Return the Tides

Resource Book

World Wide Web Version

CONSERVATION LAW FOUNDATION

by

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[1] Robert R. Bryan, Michelle(sic) Dionne, Ph.D., et al. , *Maine Citizens Guide to evaluating, Restoring and Managing Tidal Marshes.*

[2] Purinton, Timothy A. and David C. Mountain, Ph.D. *Tidal Crossing Handbook, A Volunteer Guide to Assessing Tidal Restrictions*.

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PREFACE

This resource book grew out of the Conservation Law Foundation (CFL) participation in a national initiative to restore America's estuaries and CLF''s regional marine resources project to preserve and restore marine and estuarine resources in the Gulf of Maine. At the national level, the work has produced a guide to all the possible federal sources of funding. It has introduced new federal legislation that is close to passage in Congress as of ….[1] The legislation will help integrate and coordinate the work of the various federal agencies concerned with estuary restoration. It will provide significant funding to local groups around the country that are undertaking estuary restoration projects. In New England, in collaboration with the Island Institute (II) and the Conservation Council of New Brunswick (CCNB), CLF published Rim of the Gulf: Restoring Estuaries in the Gulf of Maine. It details the extensive losses of estuary resources throughout the Gulf of Maine. CLF is, also engaged in a restoration project with the Chelsea Human Services Collaborative in Chelsea, Massachusetts.

This initial survey demonstrated the pervasive adverse human impacts in the coastal zone and convinced us that the restoration of degraded habitats is as important as preservation of the remaining estuarine and marine habitats. Of all the threats faced by vegetated tidal marshes, the most common is the loss of tidal flows. Unlike other wetlands, tidal marshes can exist only in the narrow zone along the shore that is within the range of the tide. Without tidal exchange, a tidal marsh becomes a freshwater wetland (such as Sherman Lake in Newcastle) and the marsh's unique ecological contributions are lost. Thus, free tidal exchange is essential to the existence of tidal marshes[2]

Although Maine has more tidal marsh area than any state north of New Jersey and more than any state or province in the Gulf of Maine, Maine (with notable exceptions in southern Maine's large barrier marshes) knows less about its

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[1] Restore Americas Estuaries (RAE) *Funding for Habitat Restoration Projects, A citizen's guide*, The Estuary Habitat Restoration Partnership Act, S.835 and H.R. 1775. For more details, see the RAE website: www.estuaries.org

[2] Even when assured of tidal exchange, the tidal marsh is by no means home free: filling, dredging, pollution, encroaching development and other threats can also affect its vitality.

tidal marshes than the other New England states. In one recent tabulation of restricted marshes, Massachusetts had identified over 250 marsh crossings as potential restoration sites; Maine identified less than 20 (Cornelison, 1998, pp. 5-9). This dramatic discrepancy demonstrated that Maine lacks much basic information.

CLF's "Return the Tides" (RTT) project is intended to fill this information gap, using grassroots volunteers to help develop a better marsh information base for Maine. Return the Tides undertakes to inventory restrictive tidal marsh crossings. Our goal is to establish a working inventory of potential restoration sites throughout the coast and islands of Maine and to raise citizen awareness of the importance of tidal marshes, the multiple threats to them, and the potential for their restoration.

In this effort, we are pleased to join hands with many other agencies, non-profit organizations and individuals who have been fighting for salt marshes for years such as the U.S. Fish and Wildlife Service, the Maine Coastal Program at the State Planning Office, the Maine Audubon Society, the Wells National Estuarine Research Reserve and the dedicated staff and volunteers who work with these groups. By following the approach laid out in the following pages, and learning more from the resources identified in the Appendices, citizen activists will be able to undertake a tidal marsh crossing inventory in their area and begin developing marsh restoration projects. Ultimately, this guide is an action plan for the coast and islands of Maine directed toward those people who want to work in their own communities to produce positive environmental change.

We welcome our readers as full partners in these efforts.

INTRODUCTION: WHERE THE LAND MEETS THE SEA

In the natural world, the edges of places are very special. Most often, at the edge of the land and sea, vast biological action happens, a confluence of biological abundance and overlapping species from marine and riverine environments. The reason for this is simple. This is where different natural ecological systems -- each with its own set of characteristic flora and fauna -- meet and mix. These mixing zones are like natural stews, including features and species from both systems and, in some cases, species that are unique to the mixing zone.

Estuaries fall just below rainforests in the eyes of most ecologists in terms of their habitat value and biological productivity. Estuaries are where the ocean's salt-water ecosystems meet the land's freshwater and upland ecosystems. Salt marshes are the vegetated wetland fringes of estuaries. As a result, salt marshes share certain characteristics with freshwater wetlands with the added layer of ecological complexity that emerges from their intimate and overlapping tidal connection to the marine environment. They are very special places indeed.

Scientists wax poetic on estuaries, but you don't have to be an ornithologist, a botanist or an ichthyologist to appreciate the special qualities of estuaries. You don't even have to know that these areas that most of us who live or work in coastal Maine see every day are called "estuaries." You only have to be able to open your senses to these special places. For most people, one look is all it takes.

Killing the Golden Cod

The once vast and productive estuarine systems of the Gulf of Maine are in many ways responsible for the pre-European and colonial settlements of New England. European explorers came to the coast of what is now America for the same reason native tribes camped on the coast during the summer months: fish and shellfish. Historical records make clear what is no longer true: there was an enormous abundance of cod, alewives, and other desirable fish and shellfish species in the coastal waters of the Gulf of Maine.

Some coastal bays supported fisheries that landed millions of pounds of seafood a year – largely caught by hook-and-line! Tidal marshes provided much of the hay and pasturage needed by early settlers and also provided a rich harvest of shorebirds and waterfowl. The estuaries and nearshore waters of the Gulf of Maine once supported a truly world-class abundance of coastal and marine life.

Unfortunately, the early developers of New England's coastline and coastal rivers were great fishermen, captains of industry and civilization and conquerors of the wilderness, but they weren't great ecologists. Buoyed by the naive, self-centered, and virtually universal view that the ocean's reproductive powers knew no limits, the post-colonial history of the Gulf of Maine documents a systematic assault on the essential natural resources that first brought explorers to these shores. The next section of this book describes this in more detail. Coastal wetlands were drained or filled; human and animal wastes, and, later, industrial wastes were dumped into coastal waters with little or no thought given to the effects of these practices. Fishing occurred at levels that outstripped natural rates of replenishment. Our once-productive coastline has been badly exploited.

Returning Our Coasts

Only in the last thirty years have people begun to recognize the price our natural coastal environment has paid for human "progress." A broad range of interest groups including fishing communities, recreational fishermen and ordinary citizens question:

How much of the resource base has been lost?
How much have remaining resources been degraded?
How extensive are the habitat damages associated with those losses?
How much of the original resource base can be restored?
How will habitat restoration further the recovery of lost coastal resources and productivity?
How much effect will habitat restoration have on the coastal system's baseline productivity rates?

These questions cannot be answered completely at the moment. The 1998 survey of the estuaries of the Gulf of Maine *(Rim of the Gulf: Restoring Estuaries in the Gulf of*

Maine), revealed a terrible consistency around most of the region. More than one-half of estuary marsh habitats have been lost and, in the Bay of Fundy, the losses are well over seventy-five percent. Many of these losses, like the damming of Boston's Charles River, are permanent. The losses in Maine may be less than elsewhere, but they are extensive, especially from Casco Bay south. Although there have been dramatic improvements since the 1970's, coastal water and sediment chemistry continues to be degraded by pollution. Forage species for the once enormous schools of cod and pollock have been reduced inshore as a result of habitat losses and the blockage of historic river runs of species like herring, alewives, and others. As a result, many cod and pollock stocks are greatly reduced, even in the absence of fishing pressure. We have lost a great deal and these losses still continue.

Offering a Solution

Given the current, deteriorated state of our coastal resources, the priority is to protect every functional estuary. Pollution control programs must be enforced and extended to include the contaminated runoff from lands, and the persistent complex chemicals that survive treatment processes. Fishery management throughout the Gulf needs to address the vital importance of reducing fishing to proper levels and protecting fish habitats so the fish stocks can rebuild. Finally, the strong federal and state laws and programs that have the capacity to save remaining estuarine habitats from further filling and degradation must be strictly enforced.

This book is intended to provide a tool for coastal groups and individuals who want to go beyond these important protective steps and undertake restoration of our scarce and unique tidal wetlands, The conventional goal for freshwater wetlands of "no net loss" must be modified. We must work to restore tidal wetlands, to add to the inventory. While scientists are understandably unwilling to speculate on what system-wide productivity returns will be associated with estuary restoration at particular sites, they are unanimous in supporting the critical importance of restoration. We believe that if some of these areas are restored, a significant measure of their original natural productivity and biological abundance will return.

The book is organized in two parts: the first several sections provide the citizen activist with a basic primer on estuaries and tidal wetlands; the vocabulary and fundamental concepts associated with these resources and their restoration; and some of the practical aspects of undertaking a restoration project. There are many references in the appendix to publications that will provide greater detail and understanding of these issues. In section 6, the reader is introduced to a methodology that grassroots organizations and individuals can follow to perform a baseline inventory and preliminary assessment of tidal marsh restrictions.

The Appendices present materials that can be used in training volunteers and in conducting an inventory.

The book is a work in progress and CLF welcomes your feedback on its strengths and weaknesses.

We start with a little science, a little policy, and a lot of restoration activities in the new millennium. We think that is just what the Estuary Doctor ordered.

SECTION 1: A PRIMER ON MAINE TIDAL WETLANDS[1]

If present and future generations are to use and enjoy the bounty and beauty of healthy tidal marshes, then understanding how they work, protecting them from negative impact, and restoring their ecological integrity is essential. This section presents a basic overview of Maine tidal wetlands, common terms used to describe them, a summary of their ecological functions and societal values, and an argument for their preservation and restoration.

Definition of Tidal Wetlands as used in the *Return the Tides Resource Book*

Tidal **wetlands**[2] can be divided into three broad categories: marine wetlands, estuarine wetlands, and tidal riverine wetlands. **Marine wetlands** are adjacent to or in the open ocean, and include **habitats** such as beaches, mud flats, rocky shores, and headlands. **Estuarine wetlands** include habitats protected from the open ocean but in contact with it, where saltwater from the ocean mixes with freshwater from upland rivers and surface runoff. Salt marshes and mud flats are common estuarine wetlands. **Intertidal riverine wetlands** are vegetated wetlands within a river channel that, while influenced by tides, are beyond the normal reach of saltwater. These are commonly referred to as **freshwater tidal marshes**.

The *Return the Tides Resource Book* focuses on vegetated tidal **marshes** which occur in both estuarine and intertidal riverine wetland habitats, and include salt marshes, brackish marshes and freshwater tidal marshes. The US Fish and Wildlife Service Wetland Classification System (See Appendix C) uses water **salinity** levels to differentiate among these three types of marshes. In the Gulf of Maine, **salt marshes** occur in a range of salinities from that of seawater, about 34 parts per thousand (ppt) of salt, to approximately 18 ppt. **Brackish marshes** are characterized by salinities

[1] This section is adapted from Bryan & Dionne, *Maine Citizens Guide to Evaluating, Restoring and Managing Salt Marshes*. Their permission is gratefully acknowledged.
[1] Terms in **bold face** are defined in the Glossary, Appendix A

ranging from 18 to 0.5 ppt. Freshwater tidal marshes are located where the salinities average less than 0.5 ppt, yet tides still affect water level.

Because wetland plant species vary in tolerance to salinity, marsh salinity is generally identified by the plant species present. In marsh systems with a strong marine influence and limited freshwater input, true salt marsh flora dominate. The flora associated with brackish and freshwater tidal marshes is more common in larger river systems. By learning several of the basic marsh plant species, you will be well on your way to an ability to identify any tidal wetland you encounter.

[[Insert Figure 1- Coastal marsh types (after Mitsch & Gosselink, 1993)]]

Tidal Marsh Formation

Tidal marshes form in low-lying coastal areas that are protected from excessive winds, waves, and currents. Such low energy environments allow for the deposit of sediments suspended in tidal waters. Over time, marsh plant communities develop on this sediment base. Sediment deposition and establishment of tidal marsh plants reinforce one another. Once plants are established, they trap additional sediments, and increased deposits of sediments raise the marsh elevation and expand it. These combined processes lead to the formation of marsh soil or peat made up of mineral sediments (trapped from the water column) and organic matter (derived from partly decayed plant material). This substrate of marsh soils and peat evolves over thousands of years and provides a foundation without which marsh plant communities could not survive. This substrate cannot be artificially re-created, therefore, it is an irreplaceable and unique resource.

[[Insert figure 2 — Tidal Marsh Development Diagram after Dreyer & Niering]]

Sea level has risen along the Maine coast over the past 4,000 to 5,000 years. Throughout this period, salt marshes have maintained themselves at the elevation necessary for plant growth through the accretion of sediments filtered from tidal waters and the slow formation of peat substrates. The two common salt marsh species in Maine are smooth cordgrass (*Spartina alterniflora*)[3], which grows in areas flooded by daily tides, and salt-hay grass (*Spartina patens*), which grows at a slightly higher elevation in less frequently flooded areas. A salt marsh responds to increases in sea level elevations by expanding over adjacent freshwater wetlands and gently sloping uplands, while at the same time it may erode or submerge below the rising low tide line at its seaward edge. This process is known as **transgression**. Thus, marsh areas may grow or shrink depending on rates of sea-level change, sediment input, sheltering, and degree of human interference.

[[Figure 3 - Growth of Wells Marshes (after Kelley et al., 1995)]]

A Note about Tides

Any discussion of tidal marshes necessarily requires reference to the tides. Anyone who has spent time on the coast of Maine is aware of the tides. We present a brief discussion of basic tide terms and concepts.

Tides are caused primarily by the gravitational influence of the moon and sun on the waters of the oceans (Because it is much closer, the moon has about 2.5 times more influence than the sun). In Maine, we have **semi-diurnal** tides: there are two high tides and two low tides each lunar day of about 24 hours and 50 minutes. Usually there is a **diurnal inequality**: one high each day is higher than the other and one low is lower than the other. Because the lunar day is almost one hour longer than the calendar day, the times of high and low tides are later each day.

The tides vary during the **lunar month** as the relative positions of the sun and moon change. Around the time of full and new moon, the **tidal range** is greatest because the sun and moon are aligned. These tides are called **spring tides** which are both higher and lower than average. About a week after full and new moon, when the moon is in its first or last quarter, the tidal range is at its monthly minimum and the tides are called

[3] For convenience we will cite the scientific (Latin) name of a plant when it is first mentioned, but use the common name thereafter. Common names are from Tiner, *Maine Wetlands and their Boundaries*, available

neap tides. The landward boundary of a tidal marsh is largely determined by the elevations reached by the extreme high tide levels associated with spring tides.

[[Figure 4- Spring And Neap Tide Forces (adapted from*, NOAA, 1999)]]*
[[Figure 5- Spring and Neap Tide Curves]]

Many other factors, such as the inclination of the moon's orbit to the earth's orbit, the distance of the moon from the earth, hydrographic, meteorological and oceanographic factors affect the height of any given tide at any given place.

Working with maps and nautical charts requires an understanding of tidal **datums**. United States nautical charts use **mean lower low water** as the reference level or datums for all soundings. To complicate matters, US Geological Survey topographic maps use **mean low water** as their sounding datum, but show the shoreline at **mean high water**. Surveyors and other government agencies such as the Army Corps of Engineers may use other tidal datums. Similar complexities arise when mapping precise horizontal locations because different charts, maps and GIS systems are referenced to different horizontal reference systems.

[[Insert figure 6- Tide Levels and Datums (adapted from HO chart 1)]]

Tidal **currents** are associated with tide changes. A **flood current** runs as the tide rises or **floods** and an **ebb current** runs as the tide falls or **ebbs**. The current is said to be **slack** during the time it changes direction and runs slowly, if at all.

In the complex channels of tidal marshes, both times and heights of the tide, as well as current speed and direction, are drastically affected by local conditions and may vary significantly from the times, height and speeds at the locations or "**stations**" for which predictions are published. Published predictions are based on typical conditions at the station and can also be significantly affected by local meteorologic, oceanographic and hydrologic conditions.[4]

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from the State Planning Office. See the appendix for more information about plant names, habitat and identification.

[4] Additional information about tides, tidal currents and tidal terms is available from the US National Oceanographic and atmospheric Administration (NOAA) on the Internet at

Important Tidal Marsh Habitats

Tidal marshes are complex systems. Within each marsh there may be a variety of habitats that support different plants and animals. Some of the more important habitat types are described below.

[[Insert figure 7- Marsh Zonation and Marsh Plant Communities after Tiner]]

Low marsh, lying between mean low tide and mean high tide, is flooded twice daily by tidal action. Low marsh typically occurs as a sloping fringe between the high marsh and a tidal creek or mud flat. Smooth cordgrass (*Spartina alterniflora*) is the dominant plant in salt and brackish low marshes.

High marsh is flooded only by above-average tides, usually over a 4-5 day period twice a month by spring tides, and irregularly by storm tides. It is at or just above mean high tide level. Salt-hay grass (*Spartina patens*), and black grass (*Juncus gerardii*) are the dominant plants in most high marshes. In brackish marshes with a strong freshwater influence, plants such as prairie cordgrass (*Spartina pectinata*), narrow-leaved cattail (*Typha angustifolia*) or rushes (*Scirpus sp.*) may dominate. The high marsh is usually substantially level and occurs between the low marsh and uplands.

Pannes are shallow "ponds" that form in the high marsh peat. Flooded periodically by spring tides, pannes provide an abundance of food for waterfowl and migrating shorebirds. . A short form of smooth cordgrass frequently occurs in these areas. Common glasswort, (*Salicornia europaea*) and other non-grassy plants or **forbs** often colonize shallow pannes that dry out. Much of the plant diversity on the salt marsh is associated with these shallow pannes. Deeper pannes that remain water filled may support widgeon grass (*Ruppia maritima*), which is valuable forage for waterfowl.

Tidal creeks, open water, and tidal flats are all-important components of the marsh ecosystem. For the purposes of this book, open water is defined as a permanently

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http://www.opsd.nos.noaa.gov/pub.html, where you can find their publication "Our Restless Tides" and an extensive glossary of terms.

flooded (i.e., below mean low water) water body greater than 100 meters (330 feet) wide. Tidal creeks are less than 100 meters wide at mean low water. Tidal flats are nearly level to gently sloping unvegetated areas located within the intertidal zone. Tidal flats may support commercially significant worm and clam populations.

Classification of Tidal Marsh Systems

Variation in topography, geology, tides, sediment supply, wave exposure, and rate of sea-level rise along the Maine coast lead to the development of different marsh types. The three basic **geomorphologic** types of tidal marshes used in this book are **coastal/back barrier marshes, finger marshes,** and **fringe marshes**. The three marsh types can be determined visually from maps and are described and illustrated below.

[[Insert Figure 8- Marsh Geomorphology (after Bryan & Dionne, 1997)]]

Coastal/Back Barrier Marshes

- associated with barrier beaches
- most common west of Sheepscot Bay
- marshes are located adjacent to the Atlantic coast and have direct access to the ocean
- dominated by high marsh
- marshes in Scarborough and Wells are notable examples of coastal/back barrier marshes

Finger Marshes

- area of high marsh is large compared to size of channel
- elongated marsh follows long axis of channel
- The Back River tidal marsh being restored on the north side of Route 1 in Woolwich is a noteworthy example of a finger marsh.

Fringe Marshes

- found along protected shoreline in estuarine reaches and rivers (coves, indentations, small tributaries, meanders) or at the toe of eroding bluffs

- limited development of high marsh
- strongly influenced by ice erosion; also affected by erosion from river flow and waves
- often bordered by mud flats
- The shorelines of the York River that can be seen from the Maine Turnpike are good examples of fringe marshes.

Depending on salinity levels, a range of plant communities may be found within each geomorphologic type. Moving along the main marsh channel from the inlet to the **head of tide**, salinities decline, and tidal salt marsh grades to tidal brackish marsh, and freshwater tidal marsh. Freshwater tidal marshes experience daily tidal flushing, as do salt marshes, but are dominated by freshwater plants.

Distribution of Tidal Marshes on the Maine Coast

Researchers at the University of Maine and the Maine Geological Survey have determined that Maine's convoluted shoreline, approximately 5,970 km (3,700 miles)[5] in length, contains over 79 km² (19,500 acres) of salt marsh, far more than any other New England state, New York, or Canadian province on the Gulf of Maine (Jacobson et al. 1987). In reviewing the distribution of tidal marshes, these researchers found the geologic setting and abundance of marshes varied among four broad coastal regions. The following descriptions are based on the work of Jacobson et al. (1987):

Sandy barrier beaches behind which extensive coastal/back barrier marshes have developed characterize the southwest coast (the Arcuate Embayment Complex) from Kittery to Cape Elizabeth. Although comprising a relatively short segment of the Maine coast, approximately 34% of the state's salt marshes are found in this area.

The peninsulas and islands from Cape Elizabeth to Spruce Head (the Indented Shoreline Complex) provide protection from wind and waves, thus allowing extensive salt marsh development. Approximately 35% of the state's tidal marshes are found in this region. The shoreline is highly convoluted and is dominated by narrow indented embayments and tidal rivers, with many fringe marshes and finger marshes. There are

[5] More recent, GIS analysis has yielded a coastal shoreline length of 4,568 miles. When the shorelines of 4,617 islands are included, the coastal shoreline is 7,039 miles. (Conkling, 1999)

also notable barrier beaches and back barrier marshes near the mouth of the Kennebec River in Phippsburg and Georgetown. Extensive brackish marshes occur in the Kennebec River estuary, and the majority of the state's freshwater tidal marshes are found in Merrymeeting Bay and its tributaries.

The Island-Bay Complex extends from Spruce Head to Cross Island, including Machias Bay. This region is more exposed to wind and waves, and there are fewer rivers to provide the sediment needed for marsh accretion. Thus, only 26% of the state's marshes are found in this extensive region. Most of them, approximately 16.5 km^2 (4,000 acres) are found in the estuaries associated with the Penobscot, Pleasant, and Narraguagus Rivers. Fringe and finger marshes predominate; coastal back barrier marshes are limited to occasional small pockets behind a few sandy beaches.

The area from Cross Island to the Canadian border is known as the Eastern Cliff Shoreline. Erosion-resistant bedrock and few rivers offer limited protection and sediment supply for marsh development. Only 5% of the state's tidal marshes are found in this region, with most of these in Cobscook Bay.

[[Insert Figure 9- Maine Coastal Marsh Distribution (after Bryan & Dionne, 1997)]]

Maine salt marshes can also be divided into two categories based on differences in their plant communities. Marshes south and west of Penobscot Bay, including Scarborough Marsh in Cumberland County and the York County marshes near Wells are similar to marshes in Southern New England. Well-defined high and low marsh zones that are dominated by smooth cordgrass and salt-hay grass, respectively, distinguish these marshes.

The marshes in Penobscot Bay and eastward are affected by the larger tidal range and shorter growing season of the area and are similar to the Fundy type of marsh found in New Brunswick and Nova Scotia. Although less than a third of the State's marsh is along this shoreline, there are more individual marsh units here than in the rest of the state. Eastern Maine marshes have a less distinct high/low marsh zonation. Smooth cordgrass is found in patchy stands along creeks on tidal channels, interspersed with a mixed community which includes black grass, red fescue (*Festuca rubra* L.), Baltic Rush

(*Juncus balticus*) and creeping bentgrass (*Agrostis gigantea Roth.*). The transition between low and high marsh is indistinct. The high marsh is flat overall, but has many slight rises, depressions and pannes. Principal high marsh plants in this area are salt-hay grass, quackgrass (*Agropyron repens*), red top (*Agrostis alba*), black grass, seaside arrow grass (*Triglochin maritima*) and Baltic rush. Uniform stands of black grass and Baltic rush are common, often in slight depressions. Fundy type high marshes have much more diverse vegetation than Southern New England type high marshes that typically are dominated by salt-hay grass.

Studies of southeast coastal Nova Scotia marshes have identified four distinct plant zones dominated by smooth cordgrass, salt-hay grass, chaffy sedge *(Carex paleacea*) and Baltic rush, between tidewater and upland. Although marshes on Mount Desert Island do not show such distinct zonation, these species are all present there as well. (Calhoun, 1994)

Ecological Functions and Societal Benefits of Tidal Marshes

Tidal marshes can be described in terms of the ecological functions they perform and the societal benefits they offer. Some functions and benefits, such as wildlife habitat and recreation/tourism, are closely related.

<u>Ecological Functions of Tidal Marshes</u>

Tidal marsh ecosystems are formed and persist through a combination of geological, hydrological and biological processes or functions. Several of these functions can be described in light of the tangible benefits they provide to the human community, directly or indirectly. These functions include:

- **Shoreline Anchoring** - The accretion of peat and sediment in the marsh maintains marsh elevation as sea level rises, and buffers the upland shoreline against the erosive action of open water waves and currents.
- **Storm Surge Protection** - The resistance to water flow presented by marsh vegetation slows the movement of water over the marsh and reduces erosion from storms. The marsh vegetation also encourages the deposit of sediments suspended in the water column onto the surface of the marsh.

