's rich mining history, gem production, and geology. It was edited by Vandall King, who is an authority on Maine minerals. He has collected a tremendous amount of information on mining history, including gem mining operations and the 1880s silver boom in eastern Maine. Much of this information has never appeared in print, and there are many rare photographs of people and places connected with Maine mining. Related topics include the development of the science of mineralogy in Maine, and the history of the Maine Geological Survey. Another useful chapter is a collection of maps showing precise locations of all known significant mineral localities in Maine. These maps are cross-referenced to lists giving both the preferred and alternate names of the localities."

Hydropower

A Citizen's Guide to Dams, Hydropower and River Restoration in Maine, Natural Resources Council of Maine.

Go to: *www.nrcm.org/publication_rivers.asp*

Description: Information on the history, location, and environmental effects of dams in Maine. It also discusses dam removal and river restoration.

Maine Development Commission. 1929. **Report on Water Power Resources of the State of Maine.** Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

Wells, W. 1868. ***Provisional Report Upon the Water-Power of Maine.*** Augusta: Stevens and Sayward. Available from the University of Maine Library System.

Go to: *www.library.umaine.edu*

H11 Residential Development

Maine census data from the Maine State Planning Office.

Go to: *www.maine.gov/spo/economics/census/*
Click on the downloadable Excel file to see data from the year 2000.

Description: Within this Excel file are worksheets containing information on housing by town, including the year of construction.

Regional data, Maine State Planning Office.

Go to: *www.maine.gov/spo/landuse/*

Description: The Land Use Planning Team is working with data provided by Bangor Hydro and Central Maine Power that shows the addition of new service areas between 1990 and 2005. This data can be used to create GIS maps that illustrate where new service has been added in a given region.

Town data.

Research property and building permit records in town offices.

H12 Recreation (Individual, Commercial)

Organizations devoted to particular recreational pursuits and commercial recreational service companies often can be found through the Internet or local town offices. Individuals within these groups or companies can be a great source of information about specific activities or interests in a particular marine area.

Information on kayaking routes and launches, Maine Association of Sea Kayak Guides.

Go to: *www.maineseakayakguides.com*

Description: A listing of local guides. Information on kayaking activities may also be available through staff and volunteers of the Maine Island Trail Association, *www.mita.org.*

Members of yacht and boat clubs in your area may provide information about sailing use.

Go to: *www.yachtclub.com/usycs/maineyc.html*

Description: A listing of Maine's yacht clubs.

Outdoor sports clothing and equipment shops often have guidebooks and other sources that describe where certain activities take place in regions of Maine (e.g., kayaking, sailing, canoe, biking, and hiking guides).

Published cruising guides, such as Howard and Jan Taft's *A Cruising Guide to the Coast of Maine*, often provide helpful descriptions and maps of sailing activities in an area.

Gather information on sport fishing and hunting directly from licensed guides working in your area.

Go to: *maineguides.com*

The Maine Atlas and Gazetteer. 2007. Freeport, ME: Delorme Mapping.

Go to: *shop.delorme.com/*

Description: The atlas contains a section with information about beaches, parks, public access areas, and other recreational sites.

H13 Public and Private Waterfront Access

Coastal Water Access Priority Areas for Boating and Fishing, Maine Coastal Program and Maine Department of Marine Resources.

Go to: *www.maine.gov/spo/mcp/downloads/coastal_access_report/coastal_water_access.doc*

Description: "This report on water access needs was developed for the Land for Maine's Future Board and state agencies with water access-related programs... The *Strategic Plan for Providing Public Access to Maine Waters for Boating and Fishing* guides the LMF Board's decisions on acquiring land for water access. Developed by the Departments of Conservation (DOC) and Inland Fisheries and Wildlife (IF&W) in 1995, the *Strategic Plan* contains a comprehensive, prioritized list of freshwater lakes, ponds, and rivers in need of public access. A comparable list did not exist for coastal waters. The LMF Board requested that SPO and DMR develop a prioritized list of coastal water access needs."