- **Water Quality Maintenance** - Pollutants often enter aquatic systems attached to sediment particles. Many of these particles are deposited on the marsh, limiting their movement to other ecosystems. Nutrients in the water are taken up by the vegetation, buffering the discharges of these nutrients into shallow coastal waters where they might encourage blooms of nuisance algae. Other pollutants may bind with marsh soil particles and become unavailable for uptake by plants or animals.
- **Wildlife, Finfish, and Shellfish Habitat** - The rapid growth rates of salt marsh grasses form the base of a highly productive food web. A diverse animal community, including many species of birds, finfish, shellfish and other invertebrates, uses salt marshes for food and shelter, spawning and nursery areas, and sanctuary from ever-present predators. The link between salt marsh productivity and the health of the Gulf of Maine remains to be studied, but in some parts of the United States well over 50% of the productivity of the near shore marine system is tied to the adjacent estuary systems. It is likely that coastal marshes are important contributors to the productivity of the greater Gulf of Maine ecosystem.

[[Insert figure 10- Maine Marsh Bird List }}

These ecological functions have a tremendous economic value. Two-thirds of commercial shellfish and finfish landed in the US depend on coastal wetlands for nursery and breeding habitat or on forage fish that breed in our coastal wetlands (Gosselink et al. 1974). The estimated total income for the harvest and processing of finfish and shellfish in Maine in 1997 was $653 million, resulting in twenty-two thousand jobs (Sheehan 1999). Recreational fishing, hunting, wildlife watching, and boating in coastal wetlands also contribute significant economic value.

[[insert Figure 11- Marsh and Estuary Food Pathways (after Dreyer & Niering, 1995)]]

Societal Benefits of Tidal Marshes

Humans have depended on Maine tidal marshes for millennia. Native Americans harvested birds, fish and shellfish from tidal marshes for thousands of years. In historical times, uplands adjacent to salt marshes were preferred sites for European settlement. The early colonists harvested the animals of the marshes, and, in a region dominated by extensive forest, used marsh grasses as fodder for their livestock. By 1650, 34 communities had been established near marshes in Massachusetts and Maine (Nixon 1982), including most of the present day coastal towns from the south shore of Boston north to Portland.

During the late 19th century period of industrialization and urbanization, people ceased to value tidal marshes as a natural resource. Coastal marshes were filled, restricted or blocked from the tides when railroads and highways were developed to satisfy society's desire for high-speed travel. Concurrently, development of harbors, wharves and other shoreside projects often led to dredging or filling to create land or to use as dumps.

Before mosquitoes were identified as disease carriers, the marshes themselves were often viewed as unhealthy places that caused "damps" and "miasmas". When mosquitoes were recognized as the disease-bearing vectors, marshes became feared as their breeding and were destroyed in the name of public health by being filled or drained by "mosquito ditches"[6].

Many tidal marshes were damaged or destroyed by development projects after World War II as people moved to the coastline for commerce and recreation. Only in the 1960's, as the new discipline of ecology produced detailed studies of marsh functions, did society come to a renewed awareness of the value and productivity of salt marshes. With this new knowledge, people began to appreciate salt marshes and to preserve and restore the marshes that had not been destroyed.

Today, the ecological and societal benefits of healthy tidal marshes are recognized. Tidal marshes offer opportunities for bird watching, canoeing, sport fishing, hunting and other kinds of recreation. Salt marshes are the principle native grasslands of coastal New England. Open, verdant expanses and coastal vistas also provide aesthetic pleasure. As ecosystems that have maintained themselves for thousands of years, they provide excellent outdoor classrooms for the teaching of basic ecological concepts. Many salt marsh sites are noteworthy for their importance in the history and pre-history of New England human culture.

Societal benefit include:

- **Recreational and Commercial Potential** - The use of tidal marshes for hunting, fishing, boating, birdwatching, clamming or similar activities;
- **Aesthetic Qualities** - The appearance of the tidal marsh and its contribution to the visual landscape of a community as green space or open space in a developed area;
- **Educational Potential** - The use of tidal marshes as a field trip sites or outdoor science laboratories for schools and other groups, such as research sites for endangered species habitat.

Threats to Tidal Marshes

Many of Maine's salt marshes have persisted in approximately the same sites for up to 4,500 years, demonstrating remarkable resilience throughout their geologic history. However, in the 300 to 400 years since European colonization, humans have used tidal marsh ecosystems in ways that have altered the basic geological, hydrological and biological processes that sustain their ecological integrity.

The bounty that once was harvested from Maine coastal marshes has declined significantly. Many of the tidal marsh shellfish beds in the state are closed due to poor water quality. Road and dam construction along the coast has severely altered many marshes. Over-fishing in the near coastal waters has depleted stocks of nursery fish. The numbers of ducks and shorebirds that frequent tidal marshes are a small fraction of the tremendous flocks of migrating birds that European colonists found when they

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[6] One of the great ironies of marsh management is that the mosquito control measures of ditching often aggravated the abundance of mosquitoes by insulating their water-borne larvae from fish predators. Reflooding of formerly ditched marsh has often been accompanied by a decline in mosquito populations.

arrived in North America. Marshes and inlets that were dammed for ice ponds and for tide mills no longer contribute to the marine environment

Human activities can affect the functions, values and ecological integrity of tidal marshes negatively. Freshwater tributaries can be diverted, dammed, or channeled, greatly altering the seasonal flow of fresh water and sediments to the marsh. This can affect salinity levels and alter habitat sustainability of saline-sensitive species of plants, fish, and other animals. Shorelines of tributaries and marshes may be extensively developed, as buildings, parking areas, roads and lawns replace forest and pasture. This leads to dramatic changes in the pattern and quality of freshwater runoff, including increased sediment and pollutant loads, and larger "pulses" that follow rains or snow melts. Bluffs, beaches and inlets may be stabilized with sea walls and jetties that reduce the amount of sediment available for marsh accretion. Filling and dredging have reduced salt marsh area, while ditching has altered tidal marsh hydrology and ecological function. Fill for roads and railroads, culverts, tide gates and dams fragment tidal marshes, interfere with normal tidal flow, and adversely affect water and soil quality. Bridge openings may not be wide enough to allow full flow of the tide, culverts may be undersized or perched too high to allow flow at low tide levels.

Like tourniquets on a leg or arm that cut off the flow of vital blood to the limb, these restrictions limit or prevent vital salt water from reaching portions of the marsh. The more tidal restrictions in an estuary, the more the hydrology of the marsh is altered, until marsh grasses die back, marsh water and soil chemistry changes, marsh peat degrades, and marsh elevation subsides. Areas of healthy high and low salt marsh affected by tidal restrictions are often invaded by pest plants such as purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis),* and narrow-leafed cattail *(Typha angustifolia)* or may be transformed into mudflat, salt panne, fresh marsh or upland. These changes in vegetation or marsh type have profound effects on the original ecological function and societal benefits of the salt marsh. In addition to reducing the tidal range, crossings can reduce access to tidal marshes by estuarine and marine organisms. Reduced access prevents use of the affected marshes by important bottom-tier food chain fish species, such as mummichogs (*Fundulus heteroclitus).* Culverts that are too long can be a problem for some migratory fish and other aquatic species that need light for passage. Some culverts are poorly designed and sit well above the level of the low tide line, which prevent full draining of the marsh and act as barriers to passage of organisms during much of the tidal cycle.

A vital life-support function for the food web of estuarine and marine environments, the exchange of organic matter and nutrients between salt marsh and estuary, is reduced or eliminated where tidal exchange is restricted or cut off by a culvert, tide gate, or dike. In New Hampshire, 20% of existing coastal marshes have been degraded by tidal restrictions (USDA SCS, 1994), and this figure is probably similar for large sections of the Maine coast, especially west of the Kennebec River.

High marsh habitats have been ditched for mosquito control, or more commonly, in Maine, for salt hay production. Extensive ditching can alter a marsh's natural hydrology, in some cases causing excess drainage and in others trapping water behind ditch spoils. These alterations encourage spread of invasive plants and reduce the high marsh's water exchange with tidal creeks and with the larger marine environment.

Finally, sea levels are rising worldwide.[7] Rising sea levels and the engineered armor of concrete seawalls or boulder fields created by residential and commercial developments that extend into the intertidal zone to prevent erosion, pose threats to the future of tidal marshes. Daily tidal cycles are critical to the maintenance of natural tidal marshes because flooding waters bring salt, sediment, and nutrients, and ebbing waters flush the marsh and allow marsh grasses to thrive. Through these processes, peat accumulates and marsh elevations keep pace with rising sea levels. Our oldest marshes, approximately 4,500 years old, have built a layer of peat up to 6 meters thick (about 20 feet) in response to an equivalent rise in sea level. During past periods of rising sea levels, marshes have kept pace by expanding into newly flooded areas. Today, extensive commercial and residential development along our coast makes the natural landward expansion of tidal marshes into adjacent, low-lying, developed areas problematic. Decisions will have to be made that weigh the benefits of tidal marshes against the loss of private property. As sea levels continue to rise, large areas of tidal marsh could be lost if development impedes landward movement of marshes. Marshes need sufficient sediment to grow vertically and horizontally. If adequate sediment is not

[7] For more information on the effects on Maine of global warming, a primary cause of sea level rise, see Habitat, the Journal of the Maine Audubon Society, Fall 1999, v. 16 no. 4.

available, the increased duration of flooding that accompanies sea level rise could result in the loss or dieback of tidal marshes, with dramatic changes in ecosystem functions and benefits.

Tidal marshes that have been completely lost because of dredging, draining or filling may never be replaced. However, many remaining acres of marsh in Maine, which have been degraded as the result of human activities, can be restored. Tide gates and dams can be removed, existing culverts can be added, enlarged or re-engineered to restore tidal flushing. Buffers and catch basins along highways and large paved areas that are adjacent to marshes can be installed to help restore natural runoff patterns. Tidal ditches that once drained the marsh can be plugged to restore natural hydrology. These measures help reverse the process of marsh degradation, allow the recovery of salt marsh plants and formation of peat substrate.

Although outright destruction, filling and dredging of tidal wetlands are now virtually prohibited by law, incremental and unauthorized activities need to be prevented. Vigilant and thoughtful defense of existing marshes is critical to their preservation, but prevention alone is not enough. With creative and effective restoration and management, marshes can recover their important role in the functioning of the larger ecosystem. The purpose of this book is to help local groups and individuals evaluate threatened and degraded marsh systems in their areas, establish priorities for restoration, and learn about funds and in-kind services that are available from federal and state agencies for this important work.

Section 2: Mastering the Lingo -- Restoration Terms and Techniques[1]

This section covers the concepts and terms of restoration ecology that apply to tidal marshes. The goal is to give citizen activists enough understanding and sophistication in this new field to be effective as advocates for their local wetlands.

Ecological restoration focuses on habitats and areas where ecological function and vigor have been impaired by human activity. The goal of restoration is to develop self-sustaining ecosystems that closely resemble natural systems in structure and function. The policy challenge is to define the functions and benefits sufficiently broadly. Restoration attempts to replicate the complex interactions and functions of a natural ecosystem, is a relatively new field that combines an experimental and inexact blend of science, technology and engineering. As more and more restoration is being undertaken in the United States, however, there are increasing numbers of examples of successful projects.

Tidal marshes are unique, sensitive and precious habitats. They can only function well with full and regular tidal flows flooding and draining them. Regular tidal exchange cycles prevent invasive fresh water plants from crowding out the salt marsh grasses and plants. These tidal marsh plants, in turn, provide the habitat which shelters a vast assemblage of valuable fish, shellfish, birds and other organisms that use salt marshes for all or part of their life cycle. Tidal exchange provides the link between marsh and marine habitats for these organisms.

Restoration of tidal flow to existing and former tidal marshes is the prerequisite for restoration of this habitat. Only with tidal flow can a marsh recover its function and vitality, and only with tidal interchange can a marsh contribute to the larger estuarine and marine ecosystems of which it is an essential part. Restrictive tidal crossings, which cut off full tidal exchange, are a logical starting point for tidal marsh restoration efforts.

A tidal **crossing**, for purposes of this book, is a culvert or bridge that allows tides to flow under a road or manmade structure to a vegetated tidal marsh. Crossings located at the

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[1] Much of this section was adapted from Niedowski, N. 2000 (in press). New York State Salt Marsh Restoration and Monitoring Guidelines.

head of tide, on the natural transition zone between tidal marshes and upland, are not defined as tidal crossings. A **tidal restriction** is a tidal crossing that limits water from freely passing from the upstream to the downstream salt marsh and vice versa. A crossing is restrictive when the opening is too small to allow for equal water levels on both sides of the crossing throughout the tidal cycle. Another type of restriction occurs when a culvert is positioned so high it reduces tidal range by preventing drainage as the tide drops below the culvert and delays flooding as the tide rises. Poor crossing maintenance can lead to channel blockage, causing restrictions. Dams and solid embankments, which block flows, are the ultimate restriction.

It is difficult to modify natural ecosystems. Thorough study of as many aspects as possible of the system to be restored will increase the likelihood of success. Partial successes should be viewed as lessons to help improve restoration techniques.

In broad terms, the goals of habitat restoration may be stated as follows:

1. To the greatest extent practical, achieve functional ecosystems similar in quality to undisturbed sites. Because of many variables and constraints that affect tidal marshes, complete restoration may be neither achievable, nor reasonable.
2. Restore critical habitat for fish, wildlife and plant species, including those listed as threatened, endangered, of special concern or historical interest. Restore habitat for species that are desirable for commercial and/or recreational purposes.
3. Use a regional perspective to integrate and prioritize individual restoration projects and programs within a regional framework.
4. To the extent practical, ensure that the acreage of priority habitats is restored and preserved.

Restoration Terms

To ensure effective communication, it is essential to have a commonly understood vocabulary for the various activities that may be discussed in the context of restoration projects and other habitat modification and restoration work. An overview of some common terms follows[2]:

[2] Definitions derived from NRC, *Restoration of Aquatic Ecosystems;* Mitsch and Gosselink, *Wetlands* and Niedowski, *Salt Marsh Restoration and Monitoring Guidelines*.

Compensation: Creation or restoration of "equivalent" wetland area and function comparable to areas and functions destroyed or damaged by human activity (such as oil spills as mandated by the Federal Oil Pollution Act of 1990).

Creation: The establishment of a wetland where one formerly did not exist.

Enhancement: Activities conducted in existing wetlands to achieve specific management objectives or provide conditions that previously did not exist and which increase one or more aquatic functions. Enhancement may involve trade-offs between aquatic resource structure, function and value; a positive change in one function may result in a negative impact on other functions.

Function: Various physical, chemical or biological processes which take place in wetlands. Functions that are commonly recognized are food chain production, provision for fish and wildlife habitat, waves and erosion barrier, storm and floodwater storage, nutrient and chemical uptake and exchange.

Management: At present this entails the treatment of wetlands to achieve a targeted goal such as enhancement of fish and wildlife habitat. In the past, "management" almost invariably meant elimination of wetlands by draining, filling, dredging or diking to convert tidal marsh to fresh marsh or open water (such as creating pannes in marsh to encourage bird utilization).

Mitigation: The creation or restoration of wetland to replace or "mitigate" wetland destroyed by development. Mitigation is usually done to satisfy legal mandates of wetland regulation. One example is the creation of artificial wetland as mitigation for destruction of natural wetland by construction.

Reclamation: The alteration of wetlands for the purpose of converting the area to utilitarian human uses. For example, diking or draining a tidal marsh might convert it into agricultural land.

Rehabilitation: The conversion of former wetlands of one type into some other type not previously present. A diked and drained tidal marsh could be converted to a freshwater wetland.

Restoration: Return of an ecosystem to a close approximation of its structure and function prior to disturbance. In the case of tidal wetlands this may be achieved by re-establishing the functions that have been affected by human activity: restriction of tidal flow, filling, draining, altering hydrology or contamination by toxins, freshwater, and/or invasive and exotic species, among others. For this book, restoration is distinguished from rehabilitation or mitigation, which have more narrowly defined meanings and often involve trade offs between damaged or destroyed marsh habitat.

Tidal Marsh Disturbance and Post Disturbance Conditions

Both human activities and natural events can disturb marshes. In order to understand the effect on the marsh during restoration, both of these impacts need to be considered.

Human Marsh Disturbances

Hydrologic Changes: Disruption of the hydrologic regime of a tidal marsh, or even minor elevation or gradient changes, can have profound effects on vegetated tidal wetlands. Degradation and loss of upland buffers may cause increased sediment flow, altered ground water elevation and flow, loss of nutrient filtering vegetation, and loss of wildlife habitat for wetland species. Changes in soil and water salinities will affect species composition in tidal wetland and creek communities (such as invasion by common reed). The most dramatic and common cause of hydrologic disruption is restricted tidal connection.

Historically, marshes have been cut off from the tides both inadvertently and deliberately. Inadvertent changes involve construction of roads or railroads across the marsh using causeways, bridges and culverts. Deliberate changes include diking for reclamation, or damming for conversion to freshwater systems (such as ice ponds), or to power tidal mills.

Causeways, bridges and culverts: Roads, railroads and other linear structures have frequently been built on marshes, taking advantage of their level, undeveloped topography to cut from headland to headland along the coast. The causeways built for these projects acted as dams across the high marsh and prevent sheet flooding on spring tides. Culverts and bridges were typically designed solely with flood control in mind and did not allow for the tidal exchange necessary for marsh vitality. Ill advised dumping of riprap intended to combat the erosion from the increased flow through an undersized crossing, often cause additional restriction.

Dams: Tide mills and ice ponds were built on many inlets along the Maine coast. Although today no mills or ice operations remain in use, the dams and crossings built for these projects continue to restrict flow to marsh or potential marsh areas, providing few, if any, offsetting benefits.

Ditching: Ditching is one of the oldest and most pervasive forms of human marsh disturbance in Maine. The early settlers dug ditches to increase the production of salt hay and improve marshes for grazing. Extensive grid ditches, intended to drain standing water, were dug in salt marshes in the 20th century. This practice occurred during the Depression, ostensibly as a mosquito control measure, but primarily to make work for the unemployed.

Tide gates: Various types of gates or valves have been installed in tidal channels for flood control, mosquito control or reclamation. There are several types of flow control devices. Flap gates swing open to allow drainage from the marsh and close to exclude flood tides. These gates allow water to drain from the marsh, but prevent or restrict inflow of tidal water. Slide gates can be closed manually to exclude storm tides. Automatic tide gates, which use float devices, can be adjusted to allow tidal exchange during normal tides and to close to prevent flooding during extreme high tides.

[[Figure 12- Self regulating Tide Gate (after Dreyer & Niering, 1995)]]

Impoundment: Impoundments are areas of marsh that are converted to open water by diking or installation of weirs to restrict flow of water from the marsh. Impoundment has been used to create waterfowl habitat, but its effectiveness is often impaired when invasive plants such as cattails and common reeds colonize the impoundment. The function of impounded marshes as habitat for fish and shellfish is dramatically impaired, and is eliminated for estuarine species.

Diking: Tidal marshes, especially in Washington County, were diked and tide gated during the nineteenth century for reclamation as agricultural land.[3]

Filling: Many marshes have been filled, either for development or simply as a dumping site for dredge spoil or solid waste. Filling destroys a marsh's original vegetation, ecosystem functions and habitat value.

Pollution: Pollution from oil spills or chronic introduction of oil from outboard motors, marinas and terrestrial sources, especially road runoff, can affect salt marshes. Pesticide residue from agriculture and mosquito control efforts is another type of pollution. Residuals of these pollutants can remain in the marsh sediment and be remobilized by dredging or flooding. Stormwater discharge, especially the first flush from roads, can introduce a wide range of pollutants, including oils, nutrients, and heavy metals. Stormwater may carry excessive sedimentation. Freshwater pulses associated with stormwater can lower salinity levels in the soils below the critical point and make the marsh vulnerable to invasive freshwater plant species.

Shoreline hardening and structures: Bulkheads, revetments and similar structures restrict the natural dynamics of the marsh. The development behind bulkheads and revetments restricts a marsh's ability to transgress in response to rising sea level. Light duty docks, pedestrian catwalks and observation platform can shade marsh plants and reduce their vitality unless they are built sufficiently high above the marsh or with sufficiently open decking. [4]

Sea level rise: Although marshes have kept up with the generally rising sea level for the past several thousand years, the rate of rise is accelerating and marshes' ability to keep pace will be compromised if their tidal exchange is restricted. Upland development adjacent to marshes restricts the marsh's ability to transgress landward with rising sea level, resulting in a net loss of marsh area.

[3] For an extensive review of these projects see Sebold, 1998

Natural disturbances

Winter ice, storm, and hurricane disturbances can have dramatic effects on a marsh and significantly affect marsh morphology and vegetation.

Winter ice: Ice, together with storm and tidal movements, can uproot marsh vegetation, sometimes rafting chunks of marsh onto tidal flats where they may begin to form new marsh. Ice may change the marsh elevation by erosion and accretion. Boulders and debris can be deposited on the marsh surface. Ice and winter waterfowl feeding scour and trim marsh vegetation, giving the early spring marsh a crew cut look. The debris from this scouring may be deposited in wrack lines on the high marsh, killing the rooted vegetation and creating openings, or pannes where pioneer plants such as glassworts can colonize.

Storms and Hurricanes: Storm waves can erode and change marshes, altering tidal openings in barrier beaches, eroding protective sandbars, fringing marshes and other shoreline features. Storm surges may deposit sediment and debris on the marsh, dramatically affecting vegetation.

Post Disturbance Conditions

All ecological consequences of disturbances must be considered in designing a restoration project. For example, a restriction that alters the tidal regime may also cause subsidence of marsh peat, aeration and decomposition of the peat, chemical changes in soil pore water, changed salinity in substrate and creeks, restricted exchange of animals, plants and nutrients with the adjoining estuary and invasion of nuisance plants. This summary of common post disturbance conditions demonstrates that they all derive from changes in the tidal regime. The primary characteristic of a tidal marsh is regular tidal inundation.

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[4] Buchsbaum, Coastal Marsh Management in Kent, ed. *Applied Wetlands Science And Technology* presents guidelines developed for such projects in Massachusetts.

Subsidence: In addition to limiting tidal water exchange, tidal restrictions limit the amount of sediment added to the marsh. Reduced sedimentation and decomposition of dehydrated marsh soil cause the marsh surface to subside below its original level. Restoration of subsided marshes raises special problems because full restoration of tidal flow may create open water rather than vegetated marsh. Close control of tide flooding levels may be required to achieve the goal of revegetation by marsh plants.

Freshwater flooding: Tidal restrictions, levees next to ditches, subsidence and vegetation changes can increase the risk of freshwater flooding of marshes. A degraded marsh is less effective as a barrier to flooding and as a sponge to absorb floodwater, Prolonged flooding (usually in springtime) can affect marsh soils and vegetation, accelerating change to either open water or freshwater habitat.

Changes in salinity: Changes in hydrology, especially tidal restrictions, will affect the marsh's salinity, which in turn may affect all marsh species. Freshwater flooding or rain can dramatically reduce salinity. Conversely, salinity may rise dramatically during dry periods when trapped salt water evaporates.

Changes in vegetation: All of the above changes in water and salinity conditions will have an effect on the vegetation of the marsh. The Spartina grasses that dominate Maine salt marshes can thrive only with regular salt water flooding which inhibits the establishment of other, less salt tolerant species. Small changes in the marsh can tip the balance in favor of invasive species such as the common reed ("*Phragmites*"), which often forms a dense monoculture of tall plants (up to 12 feet). This lowers plant diversity and changes the vegetative structure from a low grassy meadow to a tall reedy thicket affecting animal food webs. Reed stands can, also, pose a fire hazard. Although the effect of spreading common reed upon salt-marsh wildlife is not well understood, there is concern that typical salt marsh animals and birds will find it a less favorable habitat.[5]

Soil oxygenation: A lowered marsh water table results in the increase of soil oxygen levels. The oxidation of marsh peat leads to conversion of iron pyrite to sulfuric acid, increased soil acidity and mobilization of potentially bioavailable heavy metals.

Restoration Strategies

Restoring tidal flow: Restoration of tidal flow is the first prerequisite to tidal marsh restoration. Removing flow restrictions, cleaning crossings and removing undersized culverts and tide gates are the initial steps. Once the obvious barriers have been removed, further measures include plugging ditches to restore sheet flooding of high marsh areas, and removing dikes or spoil levees along ditches to facilitate drainage of the high marsh on ebb tides.

Duration of inundation: The duration of inundation determines the type of marsh vegetation. Smooth cordgrass does best in areas with longer periods of daily inundation where other plants cannot thrive because of excess salinity. Areas with shorter periods of inundation allow colonization by other species.

Resizing crossings: Although complete removal of all crossing restrictions, including berms and fill on the high marsh surface, is the ideal, resizing of crossings is a practical alternative. The sizing decision should be based on complete hydrologic calculations of the flow needed to allow appropriate tidal exchange and sheet flooding of the high marsh. In cases where there is extensive high marsh behind linear fill (such as roads), it may be necessary to install supplemental culverts to allow for full sheet flooding of the high marsh on spring tides. Crossings must accommodate fish as well, and recent data suggests that some fish avoid long dark culverts. Culverts must be set deep enough to avoid creating sills which block flow at lower tide levels.

Although marshland mosquito control is not practiced extensively in Maine, in nearby states, the grid ditching and pesticide methods of the past have been replaced with "open water marsh management". This approach takes advantage of the voracious appetite of marsh fishes, including mummichogs and other minnows for mosquito larvae. The marsh is managed to provide shallow channels across the high marsh to encourage minnows to forage for mosquito larvae on the high tides and retreat safely to deep-water pools created in the high marsh during low water. Healthy marsh with unaltered tidal circulation and naturally formed pannes will provide fish access to mosquito larvae.

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[5] Dreyer and Niering, *Tidal marshes of Long Island Sound*, p. 38

Restoration of vegetation: In many instances, restoration of tidal flow will result in increased salinity and which will kill off noxious species such as common reed, and allow Spartina grasses to recolonize naturally if there are nearby stands to provide propagation material. This process is slow and it may take as many as 20 years for the marsh to return to a stable, saline tidal habitat. If the affected marsh has vigorous stands of common reed, more aggressive control measures such as mowing or cutting, herbicide application and prescribed burning can be taken. These measures can often be coupled successfully with a volunteer-based marsh grass re-planting program. In several areas around the country, re-planting programs have been built into school curricula complete with long term monitoring protocols for students to follow.

Restoration of tidal flow where the marsh surface has subsided may require adjustment of tide levels or regrading to raise the marsh surface.

Low-lying development - A cautionary note: The presence of structures and other human development only slightly above high tide levels may pose a limitation on tidal flows because of concerns about possible flooding. An attractive compromise may be the installation of self-regulating tide gates. These devices, which have been used successfully in Connecticut and Rhode Island marshes, have floats that automatically close the gate when the water level reaches a predetermined level.

[[Insert Figure 12- Self regulating Tide Gate (after Dreyer & Niering, 1995)]]

Conclusion

Numerous salt marshes have been restored in Connecticut, other New England states, and other parts of the country for over more than 20 years. Although manipulation of complex tidal ecosystems may never become an exact science, the lessons learned, if thoughtfully and thoroughly applied in Maine, can improve the likelihood of successful restoration.

Many restrictive tidal marsh crossings are road culverts that require periodic maintenance or replacement. Over time, working with the Maine Department of

Transportation (MDOT) and other road agencies may make it possible to restore optimal flow to many marshes with relatively modest incremental cost and effort.

Section 3- Making Restoration Happen[1]

The first steps in restoration are the identification of sites and the preliminary assessment of their potential. The actual restoration is more difficult, but more rewarding. One person can undertake the steps identified in Phases I and II as outlined in this workbook, but usually the actual restoration will require a significant group of dedicated people. Successful restoration projects require cooperation with abutting landowners, local, state and federal government agency staffs, non-profit conservation organizations, and estuary scientists. This calls for systematic planning, sustained effort, and old-fashioned patience.

The reward is an inspiring view of a restored salt marsh from a roadway, trail or backyard that evidences the natural beauty and function that existed before human intervention. A restored marsh is worth the effort! It is testimony to the ability of people to make a difference. It becomes a building block in the regional, national, and international effort to restore the ecological life-support systems of our planet.

A Restoration Project Is a Campaign

A restoration project can be thought of and implemented as a campaign. The following aspects of a campaign contribute to a successful operation:

- develop a good business plan for your project
- identify and enlist strategic partners
- complete a site-specific restoration feasibility assessment that includes biological, hydrological, engineering, and societal aspects of the project
- build public awareness and enthusiasm through media and communications
- assess and comply with legal requirements
- supervise construction
- conduct post-project monitoring

Develop a good business plan for your project

When you contemplate restoration of a site, it is important to think of the project as a business. In any business plan, there needs to be a statement of purpose, a strategic

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[1] Adapted from Maine Citizens Guide to Evaluating, Restoring and Managing Tidal Marsh, Robert R. Bryan, Michelle Dionne, Ph.D., et al. (Maine Audubon Society 1997).

action plan that covers specific activities and resources of money and personnel that need to be developed, identification of key individuals and their responsibilities, a "marketing" plan, and a timeline. The urge to "just do it" will be irresistible in the beginning, but time spent thinking seriously about what you want to accomplish will repay itself many times over during the course of the project. Amend the plan as you develop more information and a better understanding of the project.

Identify and enlist strategic partners

It is extremely important to identify partners who share your restoration goal. Partners can add human resources, technical expertise, funding and regulatory clout. Many government agencies and non-profit conservation organizations are looking for restoration projects that already have local support. Even if these sources cannot or will not help with your project, they can refer you to others. Land trusts, watershed groups, water quality monitoring groups, local environmental organizations with experience in projects of similar complexity can be valuable partners. Their experiences are invaluable. Local businesses and individuals who have a financial stake in maintaining or restoring the health of marshes (eco-tourism outfitters, local lobstermen, fishermen and clammers) are good partners, also.

Early in the process you need to work closely with area officials and landowners to create a restoration plan that addresses local concerns. If the site is privately owned, it is critical to establish a working relationship with the owner at the beginning of the project. While *you* might be enthusiastic and convinced about the need for restoration, don't assume that everyone will share your views. Concerns about flooding, mosquitoes and other issues may arise, fortunately there are many measures that can reduce or eliminate the basis for these concerns.

Visit your town officials (conservation commission, town manager, selectmen, and councilors) early on, Take photographs of the proposed site and prepare a written description or narrative to give them a sense of the benefits and scope of the project. This is the time to find out if anything might prevent the project from going forward, such as concerns about funding, increased maintenance responsibilities or the effects of increased tidal flooding. It is important to address these concerns right away because technical funding assistance from other sources will not be available without local support.

Two other factors support the importance of these initial contacts. First, you must keep in mind that each town may have specific procedures for permitting the project. The restrictive crossing may be located in one municipality, but the actual or potential impact of clearing the obstruction may occur in an upstream or downstream municipality. Cover all bases! Some towns may ask you to notify or obtain permission from abutting landowners before permitting a project. Other towns may require approval from their planning board or endorsement by their conservation commission.

The second factor that underscores the importance of approaching municipal officials at the outset, is the possibility that a portion of the project might be paid for by the entities responsible for maintaining the road. A restrictive culvert can be replaced during regularly scheduled roadwork at a very low or no incremental cost. This solution may not even require a permit over and above the road work permits if no other changes are proposed for the road or its embankment.

State agencies have staff experienced in coastal marsh restoration who can advise you or work directly on the project. Make a point of asking your regional biologist from the Department of Inland Fisheries and Wildlife (DIFW) to make a field visit. Often, he or she has first hand knowledge of the area and can help devise a specific plan. In addition, you may need the approval of your regional biologist when you apply for a permit from the Department of Environmental Protection (DEP).

If you live between New Hampshire and the Kennebec River, contact:

Phil Bozenhard
Department of Inland Fisheries and Wildlife
Region A
328 Shaker Road
Gray, ME 04039 (207) 657-2345x110

If you live between the Kennebec and Penobscot Rivers, contact:

Jim Connolly
Department of Inland Fisheries and Wildlife
Region B

RFD 1, Box 6378
Waterville, ME 04901   (207) 547-5318

From the Penobscot River to the Canadian border, contact:

Thomas Schaeffer
Department of Inland Fisheries and Wildlife
Region C
68 Water Street
Machias, ME 04654   (207) 255-4715

Because you will probably be working in a salt-water environment, the state Department of Marine Resources (DMR) should also be consulted because of its interest in anadromous fish runs and coastal fisheries. The Bureau of Resource Management at DMR has an excellent library and knowledgeable staff. Be sure to call:

Dr. Linda Mercer
Bureau of Resource Management
Department of Marine Resources
McKown Point
West Boothbay Harbor, ME 04575   (207) 633-9565

The Maine Coastal Program in the Maine State Planning Office is very helpful, also, and can help identify additional sources of state funding and give technical assistance on your restoration plan. Contact:

Elizabeth Hertz   (207) 287- 8935
or Jackie Sartoris   (207) 287-1494
Maine Coastal Program
State Planning Office
Augusta, ME 04333

You can get invaluable technical assistance from federal wildlife biologists and scientists. They can provide wetlands information and fish and wildlife data, help you work out a specific restoration plan, provide assistance with the federal agencies responsible for permits, and guide you to sources of federal funds. Funding for restoration projects varies greatly. The more complex the project, the more technical and financial support it will need. For additional assistance on developing a restoration plan or identifying sources of funding, contact:

Lois Winter
US Fish and Wildlife Service - Gulf of Maine Project
4R Fundy Road
Falmouth, ME 04105   (207) 781-8364

Depending on the significance of the project, biologists at the US Fish and Wildlife Service may help you devise a specific restoration plan and offer knowledge of federal funding opportunities for wetland restoration, or at least steer you toward other partners.

Ron Joseph US Fish and Wildlife Service Wetland Restoration Program 1033 So. Main St. Old Town, ME 04473	(207) 827-5938
Michele Dionne Wells National Estuarine Research Reserve 324 Laudholm Farm Rd. Wells, ME 04090	(207) 646-1555 x 136
Bob Wengrzynek US Department of Agriculture Natural Resources Conservation Service 5 Godfrey Drive Orono, ME 04469	(207) 866-7249
Bill Hubbard or Larry Oliver New England District US Army Corps of Engineers 696 Virginia Road Concord, MA 01742-2751	(978) 318-8111
Rob Bryan Maine Audubon Society Gilsland Farm Falmouth, ME 04105	(207) 781-2330
Peter Shelley Conservation Law Foundation 120 Tillson Avenue Rockland, ME 04841	(207) 594-8107

The Natural Resources Conservation Service (NRCS) has funding for restoration projects, and coastal wetlands are their top priority. As of 1996, they paid 75 - 100% of the cost of a restoration project. NRCS has experienced engineers and hydrologists who can evaluate the feasibility and effects of your project, develop cost estimates, and help select contractors with experience in this type of work.

Consultants, academics, or other wetland professionals who might be contacted for assistance often live in or near the study area. For a statewide list of wetland professionals, contact:

Maine Association of Wetland Scientists
PO Box 202
Yarmouth, ME 04096
Don Phillips, President (207) 848-5714

In our experience, the earlier you identify and connect with your strategic partners, the faster and easier the entire restoration effort will go. On the reverse side, the failure to engage a strategic partner early – particularly one with regulatory interest in your project area – can make your life miserable and doom your project from the beginning.

Prepare a site-specific restoration feasibility analysis

A site-specific restoration analysis involves assessment of the biological, hydrological, societal and engineering aspects of the project and is essential to demonstrate the feasibility and value of your project. For most restoration projects beyond the most straightforward maintenance or culvert replacement situations, it is important to involve professionals. Developing a specific plan can be relatively simple or multifaceted and complex. The completed project will result in changes to the biological, hydrological, or topographical status quo. As the project proponent, you need to understand the probable nature of those changes. For example, there may be a well-established freshwater ecosystem upstream of the obstruction that is fully protected under wetland and land use regulations. If cottages have been constructed around an artificial lake or pond, restoration will be politically impracticable without a very sympathetic homeowner's association.

Even assuming no opposition to the project, you need to have technical support for the restoration action that you plan to take. How are the wetlands changing as a result of the obstruction? Where will the high tide line be after the flows are returned? How much larger should the culvert be? What is the proper elevation for the bottom of the culvert relative to tidal flows? If storm surges or flooding are historic problems in the areas, what sorts of tidal gates can be used to control the extreme storm-related events without starving the marsh of the normal tidal flows necessary for its health? What sorts of stormwater controls are available to prevent freshwater runoff from highways flooding the salt marsh? Are the sediments that have built up behind the restriction contaminated? How severely? These are the sorts of questions that you will need to answer.

The analysis of costs and benefits of a restoration project can determine whether or not funding or technical assistance is available from outside sources. Projects that restore a relatively large section of marsh for minimal cost will probably be favored over more expensive projects that do not accomplish much obvious restoration.

In our experience, the analysis is the most challenging aspect of the restoration work. It can be time consuming and very expensive. To secure taxpayer subsidized professional services, try the state and federal agencies mentioned above. Ecological evaluations might be available through Maine Audubon Society, the Wells Reserve, or other similar organizations.

Depending on the sophistication and determination of the project group, some analysis can be done with volunteers under the supervision of a trained professional. You will want your results to meet regulatory standards. A particularly good resource for determining your ability to perform the analysis is the comprehensive guide developed by the Maine Audubon Society and Wells Reserve for this process, *Maine Citizens Guide to Evaluating, Restoring and Managing Tidal Marshes.* There may be a retired professional in your community who can help volunteers understand and follow the assessment protocols set forth in the guide or who can supervise the assessment process. The Wells Reserve is developing marsh assessment tool kits that will allow volunteers to measure and interpret factors such as marsh settlement and salinity levels in marsh soils. There may also be someone at your high school or local community college who can supervise such a project, involving their students at the same time.

If you ultimately need funding, go to foundations, local businesses, or local individuals. These projects are often very attractive to the private donor community.
Be creative, don't be defeated by rejection, and don't give up. You and the marsh are in this for the long haul!

<u>Build public awareness and enthusiasm</u>

A successful estuary restoration project needs and deserves a well-developed communications plan. It took decades before the general public changed the common nomenclature of "swamps" to "wetlands," and only a slightly shorter time to shift from “jungles” to “rainforests.” People in your local area may not know the definition of an estuary, marsh or a tidal wetland or what makes them uniquely valuable to the community. A crucial part of an marsh restoration action plan is the development of public awareness and understanding of estuaries and the relation between a marsh and coastal fish and shellfish populations.

A communications plan has several elements. It is vital to identify key talking points. What is an estuary? Why are estuaries needed? It is important to develop media contacts and take time to educate reporters and editors as you would the general public. You might schedule a meeting with the paper’s editor or invite a reporter out to the project site. Getting to know a managing editor can be helpful because reporting assignments and the reporters themselves tend to change frequently.

The issue of estuary health resonates if it connects to people’s lives. In coastal Maine, many people are economically dependent to some degree on commercial fisheries. Whether everyone understands it or not many of these fisheries depend upon the health of marshes. Lobstermen, fishermen, clammers, wormers, and aquaculture site leaseholders are eloquent advocates for estuary health and often are willing to speak to the press or call elected officials. Similarly, an advocate from an “eco-tourism” business, a kayak outfitter or a schooner captain, can speak on behalf of the project, making the point that a restored marsh is good for local jobs and businesses. Any school involvement in the project is particularly appealing to media and should be exploited.

Permitting and regulatory requirements

Once you have addressed local concerns, worked with regional and federal biologists or other technical experts to create a specific restoration plan, and located potential sources of funding, you are ready to apply for the permits you need for the project. At this stage, strategic partnerships and background work on project feasibility pay off. In fact, any opposition that has not been addressed and resolved will certainly surface and protract, if not kill, your project. It is difficult to overstate how important it is to talk with regulators and other groups who have received restoration permits before you have made an investment of time, money, and energy in the effort.

For additional guidance on regulatory requirements, contact:

Peter Shelley
Conservation Law Foundation
120 Tillson Avenue
Rockland, ME 04841 (207) 594-8107

The State Permit

The Department of Environmental Protection (DEP) requires a permit for all activities conducted in coastal marshes, including restoration projects. It is helpful to meet with a project analyst at DEP for guidance before you submit an application. Depending on the type and extent of the restoration project that is proposed, the permit may be considered under the "Permit by Rule" provisions of state laws, or may be treated as an "Individual Permit," a longer process. If an Individual Permit is required, it will be sent to the Department of Inland Fisheries and Wildlife (DIFW) for review. If you have worked with the regional biologist already, this should be a simple formality.

If the study area is between New Hampshire and the Kennebec River, contact:

Doug Burdick
Southern Maine Regional Office
Maine Department of Environmental Protection
312 Canco Rd
Portland, ME 04103 (207) 822-6300

If the study area is between the Kennebec and the Penobscot Rivers (inc. Mt. Desert), contact:

Nancy Beardsley
Central Maine Regional Office
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017 1-800-452-4570

If the project site is from the Penobscot River to the Canadian border, contact:

Stacie Beyer
Eastern Maine Regional Office
Maine Department of Environmental Protection
106 Hogan Road
Bangor, ME 04401 (207) 941-4570

The Federal Permit

You may need a Federal Permit in addition to a State Permit. Maine currently requires that all activities in tidal marshes obtain an Individual Permit from the US Army Corps of Engineers (ACOE). Therefore it is important to meet with officials from ACOE *before* you submit an application to find out exactly what format to use and what types of supporting materials to include. The US Fish and Wildlife Service and Environmental Protection Agency review ACOE permit applications. Working with all these agencies and keeping them informed about the progress of your project will help the permit process. To learn about ACOE permit applications and set up an informational meeting, contact:

Jay Clement
US Army Corps of Engineers
RR 5 PO Box 1855
Augusta, ME 04333 (207) 623-8367

Once permits are in hand, actual restoration can begin.

Supervising the restoration project

Unfortunately, even the best-laid plans sometimes go astray. Marsh restoration, particularly salt marsh restoration, is an emerging specialty and there are not many experienced contractors in the field. If your project is relatively simple, for example, culvert replacement or installation, most contractors should be able to do a good job without damaging adjacent marsh. If there is more extensive work, such as plugging ditches on the marsh, reconstructing salt pannes or moving earth on the marsh, special equipment and expertise is needed. All prior effort and plans could go to waste if an over-enthusiastic contractor rips through the *Spartina* with a piece of heavy equipment not designed for that use. It is important to consult with federal and state agencies to identify experienced contractors and to monitor their work. Highway contractors in particular have been known to cut corners to save time or money probably because they do not understand the significance of all the required steps. Knowledgeable contractors are useful resources and can explain to your group what they are doing on the marsh and why.

Conducting post-project monitoring

Once reconstruction is complete and the regulatory agencies have all signed off, the fun part of the project begins: watching and enjoying the recovery of the tidal wetland's health. One of the most dramatic and visible recoveries taking place in coastal Maine right now is at the Back River marsh north of Bath, on Route 1. During the summer of 1999, travelers could watch the freshwater and upland vegetation die back as the newly restored tides returned the soil and water chemistry to state of a healthy marsh. During the summer of 2000, a new set of plants began emerging in response to the new tidal regime.

Beyond the satisfaction of seeing the results of your work, monitoring is important for scientific and practical reasons. It is important to document the rates of recovery and the process of recovery. Some of these changes will be predictable, others may not. A stand of common reed or purple loosestrife may not retreat to higher ground and may require further steps for eradication. The "self-adjusting" tide gate may not be adjusted properly, or may become inoperable because of a new obstruction. Even the best plans often require modification after they are implemented, and you should be prepared to monitor for this eventuality[2].

The Good News/Bad News about Your Salt Marsh Campaign

The good and bad news about your tidal marsh restoration campaign is that it does not end. Regular monitoring is an integral part of tidal marsh stewardship. This can be done whether restoration projects have been conducted or not. Just as regular water and air quality observations are important to detect both acute and chronic changes, it is important to watch over your unique wetland resource areas.

[2] The GPAC group at the Gulf of Maine Council on the Marine Environment has developed a regional monitoring protocol, see Neckles and Dionne, Regional Standards to Identify and Evaluate Tidal Wetland Restoration in the Gulf of Maine, a GPAC Workshop report, 2000, 21p.

Section 4: Tidal Wetlands Are Part of a Larger Landscape

Sound stewardship and management strategies for the protection of tidal marshes must take adjacent upland and ocean into consideration as well. Land use within the watershed and adjacent to a marsh has an effect on the water quality, wildlife habitat, wildlife use, recreational and commercial potential, and aesthetics of the marsh system. A municipality's decisions about comprehensive planning, shoreland zoning and development permits are critical to the health of the tidal marsh. For a more detailed discussion of land use issues in upland areas near the marsh, consult *Maine Citizens Guide to Evaluating, Restoring and Managing Tidal Marshes.* Residents of coastal towns should urge their municipal officials to consult the Maine Department of Inland Fisheries and Wildlife, the Maine Department of Marine Resources, and the Coastal Program of the State Planning Office when making land use plans that will affect land adjacent to tidal marshes. *The Estuary Book* (Maine State Planning Office, 1998) is an excellent source of information on coastal planning.

Careful land use planning should be an ongoing part of marsh system management that will require coordination between the town's planning board, code enforcement officers, conservation commission and shellfish committee. Additional sources of information to help with the planning process are included in the References section.

If a land use plan for the area exists, specific regulatory measures may help protect marsh systems. The state's Shoreland Zoning law is an important tool to control land use within 250 feet of a marsh. Zoning can be used to minimize the impact of development near areas with exceptional wildlife, finfish, and shellfish value. If a marsh scores low on some values it does not eliminate the need for protection, however. Restoration might enhance a marsh's ecological integrity, and its value for wildlife, for example. The Department of Inland Fisheries and Wildlife has rated wildlife values for most coastal wetlands, and the US Fish and Wildlife Service may have additional data. Gathering information on wetland values will support the case for proposed zoning changes.

Towns can identify ways to control **non-point pollution**, such as runoff from streets, parking lots, farms and other developed areas. It is not only point source pollution that carries enough bacteria to close clam flats. Stormwater runoff can be controlled; **best management practices** should always be used in new construction, and remediation of existing sources should be considered. The Maine State Planning Office Coastal Program and the Department of Environmental Protection can provide assistance with both point and non-point source pollution.

Other planning decisions affect marsh functions and values. One of the most important ways to protect a marsh is to protect water quality within the watershed of the marsh. Any **point sources** of pollution, such as malfunctioning or non-existent septic systems and overboard sewage discharges, should be identified and eliminated. These failures should be identified by the town's Code Enforcement Officer and corrected.

The condition of the adjacent coastal waters is as important as upland development to marsh health. Although a primary purpose of tidal marsh restoration is to support the marine ecosystem, human activities in adjacent ocean waters can undermine the ultimate restoration of the marsh. Some maritime activities that can affect marshes adversely are channel dredging and the improper disposal of dredge spoils, inshore finfish aquaculture, oil spills, ballast water discharges from commercial maritime traffic, and sewage discharge from recreational vessels. In Maine, comprehensive and integrated management planning and regulation below the high water line is far less developed than on land. However, if your study area is located in a heavily used port or bay, you may want to consult the Maine Department of Environmental Protection or the National Marine Fisheries Service about regulations and oversight.

For the Maine Department of Environmental Protection, contact:

Lee Doggett
Bureau of Land and Water Quality
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017 (207) 287-7666

For the NMFS habitat restoration office in Gloucester, MA, contact:

John Catena
National Marine Fisheries Service
Habitat Conservation and Protected Resources Divisions
1 Blackburn Drive
Gloucester, MA 01930 (978) 281-9313

It is critical to the long-term protection of marshes that restoration groups become involved in regional efforts such as the Casco Bay National Estuary Project, the Pen Bay Network or another network of organizations in your area. It is also critical that you keep informed of positive and negative developments in the Maine Legislature through organizations like the Natural Resources Council of Maine and Maine Audubon Society. All your work can be frustrated by legislation that loosens a water quality regulatory standard.

Stay involved!

SECTION 5: OVERVIEW OF RETURN THE TIDES METHODOLOGY[1]

This section presents an overview of the tidal crossing inventory methodology of the *Return the Tides* program. In our view, an integrated methodology for the identification and assessment of tidal wetland problems is crucial for several reasons. First, at the largest scale, we believe that it is important to develop a comprehensive inventory of tidal restrictions for the entire Maine coastline so that the scope of the problem can be assessed statewide in a rational manner. Since the resources do not exist to commission such an inventory by the state or federal governments, this assessment will have to be done on an incremental basis using local resource groups and interested activists. A standard approach by all groups will allow the results to be aggregated more easily as the projects are completed.

Second, at a more local scale, it is important to implement a systematic approach to identifying and evaluating tidal restrictions. The data forms (Appendices xx,y,z,) that have been developed in this methodology can be utilized by anyone to inventory sites and record observations. The data from these forms can be integrated with GIS information using forms developed by the Island Institute and can be integrated into the regional inventory for the Gulf of Maine developed by GPAC[2]. This database forms the foundation of a targeted action plan for restoration projects; further evaluations by marsh specialists, and for post project monitoring. These sites can also be visually displayed as a layer on a GIS map if one has been developed for the area.

The following methodology is based on several earlier efforts[3]. We think that it will be sufficient for identifying the universe of possible tidal crossings as well as serving as a preliminary screening of that universe for further actions. Actions might range from eliminating the site from the study, since it does not meet the definition of a restrictive tidal marsh crossing, to volunteer monitoring of a site, since it does not currently appear to be causing damage to the marsh, to further evaluation of a possible problem site for

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[1] This section is largely adapted from Tidal Crossing Handbook, A Volunteer Guide to Assessing Tidal Restrictions, Timothy A. Purinton and David C. Mountain, Ph.D., Parker River Clean Water Association, 69p.1998(?)