Maine Office of GIS map layer showing locations of boat launches (BOATLNCH).

Go to: *apollo.ogis.state.me.us*

Description: "BOATLNCH provides digital mapping of Maine boating facilities on both coastal and inland waters, and shows the locations of state-managed and state-assisted boat launches in Maine. BOATLNCH depicts locations throughout Maine at 1:24,000 scale or better....Sites may have gravel or hard-surfaced ramps and may include boarding floats, rest rooms and picnic tables. A few sites have canoe or carry-in access only. Some ramps on tidal waters may be use-

able only at high tides and are designated "part-tide" facilities. A brochure listing all the boat launches is available by calling (207) 287-4952."

Maine ports and marine facilities, Maine Port Authority.
Go to: *www.maineports.com*

Public Shoreline Access in Maine: A Citizen's Guide to Ocean and Coastal Law. Marine Law Institute, University of Maine School of Law, Maine Sea Grant College Program, and University of Maine Cooperative Extension, 2004.
Go to: *www.seagrant.umaine.edu/documents/pdf/pubacc04.pdf*

Description: This document addresses the legal issues including previous cases dealing with public access to the coast in Maine. Also discussed are ways to improve public access to the beach.

Saving Working Waterfront: Mapping the Maine Coast's Economic Future. 2005. Island Institute, Rockland, Maine.
Go to: *www.islandinstitute.org/programs.asp?section=planningGIS*

State-sponsored and assisted public boat access sites, Maine Department of Conservation.
Go to: *www.maine.gov/doc/parks/programs/boating/sitelist.html*

GIS layers of working waterfront and public access points for coastal towns, Island Institute.
Go to: *www.islandinstitute.org/programs.asp?section=planningGIS*

H14 Protected/Conserved/High-Value Natural Areas

Land

Maine Office of GIS map layer for conserved lands (MECNSLND).
Go to: *apollo.ogis.state.me.us*

Description: "MECNSLND contains conservation lands ownership boundaries at 1:24,000 scale for Maine land in federal, state, and non-profit ownership with easements. State, county, town, and coast boundary data were obtained from MEGIS town boundary dataset METWP24. 1:24,000 US Geological Survey (USGS) digital line graph data was used for hydrography and transportation features. Where state, county, and town boundaries were coincident with property boundaries, the coincident features were taken from METWP24. Where hydrography, roads, railroads and power-lines were coincident with property boundaries, the coincident features were taken from 1:24,000 digital line graph data. The ownership lines do not represent legal boundaries nor are the ownership lines a survey. MECNSLND is an inventory. Original mapping and text on this theme, produced in 1989 and updated in 1993 by R.D. Kelly Jr., Maine State Planning Office (MESPO). MESPO contacted agencies and organizations to obtain locations of conservation and public lands, and prepared hard copy maps. Mapping was based on USGS 1:250,000 quadrangles and was originally published in digital form by the Maine Office of GIS as MEPUB250. The Maine Cooperative Fish and Wildlife Research Unit, University of Maine at Orono, digitized the maps, built the attribute database and subsequently, compiled the data at 1:100,000 scale with standard USGS quadrangles as a base to produce MEPUB100. MEPUB100 was used as a basemap for the development of MECNSLND. MECNSLND was created to provide GIS coverage for the conservation lands database. The ownership lines do not represent legal boundaries nor are the ownership lines a survey. The data contained in MECNSLND is an inventory only. Users must assume responsibility in determining the usability of these data for their purposes. Data at this scale are suitable for local and regional planning."

Protected lands, Land for Maine's Future.
Go to: *www.maine.gov/spo/lmf/*

List and map of protected lands, Maine Chapter of The Nature Conservancy.
Go to: *nature.org/wherewework/northamerica/states/maine/preserves/*

Listing of Maine's parks, Bureau of Parks and Lands, Maine Department of Conservation.
Go to: *www.maine.gov/doc/parks/index.html*

Description: This interactive site allows you to find parks in Maine by county or by desired activity.