[2] See Dionne & Neckles, xx 2000

restoration.

Details of the Methodology

Preliminary Phase

The first and possibly most important step is to create a list of all potential tidal crossings in the study area. Initial identification can be done using a GIS analysis, comparing Wetland database information with transportation information (roads, railroads etc.) to highlight potential tidal marsh crossings or by a simple examination of USGS topographical maps. In both cases the focus of the study on all water features located between the shoreline and the first contour line above the shoreline. Wherever a road or railroad crosses such a watercourse, there may be a tidal crossing. Often, in our field investigations, we found marshes located above these crossings even though the map did not show marsh symbols. If a dam or a pond is indicated on these watercourse, that site should also be noted since dams and their upstream ponds may be former marshes that have restoration potential. A list of potential crossing is developed from this study using the Preliminary Listing Form (Appendix H) Separate lists are prepared for each Topographic quadrangle and each crossing is assigned an ID number.

Depending on the skill levels of the group doing the assessment, the study of other sources such as wetlands inventory maps, nautical charts, air photos, and Coastal Marine Geological Environment maps, are helpful in identifying additional potential crossings. One of the greatest resources for this phase is people. Interviews with people with local knowledge, such as members of local land trusts, conservation commissions, water quality monitors, fishermen, and residents in the study area can supplement the map study.
[[Insert Figure 13-Preliminary Listing form]]

Phase I

It is essential to get out in the field early to confirm that the sites on the preliminary listing are actually tidal crossings and to search for crossings that are not mapped, either

[3] Bryan and Dionne, 1997 and Mountain & Purinton, 1998

because they are new or too small. Also fieldwork is fun and energizing. This is where a dedicated team of trained volunteers is helpful. Each site identified in the Preliminary Listing or in the field should be visited. If the site is clearly above tide level or there is no crossing structure at the site or there is no associated marsh or potential marsh upstream, an appropriate notation is made on the preliminary listing and nothing further is done (of course if obvious problems are identified, they should be noted for another study. More information is gathered on all remaining sites.

Phase I, consists of a preliminary, visual assessment to determine which crossings are apparently restrictive. If the size and type of crossing and the resource areas upstream and downstream from the crossing show no signs of any restriction, photos and summary, estimated data is gathered using the Phase I data sheet. If a crossing appears restrictive, measured data is gathered and a sketch is made. The goal of Phase I is to visit and inventory all crossings and to gather sufficient data to identify those that need more detailed quantitative study in Phase II

[[Insert Figure 14- Sample Data Sheet (Phase I)]]

Phase II

Phase II is the first "technical" screening process and involves an intensive, daylong tidal monitoring effort. The goal of Phase II is to provide quantitative data showing the impact of the crossing on the on the tidal curve on each side of the crossing. Volunteers measure the tides every two hours, at each of several crossings, over a complete tidal cycle (approximately 12 hours). In our Casco Bay pilot study, we marketed this volunteer-driven effort as the "Return the Tides Day," which seemed to capture local interest. We think that this is a good exercise to publicize in its own right in that local people are out working on resource issues in their communities. The event also provides a vehicle to talk with local press and municipal officials about the problems of restrictive crossings and the objective of the effort in restoring marsh productivity and health. In Casco Bay, we worked with a broad cross section of people from the area; one could also use a local high school science program to help provide the labor and analyze the resulting data. The Phase II data sheets and instructions are in the Appendices.

The data from Phase II is plotted as a tidal curve that dramatically illustrates the effect of a restrictive crossing on the tide level.

[[Insert Figure 15- Sample Phase II Tidal Curve]]

<u>Phase II Follow up</u>

The data obtained in Phase II is used to create a crossing inventory for use by all interested parties. The inventory will be included in a regional database of potential restoration sites. Once the inventory is finished and the results are entered into the database or GIS map, you have a pretty accurate picture of the tidal crossings in the study area and have identified the problem crossings. At this point, the data may be used to select sites for further study or remedial action, which we identify as Phase III of the project (see Section 3: Making Restoration Happen). In Phase III, the participation of resource professionals from groups like the Maine Audubon Society or the Wells Estuarine Research Reserve and state and federal government agencies with expertise in full-scale marsh assessment and restoration is appropriate and necessary. The goal of Phase II is to provide information to officials, organizations and citizens that will help develop local and regional priorities for restoration projects.

At this point, you have a pretty good sense of where the problem situations are and, based on our experience in Casco Bay; you may also have a strong sense of what the necessary remedial action might be. In some cases, the remedial action might not require a permit and will consist of developing simply of removing debris and other obstructions that have collected around a particular culvert and are causing flow restrictions. These clean-up situations may be more common than one would initially expect. In other cases, the Phase II assessment process may have turned up a serious structural problem with a culvert so that remedial action (including widening the culvert during the repair) will be a priority for the local or state highway department to prevent damage to the roadway.

In most cases, however, the need for remedial action will be less straightforward. There may be flooding concerns with upstream landowners that need to be addressed; there may be sediment buildup above the restriction that must be evaluated; the upstream resources may not be exhibiting any signs of trouble despite an apparent restriction; if state or federal funding is required, the project will have to be compared to other competing projects in other areas for a variety of criteria.

We recommend that the results of Phases I and II be evaluated by local organizations and that an action plan be developed and endorsed to guide activities and assign responsibilities for further action to various organizations. In addition to the work associated with the sites that require further assessment and technical evaluation, we believe that an on-going monitoring program of all tidal wetlands in coastal Maine would be an important activity for watershed, water quality monitoring, and land trust organizations.

Section 6: Conclusion

Salt marsh restoration is a challenging activity with tremendous rewards for a volunteer organization. You learn a great deal about a relatively rare and biologically rich resource; you learn to work with a variety of organizations, including wetlands professionals and regulators; and you can make a tremendous on-the-ground difference that will stir your heart every time you pass your restored site. As complex as the task may seem, a phased approach works. The task is not difficult if you plan, involve multiple constituencies, and persist. In the end, you will make a difference to the coast of Maine and its indigenous flora and fauna. That is an undertaking worth serious consideration.

End of Text

Return The Tides

Figures

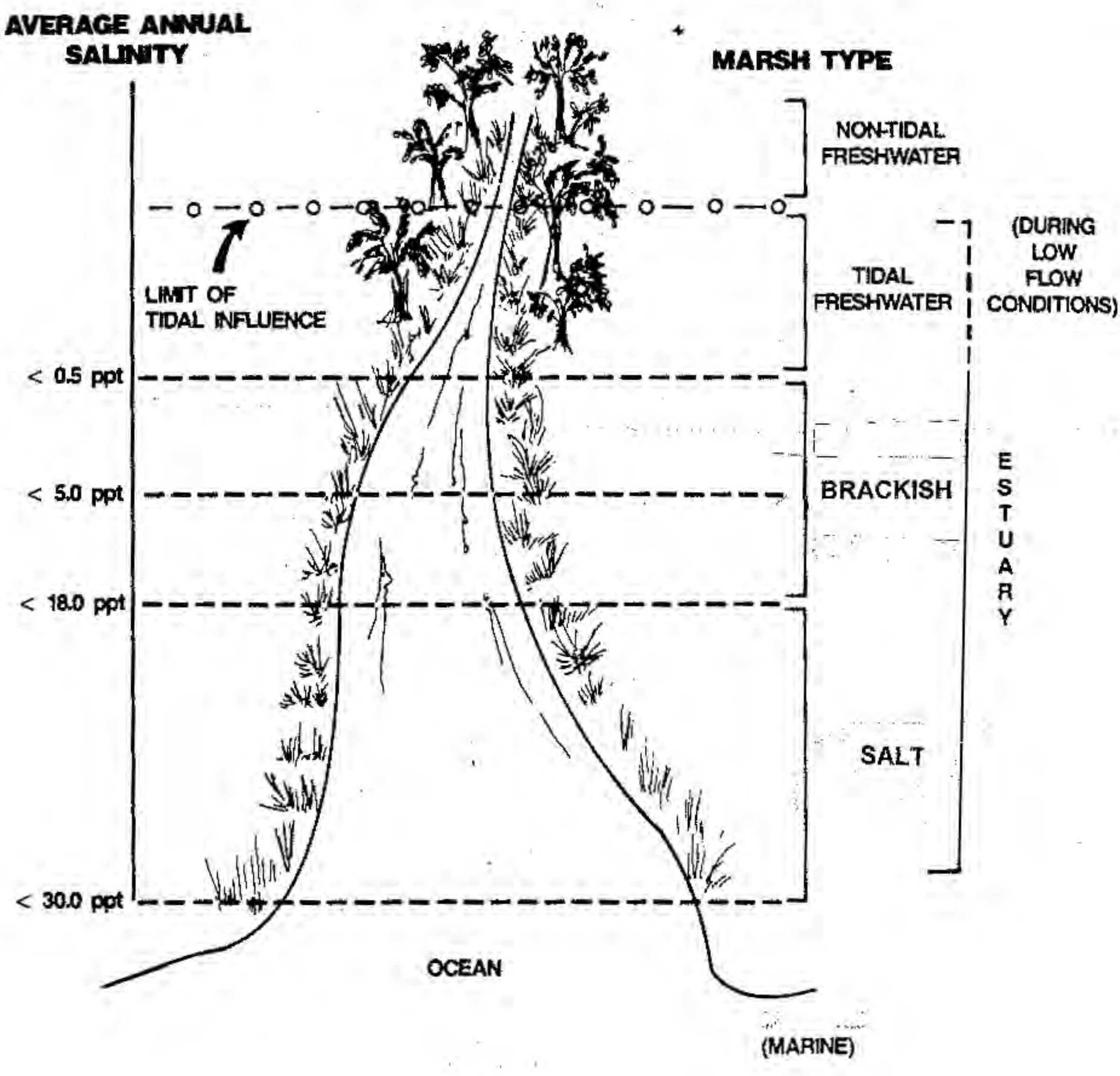
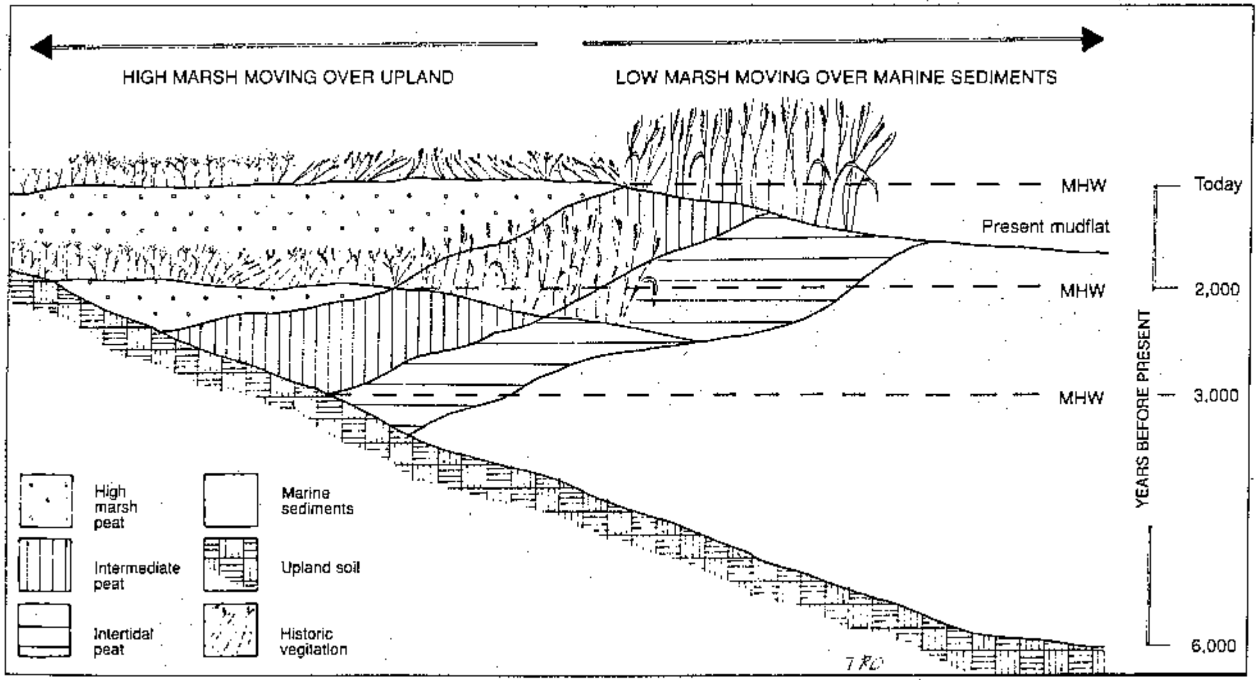


Figure 1- Coastal marsh types (after Mitsch & Gosselink, 1993)



Hypothetical cross-section of a salt marsh showing its development over time. As sea level rises, sediments, roots and rhizomes build up at the same rate to form peat. As the marsh rises, it expands out over mud flats toward the water, and also landward. The illustration shows a marsh surface, with its vegetation, at 2,000 years before the present (yrs bp). Past levels of mean high water (mhw) are also shown for 3,000 and 2,000 years ago and for the present.

Figure 2- Tidal Marsh Development (after Dreyer & Niering, 1995)

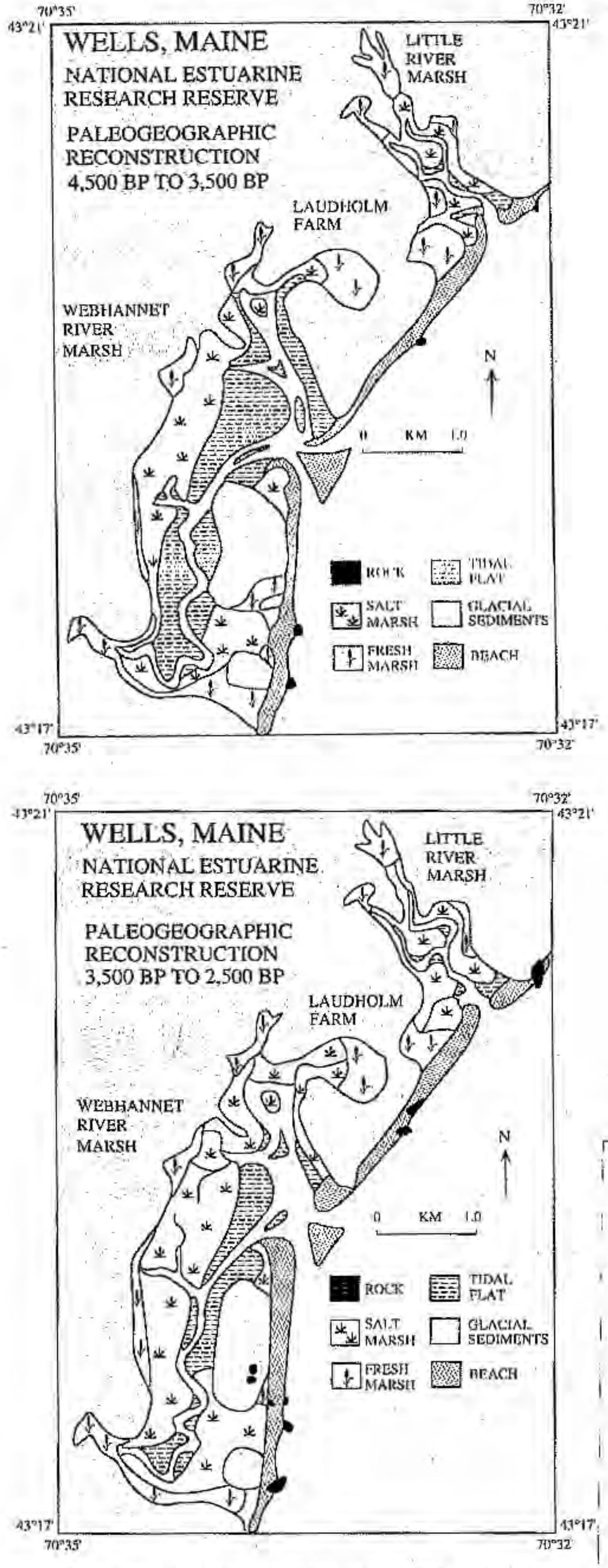


Figure 7. Paleographic reconstruction of the coastal region of Wells (a) between 4,500 BP and 3,500 BP; and (b) between 3,500 BP and 2,500 BP.

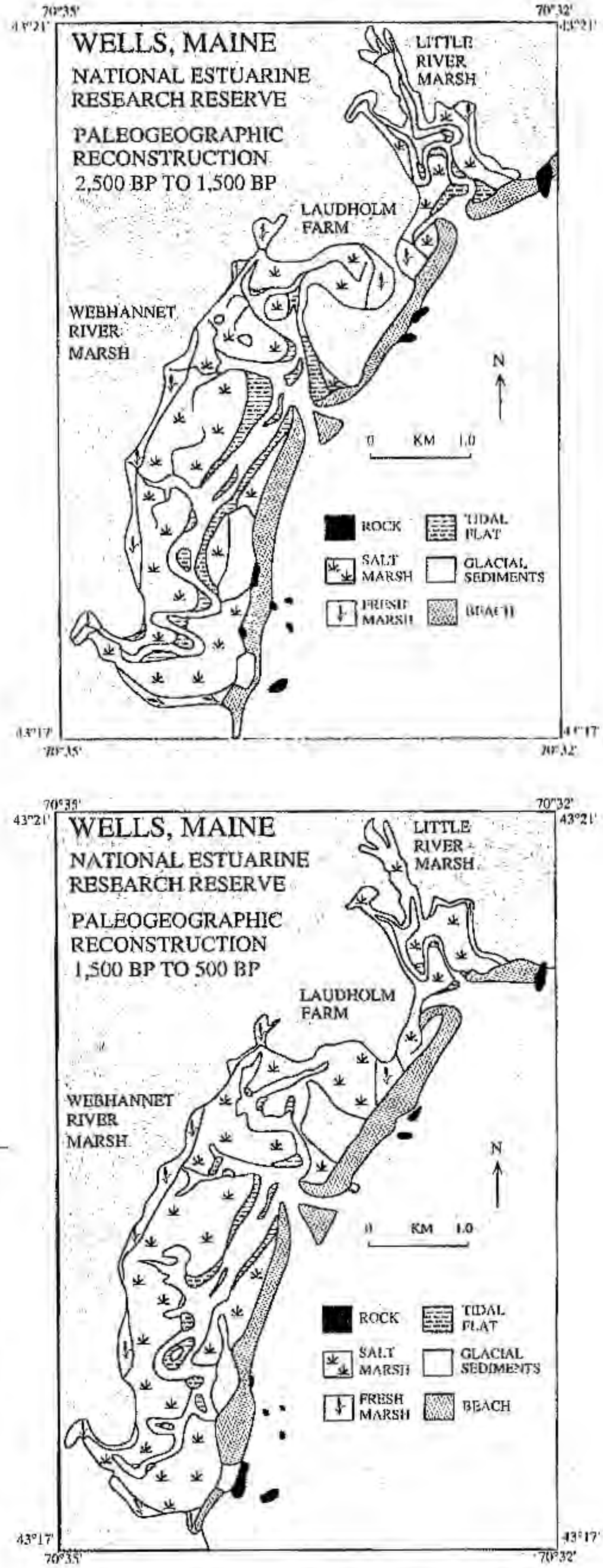


Figure 8. Paleographic reconstruction of the coastal region of Wells (a) between 2,500 BP and 1,500 BP; and (b) between 1,500 BP and 500 BP.

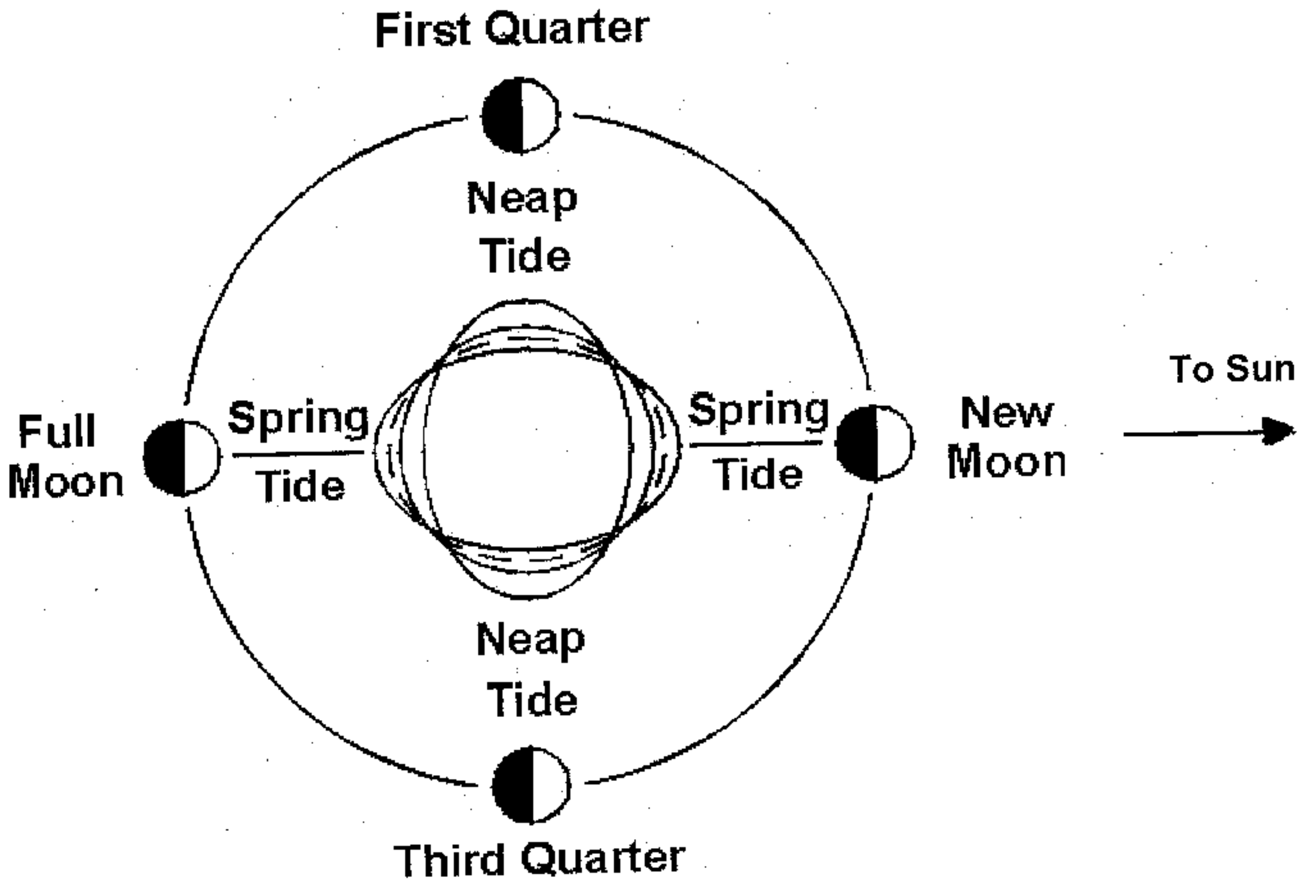


Figure 4- Spring And Neap Tide Forces (adapted from NOAA, *Our Restless Tides*)

Looking down on the earth and moon from the pole. The earth's surface is the central solid circle and the two solid ellipses represent the tidal force envelopes produced by the moon in the positions of szyzgy (new or full moon) and quadrature (first and third quarters). The dashed ellipse shows the smaller tidal force envelope produced by the sun

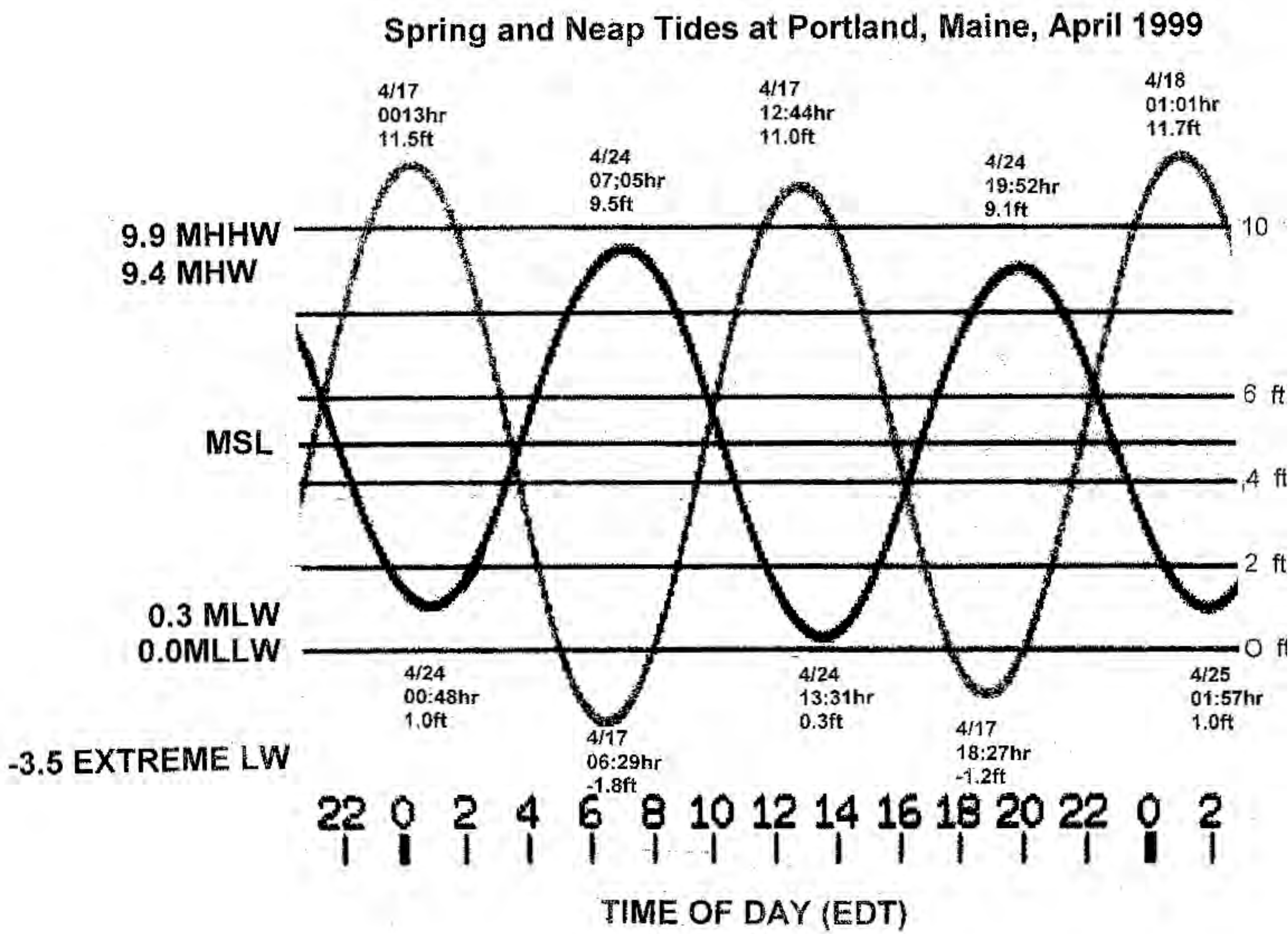


Figure 5- Spring And Neap Tide Curves

Note that during this month the spring high tides are near midnight and noon, while the neap highs are early morning and late afternoon.

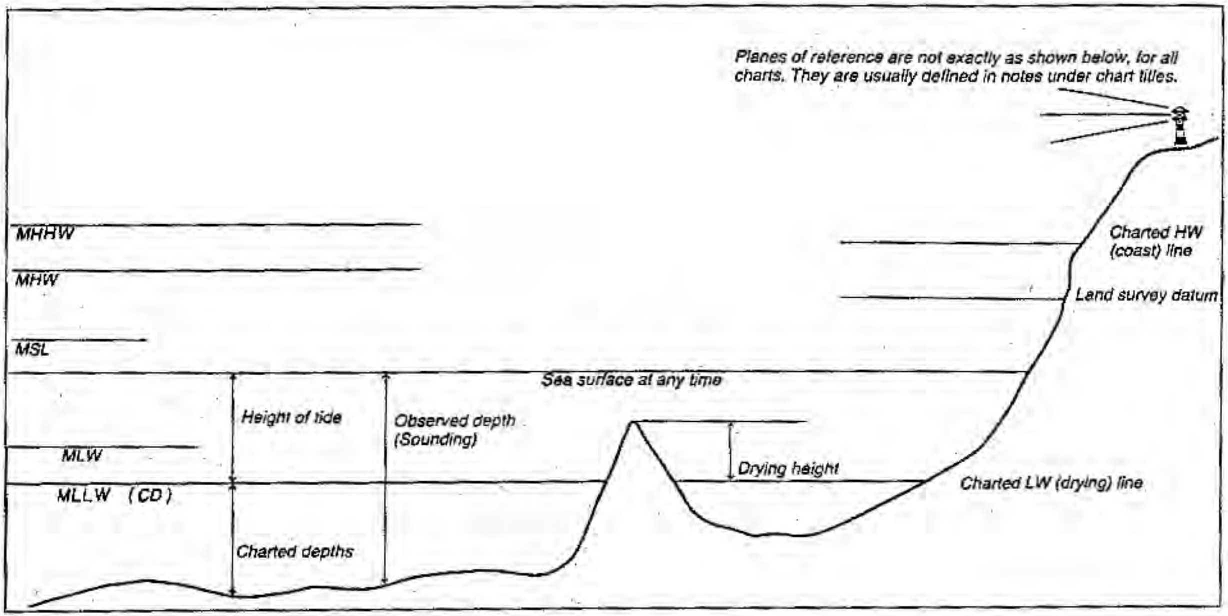
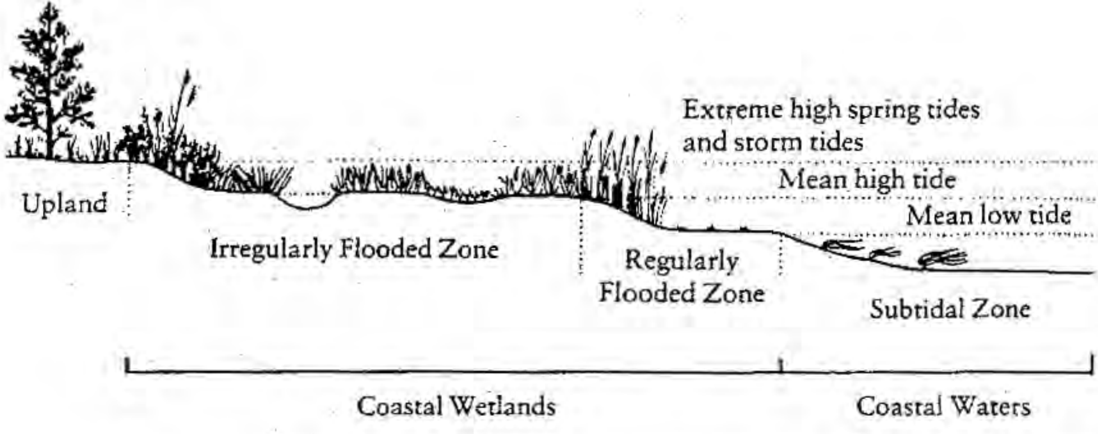
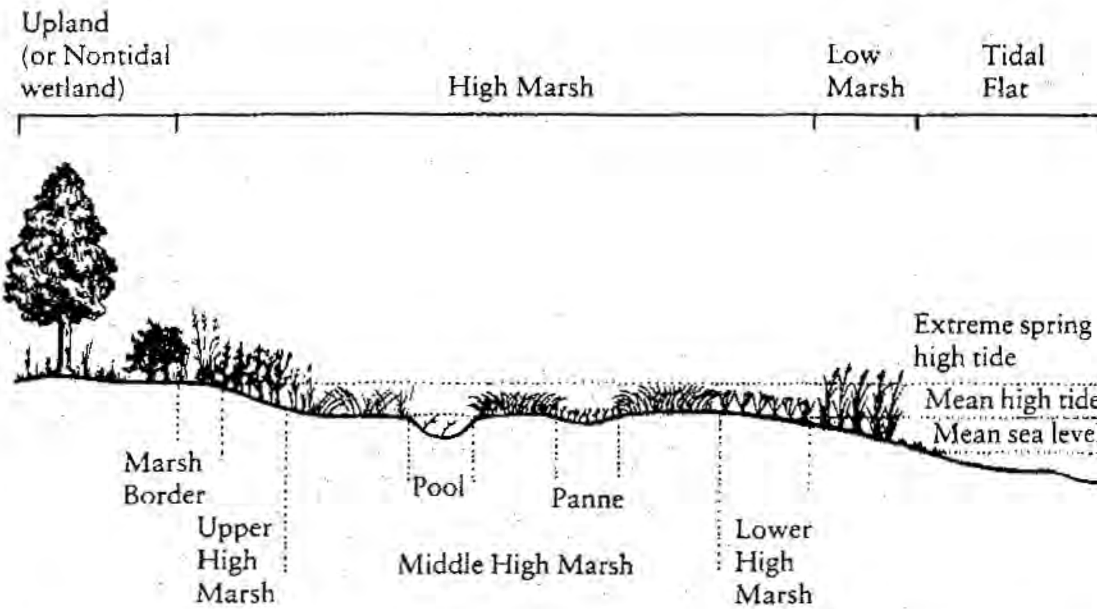


Figure 6 - Tide Levels and Datums (adapted from HO chart No.1)



Coastal wetlands can be divided into two zones, based on tidal hydrology: (1) regularly flooded zone and (2) irregularly flooded zone. The highest ocean-driven tides called "spring tides" occur during full and new moons; coastal storms can generate even higher tides, which may flood low-lying upland areas.



Generalized plant zonation in northeastern salt marshes: (1) low marsh and (2) high marsh. The high marsh can be further subdivided into several subzones. Pools and shallow depressions called "pannes" occur within the high marsh. Notice on the accompanying chart that plant diversity increases toward upland. Within individual wetlands, high marsh communities are intermixed, forming a complex mosaic.

Figure 7- Marsh Zonation (after Tiner, 1987)

	Plant Community	
Vegetative Zone	*Dominant Plants*	*Common Associates*
Low Marsh	smooth cordgrass (tall form)	smooth cordgrass (short form), rockweed (*Fucus vesiculosus*—locally), and other algae
High Marsh		
Lower High Marsh	smooth cordgrass (short form)	glassworts, salt hay grass, sea lavender, and filamentous green algae
Middle High Marsh	salt hay grass	spike grass (often codominant), sea lavender, black grass, marsh orach, and sea blites
Panne	glassworts, smooth cordgrass (short form) seaside plantain, and blue-green algae	seaside gerardia, sea blites, seaside arrow grass, sea lavender, spike grass, sea milkwort, and salt hay grass
Pool	widgeon grass	
Upper High Marsh	black grass	spike grass, salt hay grass, perennial salt marsh aster, sea lavender, high-tide bush, salt marsh bulrush, seaside arrow grass, seaside goldenrod, and seashore alkali grass
Marsh Border	switchgrass, slough grass, common reed, high-tide bush, and groundsel tree; in seepage areas: narrow-leaved cattail, three-squares, and rose mallow	seaside goldenrod, grass-leaved goldenrod, salt hay grass, annual marsh pink, creeping bent grass, red fescue, foxtail grass, American germander, hedge bindweed, poison ivy, marsh fern, baltic rush (New England), sweet gale (New England), northern bayberry

Figure 7a- Marsh Plant Communities (after Tiner, 1987)

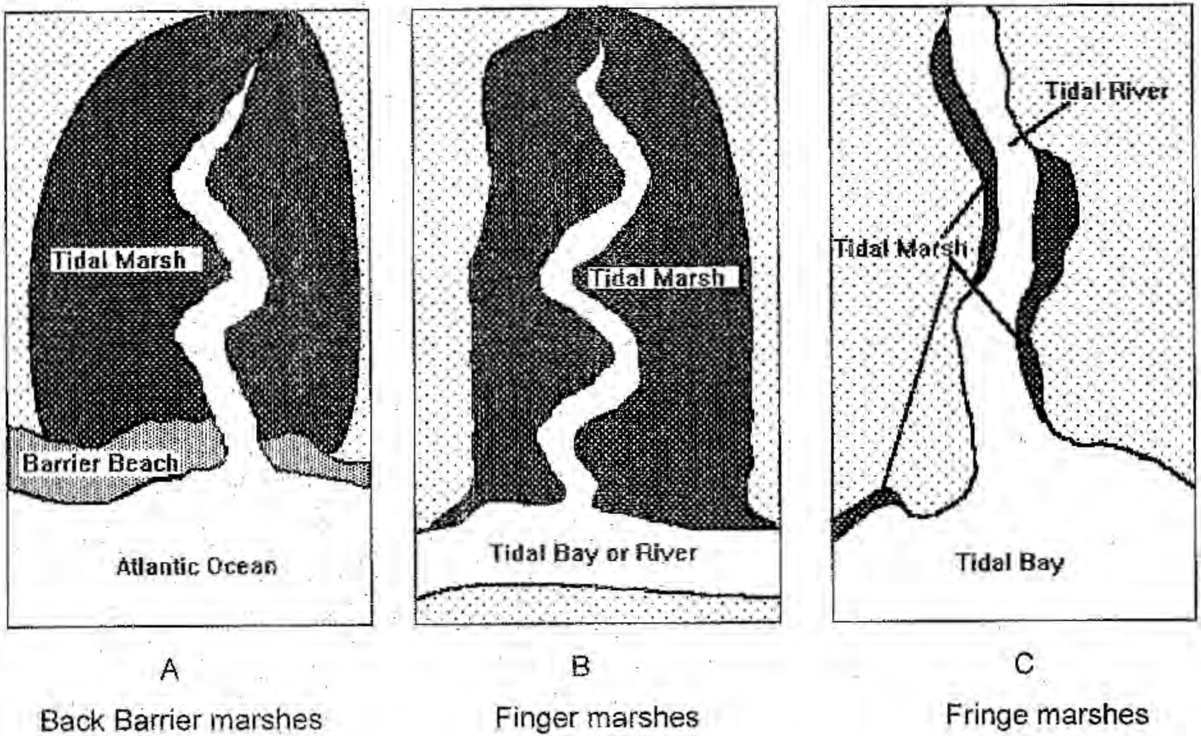


Figure 8- Marsh Geomorphology (after Bryan & Dionne, 1997)

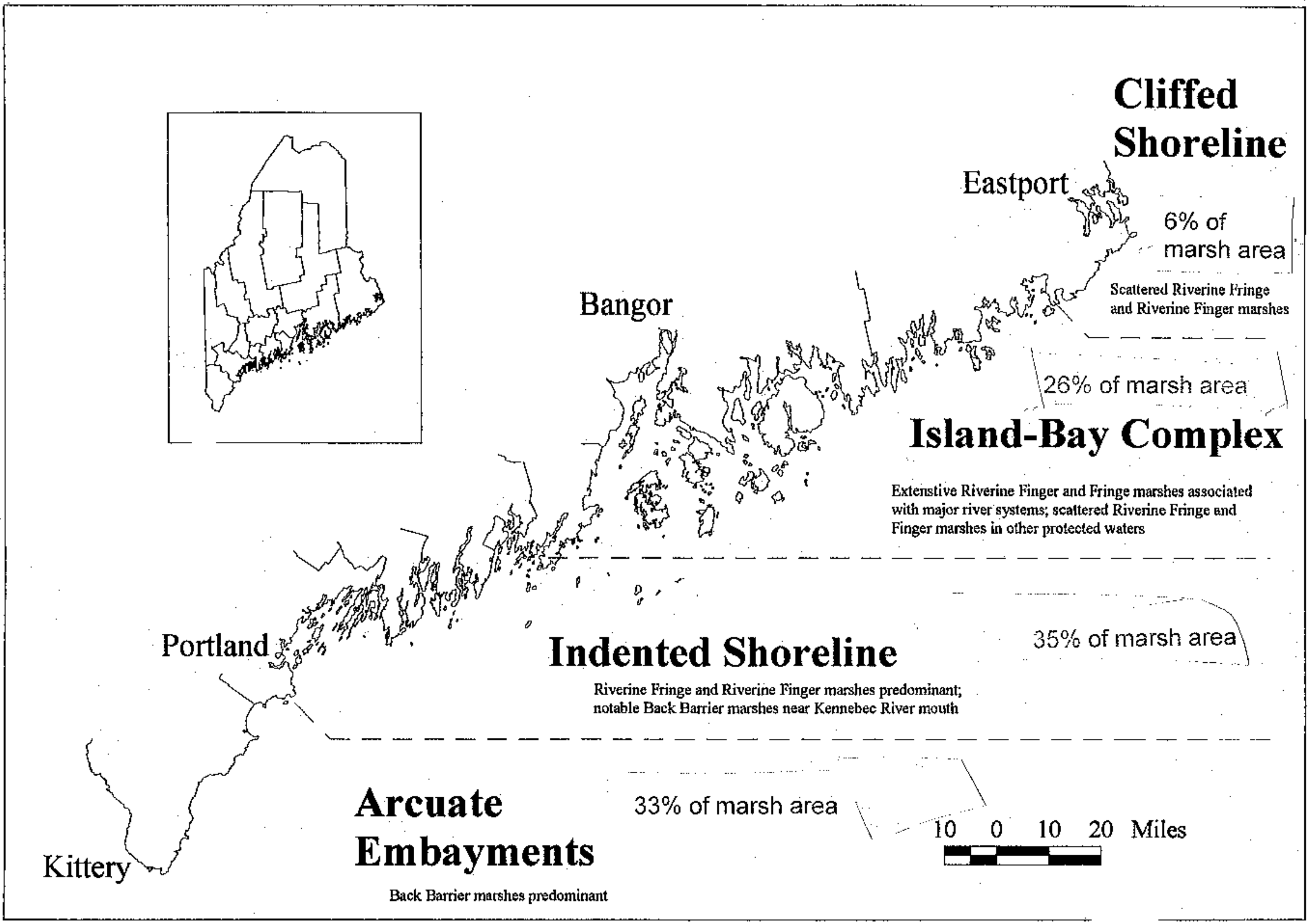


Figure 9- Maine Coastal Regions and Marsh Distribution
(after Bryan & Dionne, 1997)

MAINE TIDAL MARSH BIRDS

Nest and feed in high marsh
Sharp-tailed sparrow
Long-billed marsh wren (*Typha* or *Phragmites*)
Meadwlark
Savannah Sparrow (highest areas)
Marsh Hawk?
Short-eared owl (local)
Black rail (rare)?

Nest in high marsh but feed in pools of *S. Alterniflora* zone
Clapper rail
Willet
Black Duck
Blue winged teal
Canada goose
Seaside sparrow

Nest in high marsh but feed in open water
Gulls
Terns

Nest in upland edge but feed in high marsh
Yellowthroat
Song sparrow
Catbird
Kingbird
Redwing
Grackle

Nest in woody islands; feed in the marsh:
Herons
Egrets
Glossy ibis

Nest elsewhere; feed on insects over marsh
Swallow
Chimney swift

Migrants that use marsh for layover
White rumped sandpiper
Baird's sandpiper
Pectoral sandpiper
Short billed dowitcher
Red-necked phalarope
Red phalarope
Greater yellowlegs
Lesser yellowlegs
Least sandpiper

Coastal species (DeGraaf & Rudis)
Great Egret
Snowy Egret
Little blue Heron
Tricolored heron
Ruddy duck

Figure 10: Maine Marsh Birds
(List from Nixon, 1982, supplemented by Degraaf and Rudis 1986 and MAS Field checklist of Me Birds)

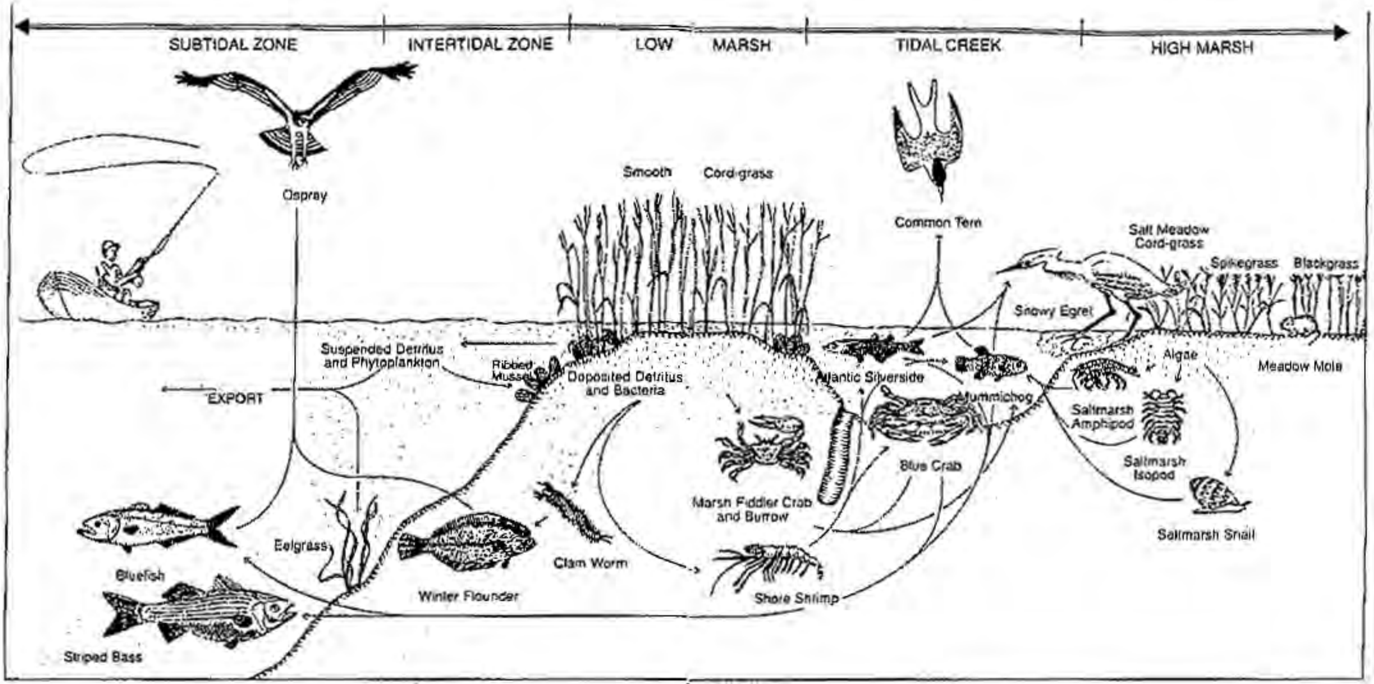


Figure 11- Simplified Food Pathways in Marsh and Estuary
(after Dreyer & Niering, 1995)

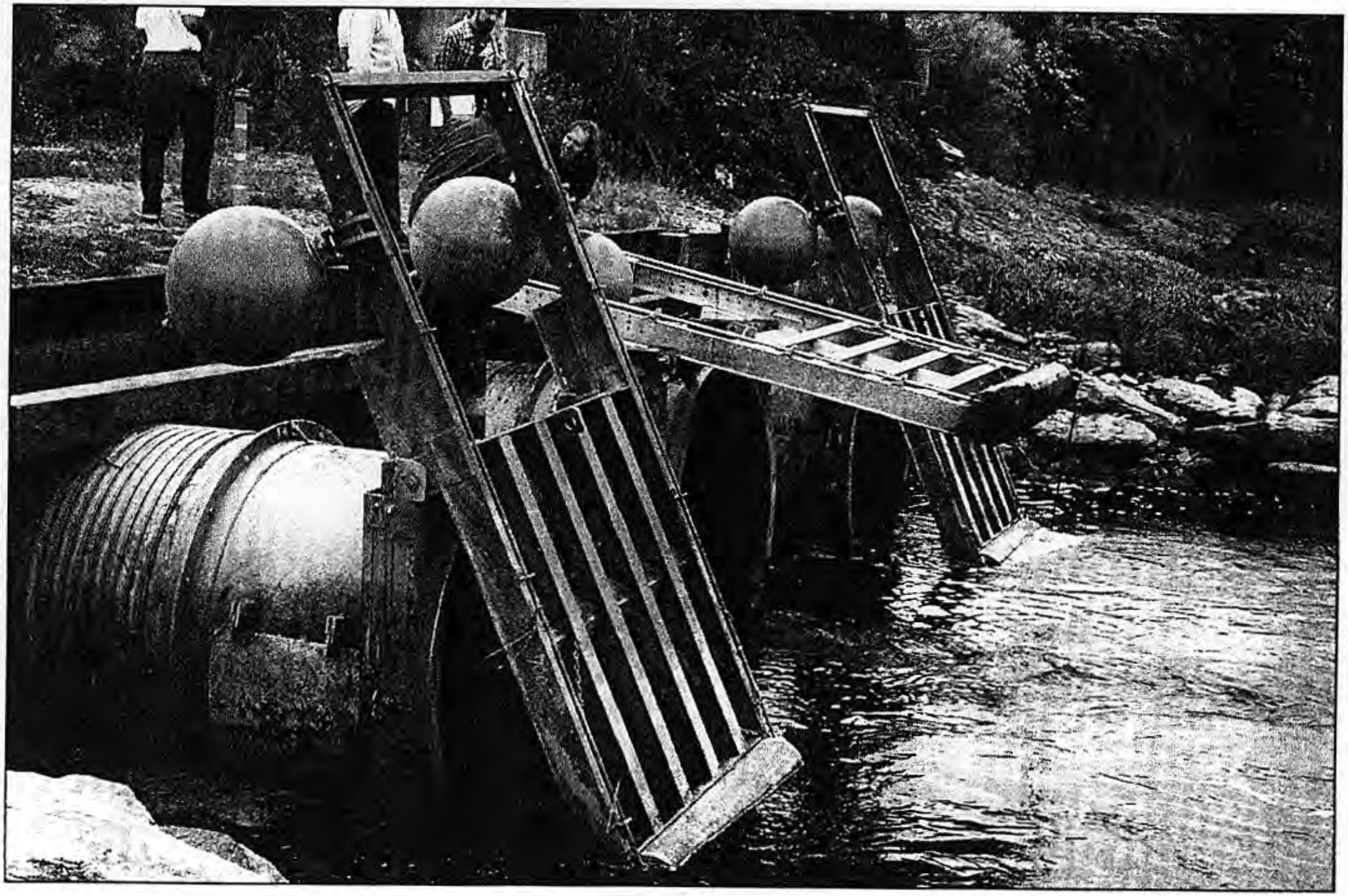


Figure 12- Self Regulating Tide Gate (after Dreyer & Niering, 1995)

RTT PRELIMINARY LIST Prepared by on , 2000

Topo Quad name [spell out] . page __ of __ .