Local land trusts listing, Maine Land Trust Network.
Go to: *www.mltn.org/*

Description: Contact your local land trust for GIS data on the properties they protect and for more information about other organizations which own or manage conservation lands.

Sea

Atkinson, J., et al. 2000. ***The Wild Sea.*** Boston, MA: Conservation Law Foundation.

Go to: *www.clf.org*

Description: Describes marine protected areas in New England and the federal, state, and local authorities under which they were established.

Recchia, C., et. al. 2001. ***Marine and Coastal Protected Areas in the United States Gulf of Maine Region.*** Washington, D.C.: Ocean Conservancy.

Go to: *www.oceanconservancy.org/site/PageServer?pagename=issues_mpa*

Description: Information and maps of marine and coastal protected areas in the U.S. and Gulf of Maine.

H16 Tidal Restrictions and Barriers to Fish Passage

Interactive map of tidal restriction sites, Gulf of Maine Council on the Marine Environment.

Go to: *www.gulfofmaine.org/maps/hrp/htdocs/index.html?map=tr*

Description: Symbols on map show location and type of tidal restriction. Click on symbols for detailed information.

H18 Habitat Restoration Project Sites

Interactive map of habitat restoration sites, Gulf of Maine Council on the Marine Environment.

Go to: *www.gulfofmaine.org/maps/hrp/htdocs/index.html?map=proj*

Description: Symbols on map show restoration project locations. Click on symbols for detailed information.

H19 Significant Cultural Sites (Prehistoric, Historical, Current)

National Historic Sites or Districts, National Park Service or the Maine Historic Preservation Commission.

Go to: *www.nps.gov/history/nr/about.htm* or *www.maine.gov/mhpc/*

For information about local and regional historical organizations, contact town offices or libraries. Many of these groups cannot be easily found on the Internet. They often have very helpful information about the area's sites and resources.

State Historic Sites, Maine Bureau of Parks and Lands.

Go to: *www.maine.gov/doc/parks/index.html*

National Register of Historic Places.

Go to: *www.nationalregisterofhistoricplaces.com/ME/state.html*

Sites of local, state and/or national significance may be described in municipal comprehensive plans.

H20 Point Source Pollution (Known or Potential)

General

Brownfields Guide for Maine Municipalities, Volume I and II. 1998. Augusta, ME: Maine State Planning Office.

Go to: *www.maine.gov/spo/landuse/pubs/bfguidevol1.php*

Description: "This is the first of two volumes about brownfield redevelopment in Maine. Brownfields are areas where there once existed industrial or commercial uses which may have left pollutants in the area. The redevelopment of such sites into productive and safe uses is a major issue for older Maine communities. In this first volume general questions are answered such as: What makes a property a 'brownfield?' How can polluted property become a valuable tool for economic development? Who are the people and what are the skills which are needed to successfully redevelop a contaminated property? The second volume in the series provides case studies of potential brownfields areas in six Maine communities: Lewiston, Auburn, Rockland, Lubec, Houlton, and Skowhegan. It also lists historic industrial uses and typical contaminants which are associated with those uses."

GIS layer of air and water discharge sites, Bureau of Land and Water Quality or Bureau of Air Quality, Maine Department of Environmental Protection.

Go to: *www.maine.gov/dep/air/ or www.maine.dep/blwq*

GIS layer of toxic spills, underground tanks, and other sites, Bureau of Remediation and Waste Management, Maine Department of Environmental Protection.

Go to: *www.maine.gov/dep/rwm*

Maine Environmental and Groundwater Analysis Database (EGAD).