ID # Locate on Map	TOPO NAME, QUADRANT, TOWN NAME Use abbreviation from list	ROAD NAME From TOPO or field	WATERBODY NAME From TOPO or field	CLOSEST LANDMARK If there is no Stream Name	CROSSIN G TYPE Use code from list	REMARKS

Figure 13 – Preliminary Listing

RETURN THE TIDES PROJECT: Tidal Crossing Data Sheet- Phase I (circle one): **MEASURED ESTIMATED**

IMPORTANT: before filling out this form review the instructions sheet and list of codes and abbreviations

Location Information			
Topo Name/ID # (copy from preliminary list)		Unique no. (assigned by GIS)	
Town		Topo quadrant (NW,NE,SW,SE)	
Water Body/Stream Name (From Topo, if not named, get local info and enter in quotes)		Marsh Ownership (P/T/S/F + cons)	
Street/Road Name (From Topo, if not named, get local info and enter in quotes)		Road Jurisdiction (P/T/S/F)	
Landmark/Location Description (From Topo, only if road or stream not named on topo)		LOCATION MARKED ON TOPO (check)	

Field visit Information	
Date/time/volunteer name(s)	
Weather (circle one)	Sunny Partly Cloudy Overcast Rain
Tide (circle height and direction)	HIGH/MID/ LOW Incoming/Outgoing/Change/Slack
	Enter Location and Description (e.g. "from crossing looking upstream")
A Photo #1 - Reference #:	
B Photo #2- Reference #:	
C Photo #3- Reference #:	
D Photo #4- Reference #:	
E Photo #5- Reference #:	

Crossing Information	**Remarks**
Type (circle one choice)	Bridge / Culvert / Dam/Other (describe in detail):
Fill (circle one choice)	Road on Marsh / Headland to Headland
Road runoff (circle one choice)	Onto Marsh / Into Creek
Shape (circle one choice)	Round/oval / Rectangular / other (sketch):
Material (circle one choice)	Iron/Aluminum/concrete / plastic /masonry / other (describe):
Dimensions of opening (Ho, Wo)	Height: ft in. Width: ft in
Nature of crossing: (circle all applicable) Upstream Downstream	Perched culvert/ pooling/ scour/ bank slumping/ rubble in stream perched culvert/ pooling/ scour/ bank slumping/ rubble in stream
Upstream Channel Width (UchW)	Ft Distance from Crossing (DC): Ft
Downstream Channel Width (DChW)	Ft Distance from Crossing (DC): Ft
Height from Channel bottom to culvert bottom: Upstream (UchH,)	Ft
Height from Channel bottom to culvert bottom: Downstream (DchH)	Ft
Length of fill over marsh (LF)	Ft
Channel Length at crossing (In middle) (CL)	Ft
Road Description (circle all applicable)	Lanes: 1 2 3 4/ curbs / paved sidewalks
Road Surface Material (circle one)	Asphalt/Concrete/Gravel/Dirt/Other (describe):
Condition (1-5*) of Bridge or culvert	1 2 3 4 5
Condition (1-5*) of Road	1 2 3 4 5

*1. Excellent 2. Good 3. Fair 4. Poor 5. Need of Immediate Repair

rev September 21, 2000

PHASE I DATA SHEET (PAGE 2/2) Topo Name/ID #: Crossing name:

Circle the Most Appropriate Response

Restriction Classification Scheme		
Classification	**Evidence of Flow Restriction/Erosion**	**Notes**
1 Upstream	Unrestricted/ No Pooling	
2 Upstream	Flow Detained/ Slight Erosion	
3 Upstream	Minor Pooling/Erosion Present	
4 Upstream	Significant Pooling/Significant Erosion Present	
5 Upstream	Major Pooling/Major Erosion Present	
Classification	**Evidence of Flow Restriction/Erosion**	
1 Downstream	Unrestricted/ No Pooling	
2 Downstream	Flow Detained/ Slight Erosion	
3 Downstream	Minor Pooling/Erosion Present	
4 Downstream	Significant Pooling/Significant Erosion Present	
5 Downstream	Major Pooling/Major Erosion Present	
Classification	**Channel vs. Crossing/ Opening**	
1 Upstream	Channel Width < Opening Width	
2 Upstream	Channel Width = Opening Width	
3 Upstream	Channel Width 1.1 to 2.0x Opening Width	
4 Upstream	Channel Width 2.1 to 5.0x Opening Width	
5 Upstream	Channel Width 5.1x + Opening Width	
Classification	**Channel vs. Crossing/ Opening**	
1 Downstream	Channel Width < Opening Width	
2 Downstream	Channel Width = Opening Width	
3 Downstream	Channel Width 1.1 to 2.0x Opening Width	
4 Downstream	Channel Width 2.1 to 5.0x Opening Width	
5 Downstream	Channel Width 5.1x + Opening Width	
Classification	**Vegetation Comparison**	
1	Upstream = Downstream	
2	Upstream Slightly Different Than Downstream	
3	Upstream Different From Downstream	
4	Upstream Much Different Than Downstream	
5	Upstream Completely Different Than Downstream	
Classification	**Flood Potential**	
1- Low	Flooding unlikely	
2- Med	Need detailed survey to determine flooding risk	
3- High	Structures likely to be flooded if restriction removed	

ADD SKETCH PAGE FOR EACH SIGNIFICANT RESTRICTION (circle) **SKETCH ATTACHED**

Narrative Description and General Notes: (attach additional pages as needed)

Volunteer signature(s): rev September 21, 2000

Figure 14 – Phase I Data Sheet

Town: Yarmouth
Date: 7/31/99
Map Reference Number: YFS2
Location: Prince Point Rd.
Data Collected by: MacVane

	Raw Data			Change	
Time	**Upstream**	**Downstream**		**Upstream**	**Downstream**
	(in)	**(in)**		**(in)**	**(in)**
6:50 AM	33.0	33.5		3.3	-6.2
9:10 AM	46.0	47		-9.8	-19.7
11:10 AM	45.5	46		-9.3	-18.7
1:20 PM	32.5	9.75		3.8	17.5
3:17 PM	18.5	0.1		17.8	27.2
5:00 PM	42.0	27.25		-5.8	0.0
Tidal Range =	27.5	46.9			
Up/Down Ratio =	59%				

Comments:

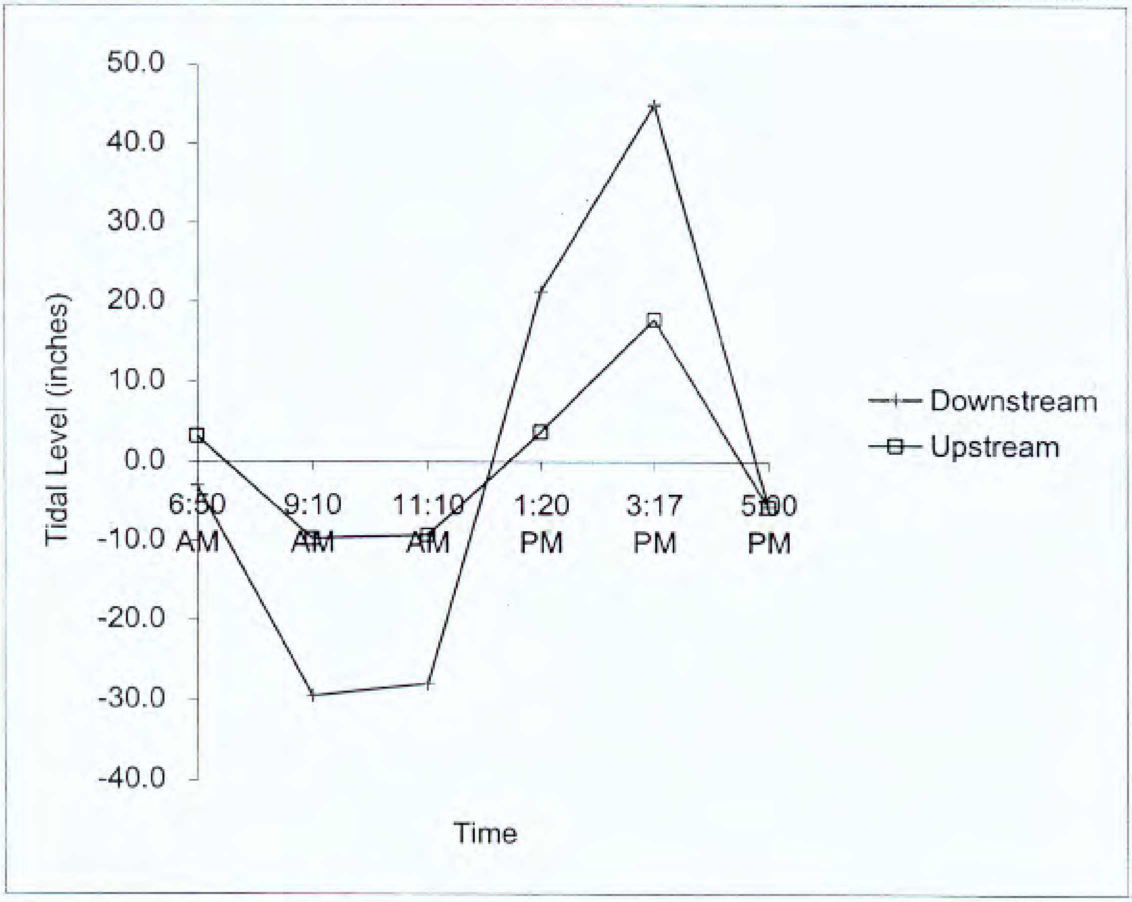


Figure 15 Sample Phase II Tidal Curve

Appendix A

GLOSSARY OF TECHNICAL TERMS

This glossary provides non-technical definitions of technical terms, some of which are used in this manual. This is by no means an exhaustive list of all the terminology pertaining to tidal marshes. For more detailed reference to tidal marsh terminology, see the references listed in Appendix B.

accretion	the gradual build up of surface elevations due to the deposition of suspended sediments on the marsh surface
adsorb	the chemical adhesion of one substance to the surface of another (e.g., nutrients and pollutants may be adsorbed to the surface of sediment particles)
aquatic	in or near water in such habitats as ponds, lakes, rivers and oceans
avian	relating to birds
back-barrier marsh	a marsh that forms in the low-lying area behind a barrier beach formation
barrier beach	an elongated landform created by the deposition of sedimentary materials by wind and wave currents, usually parallel to the shoreline, with water on at least two sides, and composed of sand, gravel, or cobblestones
benthic	relating to or occurring on the bottom of a body of water
best management practice	design or construction standards that are recommended to minimize the impact of development on the environment
biota	living organisms (plant, animals, etc.) in an ecosystem
brackish marsh	tidal marshes where the average water salinity is less than 18 parts per thousand (ppt) but greater than 0.5 ppt which is the upper limit of salinity in a freshwater tidal wetland
buffer zone	an undeveloped area bordering on a wetland that serves to lessen the impact of disturbance (e.g., urban development)
carrying capacity	the population of a species that an area can support without deterioration
chart datum	The datum to which soundings on a chart are referred. Since 1989, chart datum has been defined as mean lower low water for all marine waters of the United States
cobble	a rock fragment larger than a pebble but smaller than a stone (2.5 to 10 inches in diameter
current	Generally, a horizontal movement of water. Currents may be classified as tidal and nontidal. Tidal currents are caused by gravitational interactions between the Sun, Moon, and Earth and are part of the same general movement of the sea that is manifested in the vertical rise and fall, called tide. Nontidal currents include the permanent currents in the general circulatory systems of the sea or rivers as well as temporary currents arising from more pronounced meteorological variability
datum (vertical)	For marine applications, a base elevation used as a reference from which to reckon heights or depths. It is called a tidal datum when defined in terms of a certain phase of the tide. Tidal datums are local datums. See chart datum.
day	The period of rotation of the Earth. There are several kinds of days depending on whether the Sun, Moon, or other object or location is used as the reference for the rotation, such as lunar day and solar day.
declination	Angular distance north or south of the celestial equator. The Sun passes through its declinational cycle once a year, reaching its maximum north

	declination of approximately 23-½° about June 21 and its maximum south declination of approximately 23-½° about December 21. The Moon has an average declinational cycle of 27-1/3 days which is called a tropical month. Tides occurring near the times of maximum north or south declination of the Moon are called tropic tides, and those occurring when the Moon is over the Equator are called equatorial tides or equatorial currents. The maximum declination reached by the Moon varies from 28 to 18-½° over an 18.6-year cycle.
deepwater habitats	permanently flooded areas deeper than 6.6 feet (e.g., lakes)
degraded	characterized by loss of natural ecological structure or function
detrital food chain	food chain dependent upon decomposed plant and animal material as the source of energy
detritus	particles that result from the disintegration of organic material
diurnal	An event that occurs on a daily basis, such as “diurnal flooding”
dominant plant community	a single species or association of plants that are indicative of the ecology of an area, (e.g., in a cattail marsh the dominant plant community is cattails)
drainage pattern	the paths followed by surface runoff from precipitation within a watershed
ebb current (ebb)	The movement of a tidal current away from shore or down a tidal river or estuary related to the falling or ebb tide.
ecology	the study of interactions between living things and their environment
ecological integrity	the natural (undisturbed) quality of an ecosystem
ecosystem	a community of plants and animals and the physical environment they inhabit (such as estuaries and tidal wetlands) which results from the interactions among soil, climate, vegetation, and animal life
emergent vegetation	erect, rooted, herbaceous plants that can tolerate flooded soil conditions, but not prolonged periods of being completely submerged; these include grasses, sedges, rushes, and rooted aquatic plants; there are two types of emergent plants: *persistent* - emergent plants whose stems remain standing through the winter until the beginning of the next growing season (i.e., they persist), (e.g., cattails or bulrushes) *non-persistent* - emergent plants whose stems and leaves break down at the end of the growing season; from late fall to early spring there are no visible traces of these plants above the surface of the water (i.e., they do not persist)(e.g., smooth cordgrass)
estuarine wetlands	habitats partially enclosed by land but having an opening to the ocean where saltwater from the ocean mixes with freshwater from inland rivers and surface runoff.
exemplary community	an area selected by the Maine Natural Heritage Program as being an outstanding example of the natural plant and animals found in a particular ecosystem
fill	material, usually associated with the dredging of a harbor or inlet, placed on the surface of the marsh; the change in elevation caused by the disposal of this material in the marsh can lead to the loss of the area as a functioning tidal marsh
finger marsh	An elongated channel or riverine marsh with high marsh area large compared to size of channel. See **fringe marsh**
flood current (flood)	The movement of a tidal current toward the shore or up a tidal river or estuary related to the rising or flood tide.

food chain	an arrangement of organisms of an ecological community according to the order of production and consumption; at the bottom of the food chain are photosynthetic plants and phytoplankton; zooplankton and animals that feed on plants form the next level on the food chain, while predators form the highest levels
formerly tidal marshes	coastal wetlands that were once connected to tidal flow but have since been isolated from tidal waters by the construction of a man-made obstruction
freshwater source	the point of origin of nontidal waters including rivers, streams and surface runoff
freshwater tidal marshes	marshes that are tidally influenced, but where the average water salinity is less than 0.5 parts per thousand
fringe marsh	An elongated marsh with marsh area small compared to size of the adjacent water body. Limited high marsh development. See **finger marsh**
geomorphology	the study of the natural processes involved in the creation of landforms such as tidal marshes and barrier beaches
habitat	the environment in which the requirements of a specific plant or animal are met
half-tide level	A tidal datum. The arithmetic mean of mean high water and mean low water. Same as mean tide level.
head of tide	The inland or upstream limit of water affected by the tide. For practical application, head of tide is the inland or upstream point where the mean range becomes less than 0.2 foot.
heavy metal	a group of dense metals, including mercury, lead, cadmium, and others, that share the characteristic of being accumulated in organisms and tend to become increasingly concentrated in organisms higher up on the food chain
herbaceous plant	a non-woody plant with a soft stem (e.g., bulrushes and cattails)
high marsh	areas of tidal marshes that are irregularly flooded (frequently beyond the reach of daily flooding) and are typically dominated by salt hay grass (*Spartina patens*)
high tide	Same as high water (HW), the maximum height reached by a rising tide. The high water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions.
hydric soil	a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic (oxygen deficient) conditions in the upper part of the soil. Hydric soils are generally poorly drained or very poorly drained. *poorly drained* **-** water is removed from the soil so slowly that the soil is saturated periodically during the growing season or remains wet for long periods *very poorly drained* **-** water is removed from the soil so slowly that water remains at or near the surface during most of the growing season; this is the most dominant soil drainage class of tidal marshes
hydrology	the scientific study of the properties, circulation, and distribution of water as it occurs in the atmosphere and at the earth's surface as streamflow, precipitation, soil moisture, and ground water
hydrologic regime	the frequency and duration of flooding and/or saturation
hydroperiod	the duration of typical flooding/saturation events; in tidal marshes, the hydroperiod can range from daily flooding to irregular flooding (e.g.,

	every few days, weeks, or months); depends on the marsh elevation
hydrophyte	a plant that is adapted for life in water or in periodically flooded and/or saturated anaerobic (oxygen poor) soils (e.g., cattails, saltwater cordgrass)
intertidal emergent plant	an erect rooted herbaceous plant growing in the intertidal zone
intertidal riverine wetland	Wetlands within a river channel that are tidally influenced, but where the average water salinity is less than 0.5 parts per thousand. See **Fresh Water Marsh**
intertidal unconsolidated bottom	wetlands that have at least 25% cover of particles smaller than stones, less than 30% vegetative coverage, and are only intermittently exposed, such as pannes and tidal creeks
intertidal unconsolidated shore	wetlands which have at least 75% coverage of stones, boulders or rocks, less than 30% vegetative coverage, and are alternately flooded and exposed by tides
intertidal zone	areas that are alternately exposed and flooded by tides
invasive species	plant species that, when introduced to an ecosystem, can disturb the natural balance and habitat diversity by invading and dominating the natural tidal marsh plant community, frequently establishing dense monotypical (single species) stands of vegetation
low marsh	areas of marsh that are flooded twice a day and are dominated by saltwater cordgrass (*Spartina alterniflora*)
low tide	Same as low water (LW), the minimum height reached by a falling tide. The low water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions.
lunar day	The time of the rotation of the Earth with respect to the Moon, or the interval between two successive upper transits of the Moon over the meridian of a place. The mean lunar day is approximately 24 hours 50 minutes long.
lunar month	Same as synodical month. The average period of the revolution of the Moon around the Earth with respect to the Sun, or the average interval between corresponding phases of the Moon. The lunar or synodical month is approximately 29.5 days.
marine	relating to ocean environments
marine wetlands	Wetlands adjacent to or in open ocean such as beaches, mud flats and rocky shores
Marsh	intermittently to continually flooded wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions
marsh hydrology	this term describes (1) the hydrologic pathways such as precipitation, surface runoff, ground water, tidal fluctuations and flooding rivers which transport nutrients to and from wetlands; (2) the water depth; (3) frequency and duration of flooding in tidal marshes
marsh peat	the organic soil formed by the accumulation of dead marsh plant material and trapped sediments from tidal waters
marsh restoration	Improvement of existing marsh condition by reversing some of the adverse impacts caused by human activities
marsh system	an area of marsh associated with a single opening to the ocean, a single freshwater input, or adjacent to and contiguously along the shore of a tidal river or bay
mean high water (mhw)	a tidal datum. The average of all the high water heights observed over

(mhw)	the National Tidal Datum Epoch.
mean low water (mlw)	A tidal datum. The average of all the low water heights observed over the National Tidal Datum Epoch.
mean lower low water (mllw)	A tidal datum. The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch
mean tide level (mtl)	Same as half-tide level. The arithmetic mean of mean high water and mean low water.
mitigation	activities taken to minimize or offset wetland impacts due to development or construction; restoration and enhancement of existing wetlands or creation of new wetlands are forms of impact mitigation
national tidal datum epoch	The specific l9-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal datums. The present National Tidal Datum Epoch is 1960 through 1978.
neap tides	Tides of decreased range occurring semimonthly as the result of the Moon being in quadrature (first or last quarter).
non point source	a pollution source that does not come from a single point; typical non-point sources include parking lots, roads, and agricultural fields
open water	areas within or adjacent to a marsh that are below mean low water and greater than 100 meters wide (330 feet); this book uses an arbitrary division of 100 meters to distinguish between open water and tidal creeks
organic matter	a combination of decayed and decaying plant and animal residue
organic soil	soil consisting of at least 18% organic material (by dry weight)
overland flow	a term to describe the sheet-like flow of water over a land surface, not concentrated in individual channels; usually associated with areas of low infiltration such as paved surfaces or surfaces lacking vegetation (see also surface runoff)
pannes	shallow ponds that form on the surface of the marsh and hold salt water between tides
point source	a pollution source that comes from an identifiable point, such as a factory discharge pipe or septic system outlet
preservation	Natural resource policy that emphasizes the aesthetic aspect of the target resource and tends to favor leaving it in an undisturbed state
primary consumer	animals that eat plant material as their main source of energy
primary production	the generation of plant material by photosynthesis
range of tide	The difference in height between consecutive high and low waters. The mean range is the difference in height between mean high water and mean low water.
reference station	A tide station for which independent daily predictions are given in the "Tide Tables" and from which corresponding predictions are obtained for subordinate stations by means of differences and ratios
riverine	of or pertaining to a river
riverine emergent	riverine wetlands dominated by erect rooted herbaceous hydrophytes
salinity	The relative concentration of salts, usually sodium chloride, in a given water sample. It is usually expressed in terms of the number of parts per thousand (ppt) of chlorine (Cl). Although the measurement takes into account all of the dissolved salts, sodium chloride (NaCl) normally constitutes the primary salt being measured. As a reference, the salinity of seawater is approximately 34 ppt
salt marsh	Vegetated tidal wetland with salinity between 18 and 34 parts per thousand

	thousand.
scrub-shrub	Woody vegetation less than 20 feet in height including true shrubs, saplings and trees and shrubs stunted by environmental conditions
sea level	the level of the surface of the ocean at its mean (average) position between high and low tide
sheet flow	Unchannelized flow of water across the surface of a marsh or upland
shell middens	a pile of shells remaining from the harvesting of shellfish by Native Americans and early settlers; shell middens are historic relics
site specific method	an evaluation method which examines only the subject area without comparison to any other area
slack water (slack)	The state of a tidal current when its speed is near zero, especially the moment when a reversing current changes direction and its speed is zero. The term also is applied to the entire period of low speed current near the time of turning of the current when it is too weak to be of any practical importance in navigation. The relation of the time of slack water to the tidal phases varies in different localities.
spit	a small point of land, especially sand or gravel, formed by the deposition of material by wind and water currents that runs into a body of water
spoils	Dredged or excavated soil
spring high tide	tides associated with the full and new moon that are higher and lower than the average tide
spring tides	Tides of increased range occurring semimonthly as the result of the Moon being new or full. (szyzgy)
staddle	a structure consisting of numerous pilings driven into the marsh on which to stack salt hay to keep it above the tidewaters until it could be hauled off
station	The geographic location at which tidal or current observations are conducted. independent daily predictions are given in the "Tide Tables" and "Tidal Current Tables for “reference stations.” Corresponding predictions for “subordinate stations” are calculated by applying differences and ratios from the tables to the reference station predictions.
Stone	a rock fragment larger than a cobble but smaller than a boulder (10-24 inches)
Subordinate tide station	A station listed in the Tide Tables from which predictions are to be obtained by means of differences and ratios applied to the full predictions at a reference station. See reference station.
subsidence	a sinking of the marsh surface, through compaction and degradation of marsh peat; often occurs when *Spartina patens* is deprived of tidal flow
substrate	the type of bottom sediments such as sand, gravel, peat
surface runoff	the movement of water over the land surface (usually in defined channels), resulting from rainfall or snowmelt; percentage of precipitation that becomes runoff varies depending on the slope of the area, the degree of soil saturation, amount of vegetated coverage, or type of surface (e.g., paved areas)
syzygy	Position of the Moon when it is new or full.
tidal amplitude	the variations in the height of tides caused by the lunar cycle, elevation above sea level, the barometric pressure, tidal restrictions and the seasons
tidal creeks	streams in the tidal marsh that are less than 100 meters wide at mean low water and whose water level and flow is dominated by tidal action

tidal flats	areas that are irregularly exposed and are devoid of emergent vegetation, also called mud flats or unconsolidated bottom
tide range	The difference in height between consecutive high and low waters.
Transgression	The spread or extension of marsh or sea over land areas, and the consequent evidence of such advance such as where the new marsh deposits are spread over the former land surface.
transition zone	area surrounding a wetland where conditions gradually change from wetland biota to upland biota
Turbidity	the clarity of the water column as determined by the presence of suspended particles making the water cloudy
upland islands	areas of upland soils and vegetation located within a tidal marsh
upland peninsula	areas of upland soils and vegetation that extend into the tidal marsh, and are surrounded on three sides by the tidal marsh
vegetated tidal marsh	marshes dominated by emergent vegetation and influenced by the tides
water column	the habitat that exists in standing or flowing water extending in a column from the surface of the water to the surface of the substrate
Watershed wetlands	the area from which all water including precipitation, streams and rivers drain to a single point those areas that are inundated or saturated by surface or ground water, support a prevalence of vegetation adapted to life in saturated conditions (i.e., hydrophytes), and are characterized by hydric soils; these include bogs, marshes, swamps, wet meadows, and similar areas
Wetland	A wet habitat transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.
zone of influence	area surrounding a wetland in which the activities that take place have an impact on the wetland; the Return the Tide program considers a 1/2 mile Zone of Influence, with particular focus on activities within the 250 foot shoreland Zone

Appendix B

REFERENCES

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Appendix C

SUGGESTED SOURCES OF INFORMATION

Information on:	Available From:
Aerial Photographs	James W. Sewall Co. Greater Portland Council of Governments Muncipal Offices
Archaelogical and Historic Information	Maine Historic Preservation Commission
Endangered and Threatened Wildlife	Maine Department of Inland Fisheries and Wildlife Endangered and Nongame Program U.S. Fish and Wildlife Service Gulf of Maine Project
Exemplary Natural Community and Rare Plant Listings	Maine Natural Areas Program
Municipal Tax and Zoning Maps	Municipal Offices
National Wetland Inventory Maps	Maine Geological Survey Maine Office of GIS (digital information) U.S. Fish and Wildlife Service Gulf of Maine Project 1(800)USA-MAPS www.nwi.fws.gov
Protected Lands	Local Land Trusts Municipal Offices Maine Coast Heritage Trust Maine Office of GIS
Public Boat Launches	DeLorme *Maine Atlas and Gazetteer* Department of Conservation, Bureau of Public Lands
Restoration	U.S. Fish and Wildlife Service U.S. Army Corps of Engineers Maine Department of Inland Fisheries and Wildlife Maine Department of Environmental Protection
Shellfishing Information	Maine Department of Marine Resources
USGS Topographic Maps	Maine Geological Survey local bookstores and sporting goods stores 1(800)USA-MAPS
Migratory Birds, Anadromous Fish, and Wetland Wildlife Habitat	U.S. Fish and Wildlife Service Gulf of Maine Project, Maine Department of Inland Fisheries and Wildlife Maine Department of Marine Resources

Contact Addresses

Greater Portland Council of Governments
233 Oxford Street
Portland, ME 04101 (207)774-9891

James W. Sewall Co.
P.O. Box 433
147 Center Street
Old Town, ME 04468 (207)827-4456

Maine Audubon Society
P.O. Box 6009
118 US Route 1
Falmouth, ME 04105 (207)781-2330

Maine Coast Heritage Trust
167 Park Row
Brunswick, ME 04011 (207)729-7366

Maine Dept. of Environmental Protection
State House Station #17
Augusta, ME 04333-0017 (207)287-7688

Maine Department of Inland Fisheries & Wildlife
Endangered and Nongame Wildlife Program
650 State Street
Bangor, ME 04401-5609 (207)941-4466

Maine Dept. of Marine Resources
State House Station #21
Augusta, ME 04333-0021 (207)287-2291

Maine Dept. of Transportation
State House Station #16
Augusta, ME 04333-0016 (207)287-2841

Maine Office of GIS
State House Station #125
Augusta, ME 04333-0125 (207)287-6144

Maine Geological Survey
Dept. of Conservation
State House Station #22
Augusta, ME 04333-0022 (207)287-2801

Maine Historic Preservation Commission
55 Capital Street
State House Station #65
Augusta, ME 04333 (207)287-2132

Maine Natural Areas Program
Dept. of Conservation
State House Station #93
Augusta, ME 04333-0093 (207)287-8044

State Planning Office
Maine Coastal Program
State House Station #38
Augusta, ME 04333-0038 (207)287-3261

Wells National Estuarine Research Reserve
342 Laudholm Farm Road
Wells, ME 04090 (207)646-4521

U.S. Army Corps of Engineers
696 Virginia Road
Concord, MA 01742 1(800)343-4789

Or
675 Western Ave #3
Manchester, ME 04351 (207)623-8367

Casco Bay Estuary Project
Room 408, Law School
PO Box 9300
Portland, ME 04104 (207)780-4820

U.S. Fish and Wildlife Service
Gulf of Maine Project
4R Fundy Road
Falmouth, ME 04105 (207)781-8364

U.S. Department of Agriculture
NRCS
967 illinois Ave #3
Bangor, ME 04401-2700 (207) 990-9100

U.S. Fish and Wildlife Service
1033 So. Maine Street
Old Town, ME 04468 (207)827-5938

Appendix D

U.S. FISH & WILDLIFE SERVICE WETLAND CLASSIFICATION SYSTEM

In 1979 the U.S. Fish & Wildlife Service (USFWS) published a classification of wetlands and deepwater habitats (Cowardin el al., 1979). In this classification scheme, wetlands are defined by hydrology, soils, and vegetation. The USFWS classification scheme serves as the national standard for wetland classification, and has been used to classify wetlands appearing in National Wetlands Inventory (NWI) maps which are used to define marsh systems in the *Maine Citizens Tidal Marsh Guide.*

The wetland and deepwater habitats of the coastal zone are defined in the USFWS classification as follows:

Wetlands: Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water. For the purposes of the classification, wetlands must have one or more of these three attributes: (1) at least periodically, the land must support predominantly hydrophytes (wetland plants); (2) the substrate is predominantly undrained hydric soil; and (3) rocky, gravelly, or sandy areas that are saturated with or covered by shallow water at some time during the growing season.

Deepwater Habitats: Deepwater habitats include permanently flooded areas deeper then 6.6 Feet (2M). Shallower permanently flooded areas are often vegetated with emergent plants and are considered wetlands rather than deepwater habitats.

The structure of the classification scheme is hierarchical, with <u>systems</u> forming the highest level of the classification hierarchy. Of the five major systems, three are of interest with regard to tidal waters.

1. **Marine System -** Open ocean overlying the continental shelf including high energy shore line such as beaches and rocky headlands.

2. **Estuarine System -** Deepwater and wetland areas that are usually semi-enclosed with an opening to the ocean and in which there is some mixing of fresh and sea water.

3. **Riverine System -** Freshwater rivers and their tributaries along with most associated wetlands.

<u>Marine and Estuarine systems</u> are divided into two <u>sub-systems:</u>

1. **Sub-tidal -** Areas that are continuously submerged.

2. **Intertidal -** Areas that are alternately flooded and exposed.

Riverine systems are divided into four sub-systems, only one of which is relevant to tidal wetlands:

1. **Tidal -** the movement of the water is influenced by the tides but water salinity is less than 0.5 ppt.

The next step in the hierarchical system is class. These classification terms describe the general appearance of the habitat in terms of substrate or the dominant plant community type.

1. **Aquatic Bed -** Wetlands that are dominated by plants that grow principally on or below the surface of the water.

2. **Rocky Shore -** Wetlands that are characterized by bedrock, boulders or stones which cover more the 75% of the area (rock fragments over 10 inches).

3. **Unconsolidated Shore -** Wetland habitats having three characteristics. (1) less than 75% coverage by bedrock, boulders, or stones; (2) less than 30% coverage by persistent vegetation; and (3) alternately exposed and flooded.

4. **Unconsolidated Bottom -** Wetland habitats having at least 25% cover of particles smaller than stones, and a vegetation cover of less than 30%.

5. **Emergent Wetland -** Wetlands dominated by erect, rooted herbaceous hydrophytes.

These wetland classifications should cover any tidal wetland that will be evaluated in the Return the Tide program. Formerly tidal areas that will be included in the inventory may have changed to any one a variety of freshwater systems. A brief description of some of these systems may help in the identification of these formerly tidal wetlands.

1. **Palustrine System -** All non-tidal wetlands dominated by trees, shrubs, and persistent emergent vegetation.
2. **Lacustrine System -** Open water wetlands situated in topographic depressions with less than 30% vegetative cover and greater than 20 acres in size.

Some of the classes that may apply to these formerly tidal areas are:

1. **Scrub-shrub -** Wetlands dominated by shrubs and tree saplings less than twenty feet in height (e.g., buttonbush, alders and red maple saplings).

2. **Forested Wetland -** Wetlands dominated by trees greater than twenty feet in height (e.g., red maple, ash, spruce).

3. **Emergent Wetland -** Wetlands dominated by erect, rooted herbaceous hydrophytes.

Also included in the classification scheme are a number of modifiers that are added to the end of the classification abbreviation. One of these is important in the recognition of formerly tidal areas. A small “h” signifies that a wetland has been impounded by the purposeful obstruction of flow.

The USFWS wetlands classification system is used as the basis for the wetland identification codes used on the National Wetland Inventory maps. On the bottom of each NWI map is a key to the complete codes. The examples below provide examples of some of the wetland classes that will be encountered when using the NWI maps in coastal areas.

E2EM1P	E = Estuarine	E2US4M	E = Estuarine
	2 - Intertidal		2 = Intertidal
	EM =Emergent		US = Unconsolidated Shore
	1 = Persistent		4 = Organic
	P = Irregularly Flooded		M = Irregularly Exposed

E2US3N	E = Estuarine 2 = Intertidal US = Unconsolidated Shore 3 = Mud N = Regularly Flooded	PUBHh	P = Palustrine UB = Unconsolidated Bottom H = Permanently Flooded h = Diked/Impounded
E1UB4	E = Estuarine 1 = Subtidal UB = Unconsolidated Bottom 4 = Organic	RIUBH	R = Riverine 1 = Tidal UB = Unconsolidated Bottom H = Permanently Flooded

For a more complete explanation of the classification scheme, the reader may obtain copies of the *Classification of Wetlands and Deepwater Habitats of the United States* from the US Fish & Wildlife Service. Reprints of the publication may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia.

LEGEND

Tidal Wetlands

E1UBL - Tidal creek
E2EM1P - Intertidal emergent marshes
E2US3N - Mudflat / Sandflat
E2US4M - Salt marsh panne
R1UBV - Riverine tidal wetland

Non-Tidal Freshwater Wetlands

PF01C,E,R - Deciduous forested wetlands
PF04E - Coniferous forested wetlands
PSS1E, R - Shrub Swamps

Upland

ʊ - Upland

SCALE: 1 : 24,000
1 in. = 2,000 ft.

. Sample National Wetlands Inventory (NWI) Map

Appendix E

COASTAL WETLAND TYPES

Aquatic Beds: These wetlands form in sub-tidal areas of both marine and estuarine waters. Along the coast, aquatic beds are areas of seaweed that grow below the low tide level. In the estuarine waters of the state the most important aquatic beds are eelgrass *(Zoster marina)* found in protected bays and the major tidal rivers. Eelgrass beds are important as nursery and feeding areas for fish**,** as feeding areas for geese, ducks and wading birds, and for trapping and accreting suspended sediments in the water column. Within some of the larger tidal marshes along the Maine coast aquatic beds of widgeon grass *(Ruppia maritima)* can add to the diversity of the tidal marshes.

Brackish Marshes: In areas where average salinities range from 0.5 ppt. to 18 ppt., a wide variety of plant communities can grow which represent the transition from salt marsh to freshwater marsh. These marshes can be found along the major tidal rivers and bays and along the smaller freshwater tributaries flowing into salt marshes. Plants that can be found in brackish areas include black grass *(Juncus gerardii***),** narrow-leaved cattail *(Typho angustifolia),* and salt marsh bulrush *(Scirpus robustus).*

Cobble, Gravel, and Sand Beaches: These are high-energy coastal wetlands formed by the sorting of sediment material moved by wind and wave energy. The intertidal zone of these wetlands is nearly devoid of visible plants or animals. The higher reaches of these wetlands, where the wave energy only reaches during storm events, may form sand dunes. Maine has few remaining dune fields, but all of these areas are presently protected by law. Dunes support a specialized plant community that is very susceptible to damage during the dune overwash that accompanies large storms.

Freshwater Tidal Marshes: In areas where the tides still affect the flow of waters but where the average salinity is below 0.5 ppt. freshwater tidal marshes can form. Vegetation in these marshes is extremely diverse. In the regularly flooded areas one may find pickerel weed *(Pontederia cordata)* and wild rice *(Zizania aquatica).* In areas that are irregularly flooded sweet flag *(Acorus calamus)* and river bulrush *(Scirpus fluviatillis)* are common. Freshwater tidal marshes are predominantly associated with the Kennebec River above Bath.

Rocky Shores: This type of coastal wetland is very common in northern New England. It can be found in areas where bedrock is exposed by nearly continuous wind and water driven energy. These wetlands can be divided into three zones: the salt spray zone - rarely flooded but influenced by waves; the intertidal zone - regularly flooded and exposed by the tides; and the sub-tidal zone - rarely exposed and underwater most of the time. Plants and animals such as seaweeds, barnacles, and periwinkles can be easily found.

Salt Marshes: These vegetated tidal wetlands, where salinities range from 18 ppt. to 34 ppt. (the latter is that of seawater), are dominated by *Spartina* grasses. In low marsh areas that are flooded twice daily, saltwater cordgrass *(Spartina alterniflora)* forms nearly mono-specific stands that vary in height from a few inches to five feet in height. On the high marsh salt meadow grass *(Spartina patens)* is the dominant plant, but it is usually found in association with numerous other plants that can tolerate high salinity levels (halophytes).

Tidal or Mud Flats: These wetlands are unvegetated, low relief environiments particularly common in protected coastal environments. They are of critical importance for the production of numerous invertebrate species which are a food source for many bird and fish species. When flooded, the mud flats are scoured by fish feeding on the worm and mollusk population found in the muddy substrate. As the tide recedes, wading birds feed on the same food source. Mudflats can also be found in the larger tidal marshes providing diverse habitat within the marsh.

Appendix F

Maps of COASTAL MARINE GEOLOGIC ENVIRONMENTS

available from the

Maine Geological Survey
DEPARTMENT OF CONSERVATION

Walter A. Anderson, State Geologist

Index compiled by Robert D. Tucker and Robert A. Johnston

INTRODUCTION

Maine has one of the most diverse shorelines on the eastern seaboard of the United States. In addition to rocky ledges, the Maine coast is made up of a significant amount of sediment including accumulations of gravel, sand, silt, and clay. Broad sandy beaches, extensive salt marshes, steep rocky cliffs, shallow tidal channels, and deep tidal embayments constitute a remarkable land-ocean boundary extending for well over 3000 miles from New Hampshire to the Canadian border. The coastline is constantly being altered by waves, tides, and other forces. Sediments are moved on a daily basis, with particles transported into and out of bays, along beaches, and up and down the length of the shoreline. Rock surfaces are weathered by waves and windblown particles, gradually changing the shape of the shoreline.

INFORMATION SHOWN ON COASTAL MARINE GEOLOGIC ENVIRONMENTS MAPS

Coastal Marine Geologic Environments Maps show the geologic environments located between the mainland and shallow subtidal depths approximately 25-30 feet below the low tide mark. The map explanation is divided into three groups: supratidal, intertidal, and subtidal environments.

Supratidal environments exist above the average high water mark and represent the lowest portion of the coastal uplands. The supratidal zone is periodically exposed to one or a combination of the following marine processes: salt spray, onshore winds, storm wave wash, and storm or hurricane flooding by salt water. Most of the time, however, these regions are not submerged. Examples of supratidal environments include: sand dunes and vegetated beach ridges, fresh or brackish marshes, and eolian or washover flats.

Intertidal environments are located between the average low and high tide marks. All intertidal environments are subject to twice daily tidal flooding, wave erosion and deposition, and many other marine processes. Intertidal terrains constitute the largest area mapped on the coastal marine geologic environments maps. Examples of these environments include salt marshes, beaches, and mud flats.

Subtidal environments exist below the average low water mark to depths of approximately 25-30 feet. These environments are subject primarily to tide and wave-generated currents, with the tidal currents being dominant. Examples of subtidal environments are submerged mud flats, seaweed flats, channels, and deltas.

PREPARATION OF THE MAPS AND LIMITATIONS OF THE DATA

To begin the map compilation, several sections of the coastline were inspected using aerial photographs and checked by geologists in the field. This initial inspection indicated that fifty-five separate geologic environments could be represented at a map scale of 1:24,000. These environments are differentiated on the basis of their position with respect to the tidal zone (supratidal, intertidal, or subtidal), the size of their constituent sediments, and the dominant marine processes acting on the geologic environment. The map explanation is organized to emphasize these three characteristics which govern the distribution of the fifty-five environments.

The boundaries of the geologic units were delineated based on interpretation of black and white aerial photographs at a scale of 1:20,000. Factors such as photographic tone, texture, shape, and relative elevation enable the geologist to recognize the different geologic environments on the photographs. Changes in these factors help delineate the boundaries between units. Due to limitations in photographic interpretation, the delineation of subtidal environments and boundaries is less accurate than the interpretation of intertidal or supratidal environments.

After the units were delineated, the information was plotted on a uniform topographic map base at a scale of 1:24,000. Most of the information shown on this map series was derived from photographic interpretation. Less than two percent of the shoreline's length was field-checked during the original mapping. Field investigations were necessary where information from the photographs was inadequate to identify geologic environments.

ORDERING INSTRUCTIONS

Black-line paper prints of maps are $1.25 per quadrangle plus 7¢ sales tax. All coastal environment maps are at a scale of 1:24,000 (7.5 minute quadrangles). Where 7.5 minute quadrangles were not available, 15 minute quadrangles were enlarged to 1:24,000. Order maps by quadrangle name as shown below (for example Phippsburg, Bath NE, or Bath NW).

Quadrangle names as shown on the index map

Area covered by 7.5 minute quadrangle

Copies of all maps are available for inspection in the Resource Center located in the Maine Geological Survey office.

PREPAYMENT IS REQUIRED BY LAW and may be made by money order or check payable to the **Treasurer, State of Maine.** Order copies from the Maine Geological Survey, Department of Conservation, State House Station #22, Augusta, Maine 04333. SALES TAX DOES NOT APPLY TO OUT OF STATE PURCHASES.

FIGURE 1 Marine Geologic Environment Map and Legend

MAP SYMBOL	GEOLOGIC ENVIRONMENT
	SUPRATIDAL ENVIRONMENTS
Sd	Dunes & Vegetated Beach Ridges
Sw	Fresh-Brackish Water
Sm	Fresh-Brackish Marsh
Sz	Man-Made Land
Sx	Landslide Excavation & Deposits
	INTERTIDAL ENVIRONMENTS
	Marsh Environments
M1	High Salt Marsh
M2	Low Salt Marsh
M3	Marsh Levee
M4	Salt Pannes & Salt Ponds
	Beaches
B1	Sand Beach
B2	Mixed Sand & Gravel Beach
B3	Gravel Beach
B4	Boulder Beach
B5	Low-Energy Beach
Br	Boulder Ramps
Bw	Washover Fan
Bs	Spits
	Flat Environments
F	Mud Flats
F1	Coarse-Grained Flat
F2	Seaweed-Covered Coarse Flat
F3	Mussel Bar
F4	Channel Levee
F5	Algal Flats
F6	Veneered Ramp
	Miscellaneous Environments
M	Ledge
Mc	Fluvial-Estuarine Channel
Mp	Point or Lateral Bars
Ms	Swash Bars
Mf	Flood-Tidal Delta
Me	Ebb-Tidal Delta
Mb	Fan Delta
Md	Spillover Lobe
	SUBTIDAL ENVIRONMENTS
	Flat Environments
Fm	Mud Flat
Fc	Coarse-Grained Flat
Fe	Eelgrass Flat
Fs	Seaweed Community
Fb	Upper Shoreface
Fp	Lower Shoreface
	Channel Environments
C1	High-Velocity Tidal Channel
C2	Medium-Velocity Tidal Channel
C3	Low-Velocity Tidal Channel
C4	Estuarine Channel
C5	Estuarine Flood Channel
C6	Estuarine Ebb Channel
C7	Inlet Channel
C8	Dredged Channel
Cs	Channel Slope


Tidal Creeks

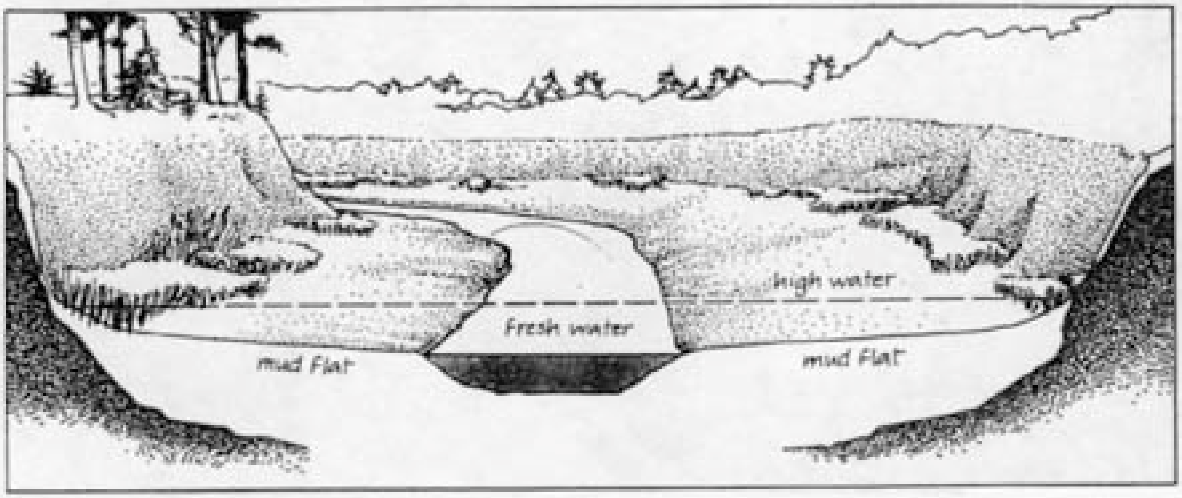

Marsh Drainage Ditch


Unit Boundary


Approximate Unit Boundary

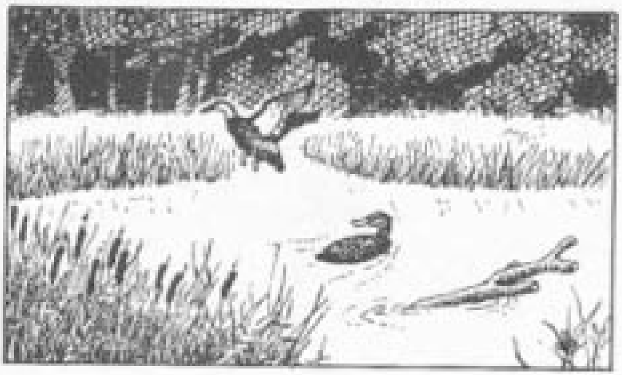

Approximate Transition Boundary Between Estuarine and Marine (30 ppt salinity) Waters and between Estuarine and River (0.5 ppt salinity) Waters.

Fluvial Marsh



Fresh to Brackish Marsh
Map Legend — Sm
Color — Silver
Percentage of Total Coast Area Mapped—4.00%

FIGURE 29 **Fresh to Brackish Marsh**



Characteristics: Fresh to brackish marshes are wetland adjacent to salt marsh or in coastal impoundments where waters maintain a relatively low salinity of less than 5 parts per thousand. These marshes generally support lush growths of aquatic vegetation and have surfaces which are often several centimeters to one-half meter above the mean high water mark. Fresh-brackish marshes represent a stage between salt marsh and upland, forming where sediment is deposited from mainland drainage or marine flooding. Most tracts are subject to occasional tidal flow and submergence during floods.

Importance: Fresh to brackish marshes are an important segment of a number of depositional systems, including coarse- and fine-grained estuaries, tide-dominated neutral embayments, constructional and destructional deltas, and coastal marshes. They provide significant habitat for many species of ducks and other waterfowl and for some valuable game animals, such as beaver and muskrat. Because they are able to temporarily store flood waters, these units help reduce the effects of coastal flooding.