Go to: *www.maine.gov/dep/rwm/egad*

Description: EGAD is "designed to store site and water quality information. It currently includes spatially located data for 37 different types of potential and actual sources of contamination to groundwater in Maine.

Access to comprehensive up-to-date analytical data allows DEP to assess trends in regional ground water quality and quantity. It also improves automated analysis and map-making capability including rapid access to information for emergency response to hazardous materials spills. Detailed well and analytical information in the database is used by staff to design remedial action at hazardous spill sites. It is also used by staff to evaluate potential for cumulative impacts of real estate development on ground water quality." Site data managers in DEP's Bureau of Land & Water Quality can use this data to provide digital maps of specific locations in the database, for any area in the state.

Casco Bay

2007 Toxic Pollution in Casco Bay: Sources and Impacts, Casco Bay Estuary Partnership.
Go to: *www.cascobay.usm.maine.edu/toxicsreport07.html*

Assessment of Sediment Contamination in Casco Bay, 2005. Casco Bay Estuary Partnership.
Go to: *www.cascobay.usm.maine.edu/publications.html*

Historic Sources of Pollution in Portland Harbor, 1840-1970. 1993. Casco Bay Estuary Partnership.

The Dirty History of Portland Harbor. 2005 (reprinted from a 1994 publication). Casco Bay Estuary Partnership.
Go to: *www.cascobay.usm.maine.edu/publications.html*

Twelve-Year Water Quality Data Analysis: 1993–2004 Report. Friends of Casco Bay.
Go to: *www.cascobay.usm.maine.edu/publications.html*

H21 and H22 Management and Regulatory Framework for Shore and Water

Managing Maine's Nearshore Coastal Resources, Final Report of Bay Management Study.
Go to: *www.maine.gov/dmr/baystudy/baystudy.htm*

Management plans for lobster, striped bass, herring, and 19 other interstate coastal fish species or groups, Atlantic States Marine Fisheries Commission
Go to: *www.asmfc.org/*

Federal Fisheries Management Plans, New England Fisheries Management Council.
Go to: *www.nefmc.org/nemulti/index.html*

GIS map layer of lobster zone districts, Maine Department of Marine Resources.
Go to: *www.maine.gov/dmr/council/lobsterzonecouncils/index.htm*

Maine Office of GIS layer of seafood safety restrictions on mollusk harvesting.
Go to: *megisims.state.me.us/metadata/class03w.htm*

Maine/New Hampshire Sea Grant. 1998. ***The Maine Clam Handbook: A Community Guide for Improving Shellfish Management.*** Orono, ME: Maine Sea Grant.
Go to: *www.seagrant.umaine.edu/pub/pubalphadir.htm*

Description: Contains information on history of the soft-shell clam fishery, clam biology, aquaculture, and related legal issues.

Marine Law Institute. 1993. ***Maine Citizens' Handbook on Coastal Water Quality Enforcement.*** Orono, ME: Maine Sea Grant.
Description: An introduction to the legal standards and penalties established by state and federal coastal water quality laws.

Natural Resources Protection Act, Maine Department of Environmental Protection.
Go to: *www.maine.gov/dep/blwq/docstand/nrpapage.htm*

Description: The Natural Resources Protection Act contains regulations or restrictions on building in the shoreland zone, sand dune rules, and rules for protection significant wildlife habitat.

Recreational fishing regulations, Maine Department of Marine Resources.
Go to: *www.maine.gov/dmr/*

Marine harvesting laws and regulations, Maine Department of Marine Resources.
Go to: *www.maine.gov/dmr/lawsandregs.htm*

Waterbody classifications, Maine Department of Environmental Protection.
Go to: *www.maine.gov/dep/blwq/monitoring.htm*

Description: General information about the water quality classification system that regulates discharge into receiving waters.

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55 South Main Street • Ipswich • Massachusetts • 01938 • USA
QLF Marine Program • 28 Martin Point Road • Friendship • Maine • 04547 • USA
www.QLF.org

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