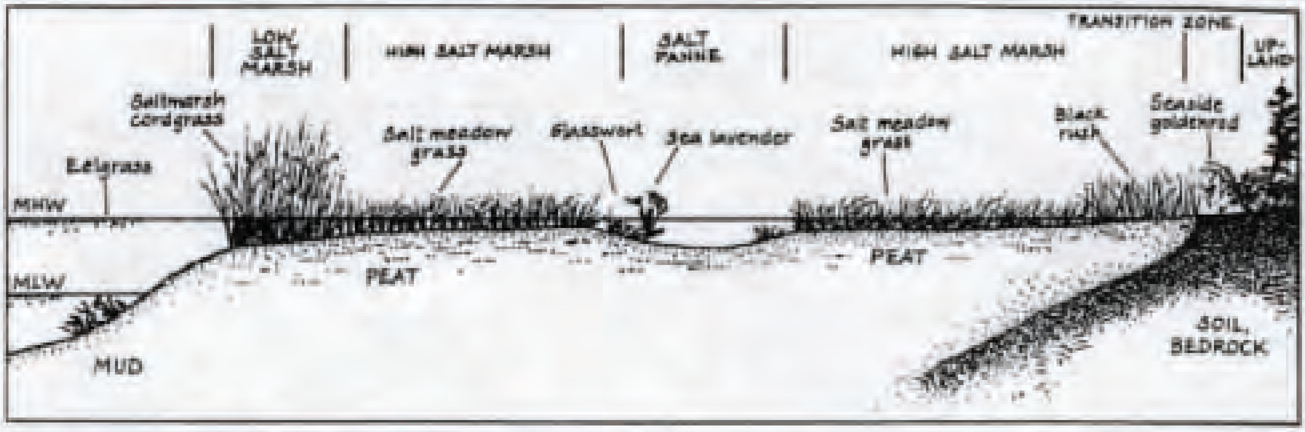
Planning Considerations: Fresh to brackish marshes are generally unsuitable for any kind of development, agricultural use or waste disposal. They are particularly sensitive to drainage, ditching or filling. Though it has been practiced in the past, applications of pesticides or herbicides on fresh-brackish marshes poses a grave threat to their environmental health and can have serious adverse consequences for the valuable wildlife species who live in them. In many cases, however, such marshes can be suitably used for some human activities, most notably, recreational fishing, hunting, and bird watching.

Fluvial Marsh
Map Legend — Sr
Color — Slate gray
Percentage of Total Coast Area Mapped—1.00%

Characteristics: Fluvial marshes include sparsely-to-moderately vegetated tidal river flats and floodplains of sandy mud or mud. They are subject to flooding twice daily by fresh water backed up by tides, and occasionally by flooding rivers, which deposit the river sediments that make up this unit.

Importance: Fluvial marshes are a significant part of many constructional delta systems, serving as a "storage area" for sediments eventually

FIGURE Salt Marsh Cross Section



transported to other geologic environments. They also provide feeding and breeding habitat to various valuable wildlife species, including beaver, muskrat, otter, great blue heron, and numerous ducks and geese.

Planning Considerations: Like other geologic units found in delta systems, fluvial marshes may be adversely affected by the construction of dams on rivers entering them due to a loss of sediments (see page 18). Their role in maintaining delta systems and as important wildlife habitats can also be destroyed by any dredging, filling or draining activities in the area. They may be suitable sites for some types of activities, such as hunting and fishing, pier construction and placement of pipelines after careful consideration of potential impacts. Generally, however, waste disposal and light or heavy development are unsuitable in fluvial marshes.

INTERTIDAL ENVIRONMENTS

High Salt Marsh
Map Legend — M1
Color — Peacock Green
Percentage of Total Coast Area Mapped—5.00%

Characteristics: This estuarine environment consists of peat, mud or sand flats densely overgrown with salt-tolerant grasses and situated at or slightly above the mean high water mark. Wetland vegetation plays a key role in the creation and maintenance of a high salt marsh by slowing down and capturing sediments brought in by streams, rivers, and tides. Such marshes commonly occur behind barrier beaches or along and at the mouth of river estuaries. Low salt marsh (Map Legend — M2) becomes high salt marsh as sedimentation builds up on intertidal flats, raising them to the mean high water level. As relative sea level rises (see page 13) coastal salt marshes rise with it, slowly migrating landward.

Importance: The environmental and economic significance of high salt marshes is difficult to overstate. As a wildlife habitat, they are particularly valuable to migratory ducks and geese, numerous shorebird species, many colorful songbirds, ospreys and bald eagles. A great variety of animals important to marine food chains also live here, such as mud snails, copepods and flatworms. Tidal channels and streams running through high salt marshes are breeding and nursery grounds for dozens of commercially important fish and shellfish species. Marsh food chains are heavily dependent on the nutrients and bacteria absorbed and held by marsh vegetation. Beyond its function as a habitat, a high salt marsh temporarily stores flood waters, thus reducing the severity of coastal flooding. Wide bands of marsh in front of upland shores absorb the brunt of heavy storm waves, protecting the mainland from severe erosion. And the dense vegetation that grows here acts as a kind of giant natural water purifier by capturing and holding pollutants and sediments that could otherwise degrade shellfish beds or fill navigational channels.

Planning Considerations: Like other estuarine environments, high salt marshes are very sensitive to changes in the volume of water flowing into or out of them. Any kind of draining, ditching, dredging or filling activities on or near a high salt marsh can have detrimental consequences in terms of the maintenance and productivity of this environment. Light or heavy development, roadbuilding, and most other types of construction are not considered suitable here; nor, despite a high marsh's purifying capabilities, is the disposal of solid or liquid waste. On the whole, the most appropriate human activities in this unit are recreational, such as birdwatching, hunting, and canoeing. Even these activities can have adverse impacts on a high marsh since erosion-prone spots on marsh plots and heavy foot traffic along channel banks can cause devegetation and accelerated bank erosion. In some cases, changes made in nearby environments can affect a high salt marsh significantly. A dam constructed on a river entering a marsh can cut off sustaining sediment supplies; a breakwater constructed offshore can cause increased sedimentation that could smother parts of the marsh surface; and development of adjacent barrier beaches often results in restriction of the tidal channels feeding into marsh systems, leading to a slow destruction of these productive wetlands.

Low Salt Marsh
Map Legend — M2
Color — Peacock Green
Percentage of Total Coast Area Mapped—0.10%

Characteristics: Low salt marshes are sparsely to densely vegetated sand or mud tidal flats located between mean tide and the high water mark. They generally have a slope of from 5° to 20° and lead up to areas of high salt marsh, though isolated strands of low salt marsh are sometimes found. The vegetation here consists solely of salt cord grass (Spartina alterniflora), which grows in stands up to one meter in height. The substrate between stands is bare mud or sand.

Importance: Although they are associated with a variety of coastal depositional systems, including coarse- and fine-grained estuaries, tide-dominated neutral embayments, and constructional deltas, low salt marshes are a relatively scarce geological environment in Maine. They are, nevertheless, one of the most important in terms of economy and ecology because of their crucial role as habitat for numerous commercial fish and shellfish species. Indeed, nearly three-fourths of Maine's fisheries resources are directly or indirectly dependent on the existence of low salt marsh environments as a source of nutrients

FIGURE Plan View; Typical Transition Zone – Salt Marsh to Fluvial Marsh

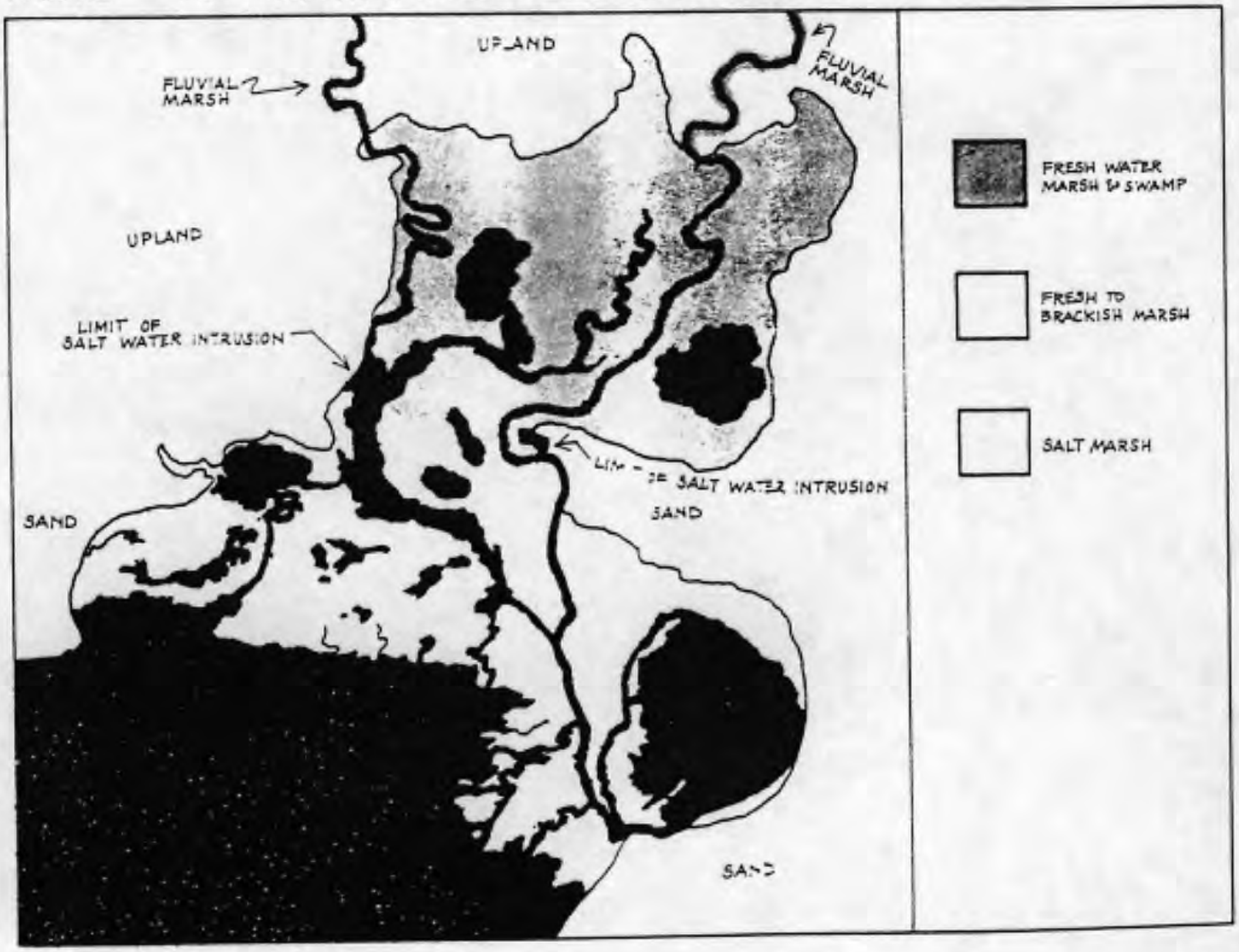
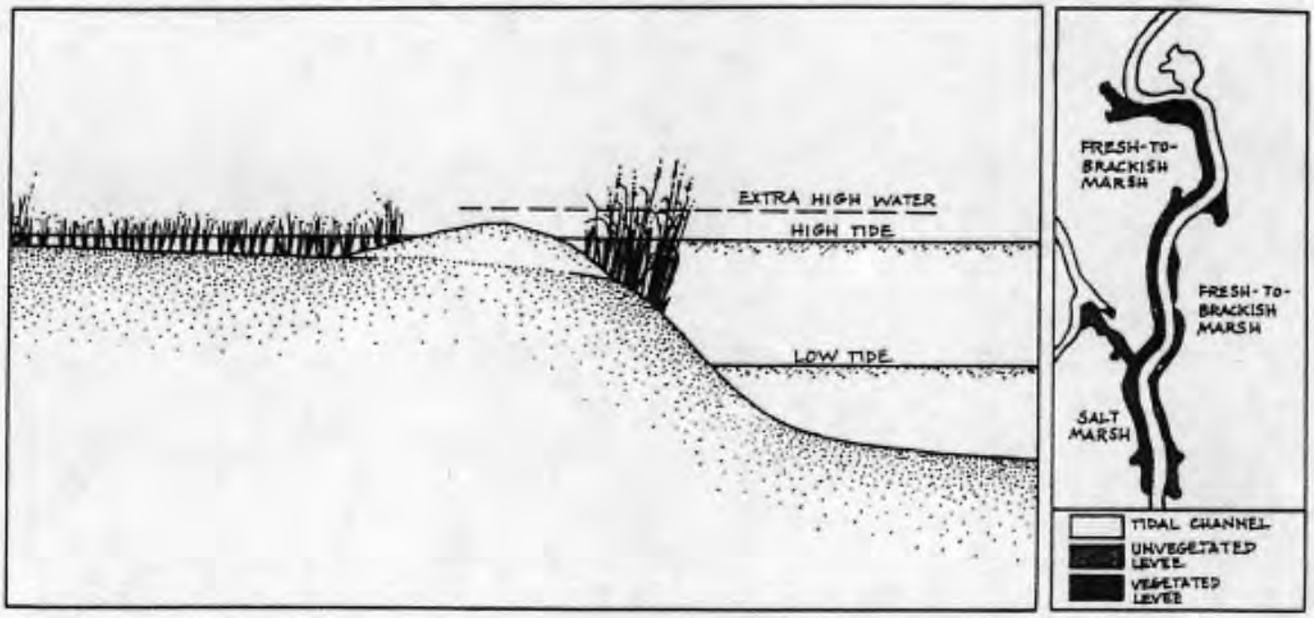


FIGURE Marsh Levee, Two Views



or as a breeding and nursery ground. Over 60 important commercial species, from clams and crabs to menhaden and flounder, live, feed or grow up in these units.

Planning Considerations: Like the high salt marsh environment, low salt marshes are adversely affected by dredging, draining, filling and any other activity that alters the natural flow of water into and out of them. Dredging of nearby high salt marsh areas can disrupt the natural transport of sediments in a low marsh, increasing turbidity and sedimentation. Dredging on the high marsh can also release chemicals or heavy metals formerly bound up in the high marsh sedi-

Marsh Levees
Map Legend — M3
Color — Peacock Green
Percentage of Total Coast Area Mapped—0.01%

Characteristics: Marsh levees form as deposits of sand or silt along the margins of tidal channels in high salt marshes. The levee surfaces are generally up to ten centimeters higher than the mean high water mark and surrounding marsh surfaces. These units are created when storm waters overflow channel banks and spread onto the high salt marsh. The sudden reduction of current velocity as the water hits the vegetated marsh surface causes rapid sedimentation of sand and silt, building the marsh levees.

Importance: Marsh levees provide dry walkways through a marsh.

Planning Considerations: There are no special planning considerations associated with marsh levees other than those relating to the maintenance of the high marsh environment as a whole (see page 46).

Salt Pannes and Ponds
Map Legend — M4
Color — True Blue
Percentage of Total Coast Area Mapped—0.05%

Characteristics: Circular unvegetated depressions existing on high salt marsh surfaces are called salt pannes or salt ponds. They are thought to form where bare, rotten spots occur on marshes or in segments of "abandoned" tidal channels. Pannes usually contain seawater from spring tide flooding for a while each year, but during the summer it gradually evaporates, eventually leaving a dry panne covered by mats of algae (the only plants that can grow in this highly saline environment).

Importance: Salt pannes were once used as a source of sea salt.

Planning Considerations: None, other than those given for high salt marsh environments.

Salt Marsh Habitats

Description: Salt marshes are dominated by thick stands of marsh grasses, characteristically cord grass *(Spartina alterniflora)* and salt marsh hay *(Spartina patens)*. The nutrient-rich substrate in these environments is composed of mud, grass roots and peat (the decomposed remains of marsh plants). Maine has a relatively limited amount of salt marsh along its coast, comprising only about 5 percent of the total shoreline zone. Most of these marsh lands are found on the southern and central coast. They range from fringe marsh at the heads of mud flats and estuaries to the broad expanses of marsh often found behind dune-beach systems. For example, the Scarborough Marsh behind Pine Point at the northern end of Old Orchard Beach includes about 20 percent of Maine's total salt marsh area.

Biological Characteristics: Salt marshes are ecologically rich environments, with relatively high numbers of individual organisms per square meter. The diversity of resident species is only moderate, but many "transient" species of fish, birds and mammals use marshes as feeding, nesting or nursery habitats. In the mud beneath the dense growths of marsh grasses, burrowing marine worms are particularly abundant. Other common resident species include amphipods, snails, ribbed mussels and soft-shelled clams. Crabs and juvenile fishes of various species frequently live in the tidal streams running through salt marshes.

Importance: Salt marshes, once viewed as useless, mosquito-breeding wastelands, are now generally considered one of our most valuable intertidal habitats. The rich organic detritus flushed from marshes by the tides provide crucial nutrients upon which many oceanic food chains are based. Many species important to Maine's commercial fisheries live, feed, or spend their early life stages in salt marsh habitats. Ospreys, bald eagles, various shorebirds and waterfowl and numerous colorful songbirds feed or nest in marsh areas. Beyond their significant function as wildlife habitats, marshes temporarily store flood waters, thus reducing the severity of coastal flooding. Wide bands of marsh land in front of upland shores absorb the brunt of heavy storm waves, thus protecting the mainland from severe erosion and property damage. In addition, the dense marsh vegetation often captures and holds pollutants and sediments that could otherwise run off into shellfish beds and navigational channels.

Planning Considerations: Salt marshes are very sensitive to changes in the volume of water flowing into and out of them. Dredging, ditching or filling activities on or near marshes can change the hydrology of these habitats and thus their ecological productivity. Dredging can also release chemicals or heavy metals formerly bound up in the marsh sediments which may be toxic to fish and shellfish. Pollution by pesticides or oil can have similarly adverse effects on marsh organisms. Light or heavy development, roadbuilding and most other types of construction are not considered suitable on marshes, nor is the disposal of solid or liquid wastes. On the whole, the most appropriate activities in these environments are recreational, such as hunting, birdwatching, boating, and canoeing. Occasionally, in areas of heavy use, foot traffic can cause devegetation that may lead to minor erosion problems. Excessive boat traffic may also lead to bank erosion and increased water turbidity along tidal streams.

Geologic Units Included:

HIGH SALT MARSHES
Map Legend — M1
Color — Peacock Green
Percentage of Total Coast Area Mapped — 5.00%

LOW SALT MARSH
Map Legend — M2
Color — Peacock Green
Percentage of Total Coast Area Mapped — 0.10%

MARSH LEVEES
Map Legend — M3
Color — Peacock Green
Percentage of Total Coast Area Mapped — 0.01%

SALT PANNES AND PONDS
Map Legend — M4
Color — True Blue
Percentage of Total Coast Area Mapped — 0.05%

From: *Maine's Intertidal Habitats*. SPO, 1985

CPL p

Appendix G

Plant Terms and Taxonomy

The following materials introduce basic botany concepts and terms related to tidal marshes. The separate sheets are suitable for use as handouts at volunteer training sessions or briefings.

BENEFITS AND DETRIMENTS OF NATIVE SALT MARSH PLANTS AND INVASIVES

BENEFITS OF NATIVE SALT MARSH PLANTS

Native salt marsh plants benefit ecosystems in many ways:

- Submersed plants pump oxygen into the water for animals such as fish.
- Aquatic and salt marsh plants provide hiding places and nurseries for animals.
- Aquatic and salt marsh plants provide surface area for small organisms such as algae and shrimp that are often eaten by larger organisms.
- Aquatic and salt marsh plant parts are eaten by fish, waterbirds, and other animals.
- Aquatic and wetland plants absorb excess nutrients and other forms of pollution.

DETRIMENTS OF INVASIVES (WEEDS)

Non-native and native aquatic and wetland plants can become "weeds" in alien habitats:

- Aquatic and wetland weeds can replace native plants, depriving native animals of their natural habitats and food supplies.
- Aquatic and wetland weeds can cover water bodies and wetlands, preventing oxygenation and "suffocating" fish and other animals.
- Aquatic and wetland weeds can prevent the use of water bodies for fishing, swimming, and other recreation.
- Aquatic and wetland weeds can disrupt navigation by both small and large vessels.
- Aquatic and wetland weeds can greatly slow or even stop water flow, disrupting flood control and irrigation systems.

TERMS

WHAT IS A GENUS AND WHAT IS A SPECIES?

Taxonomy is the scientific classification of organisms. Plant and animal taxonomy is arranged in a hierarchy, from phylum down to species.

`

Phylum or Division
Class
Order
Family
Genus
Species

A species is a group of individuals that can successfully interbreed with individuals of the same species, producing fertile offspring. A genus is a group of closely related species.

In scientific names, the first word is the genus name, and the second word species name. Thus, in the example, *Typha latifolia, Typha* is the genus name, and *Typha latifolia* is the species name*.*

The term, *Typha spp*., refers to all species in the *Typha* genus.

DEFINITION OF TERMS FOR PLANT IDENTIFICATION

Here are several descriptions that **must** be remembered if you **really** want to be able to identify plants, particularly the grasses, sedges and rushes. There are many other parts and terms of course, but here we describe only the terms used for basic plant identification.

Some leaves have **sheaths**. The sheath is at the base of the leafblade and it may completely surround the stem, or it may not. The sheath may be short or it may be very long.

Another part is the **ligule**. The ligule is an outgrowth at the junction of the leaf blade and the leaf sheath. The ligule may be hairy, or bristly, or hard or soft or may be absent altogether.

An **inflorescence** is a structure that holds the flowers of a plant. There are different types of inflorescences having various degrees of complexity. Often, inflorescences are described as being closed or opened. The main axis of an inflorescence is called a **rachis**. The rachis may have a few **branches**, or many branches. The branches may be further divided into **branchlets**.

The inflorescence may have structures called **spikelets**. Spikelets are parts that contain the **flowers** of the plant. Spikelets may grow in rows, or in spherical clusters, or in other arrangements. Depending on the species, spikelets may be extremely small, or quite large, an inch or more long. Spikelets often have scales and/or **bristles**.

The base of the inflorescence or its branches may have **bracts**. Bracts are leaf-like parts that may be very small and inconspicuous, or they may be relatively large or long, in which case they may be mistaken for leaves.

The individual flower of grasses, sedges and rushes are usually not conspicuous and colorful like the flowers of other plants. In fact, non-botanists often don't recognize them as flowers at all, even when magnified. The flowers may be so tiny that they require a magnifier to see, such as *Juncus*. Or they may be so numerous that they are very obvious, such as *Phragmites*.

IDENTIFICATION OF GRASSES, SEDGES AND RUSHES

Many people have difficulty separating grasses, sedges and rushes from one another. However, the most basic and helpful way to remember these different types of salt marsh plants is by this catchy phrase:

"Sedges have edges, rushes are round, grasses have joints when the cops aren't around!"

The following are more formal biological terms for distinguishing the three different groups.

Grasses: Grasses have jointed, hollow stems that are round in cross-section. Leaves are distinctly two-ranked and connected to the stem by open sheaths. Leaves possess a ligule (membranous or hairy appendage) at the junction of the leaf and the leaf sheath. Flowers are born in spikelets, and each flower consists of two glumes (bracts) and one or more florets (each of which has two different bracts, the lemma and the palea, and a flower). Fruits are grainlike seeds.

Sedges: Sedges have solid, triangular edges for the most part. Leaves are three-ranked with closed sheaths. Flowers are born in the axils of overlapping scales, which may collectively resemble a bud. Each flower consists of a single pistil with two to three stigmas and one to three stamens. Fruits are lens-shaped or three angled nutlets called achenes.

Rushes: Rushes have solid stems, mostly round in cross-section. No ligule is present. They have regular flowers with three sepals, three petals, three or six stamens, and a fruit capsule. Fruit capsules are usually three-halved but sometimes one-celled. Rushes can be easily separated from grasses and sedges by their multiseeded capsules, because grasses and sedges have only one seed per flowering scale.

IDENTIFICATION OF INVASIVE PLANT SPECIES

Within a salt marsh, invasive plants often thrive in areas of reduced salinity or high nutrient levels. Thus, they are often the symptom of restricted tidal flows and/or other human influences on the marsh system, such as input of nutrients from runoff and septic systems or improperly installed culverts. The objective of this section is to outline the types of invasive species that may be found in some of the salt marshes you inventory. The presence of these species are a good indication that a restriction is occurring. Combining this information with an inventory and evaluation of tidal restrictions will help to prioritize sites for more detailed monitoring and possible restoration.

The target invasive species of the search are common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*). Volunteers should also record the presence of narrow-leaf cattail (*Typha angustifolia*) and broad-leaved cattail (*Typha latifolia*), as extensive growth of these species may indicate the effects of a tidal restriction or nutrient source.

Common reed *(Phragmites australis)*
Tall perennial grass up to 14 feet high often forming dense stands, with long tapered conspicuously two-ranked (up to 24 inches long and 2 inches wide), and dense much-branched purplish to brownish terminal inflorescence (8 to 16 inches long); July through September; salt and brackish marshes and freshwater tidal and nontidal marshes.

Purple Loosestrife (*Lythrum salicaria*)
Medium height to tall perennial herb up to 6 feet high with angled almost woody stems, entire lance-shaped leaves often having heart-shaped bases, sometimes in whorls of three, and many pink to purplish five to six petaled flowers borne in leafy spikelike inflorescence (up to 16 inches long); July through September; inland marshes, wet meadows, shrub swamps, tidal fresh marshes, and upper edges of coastal marshes.

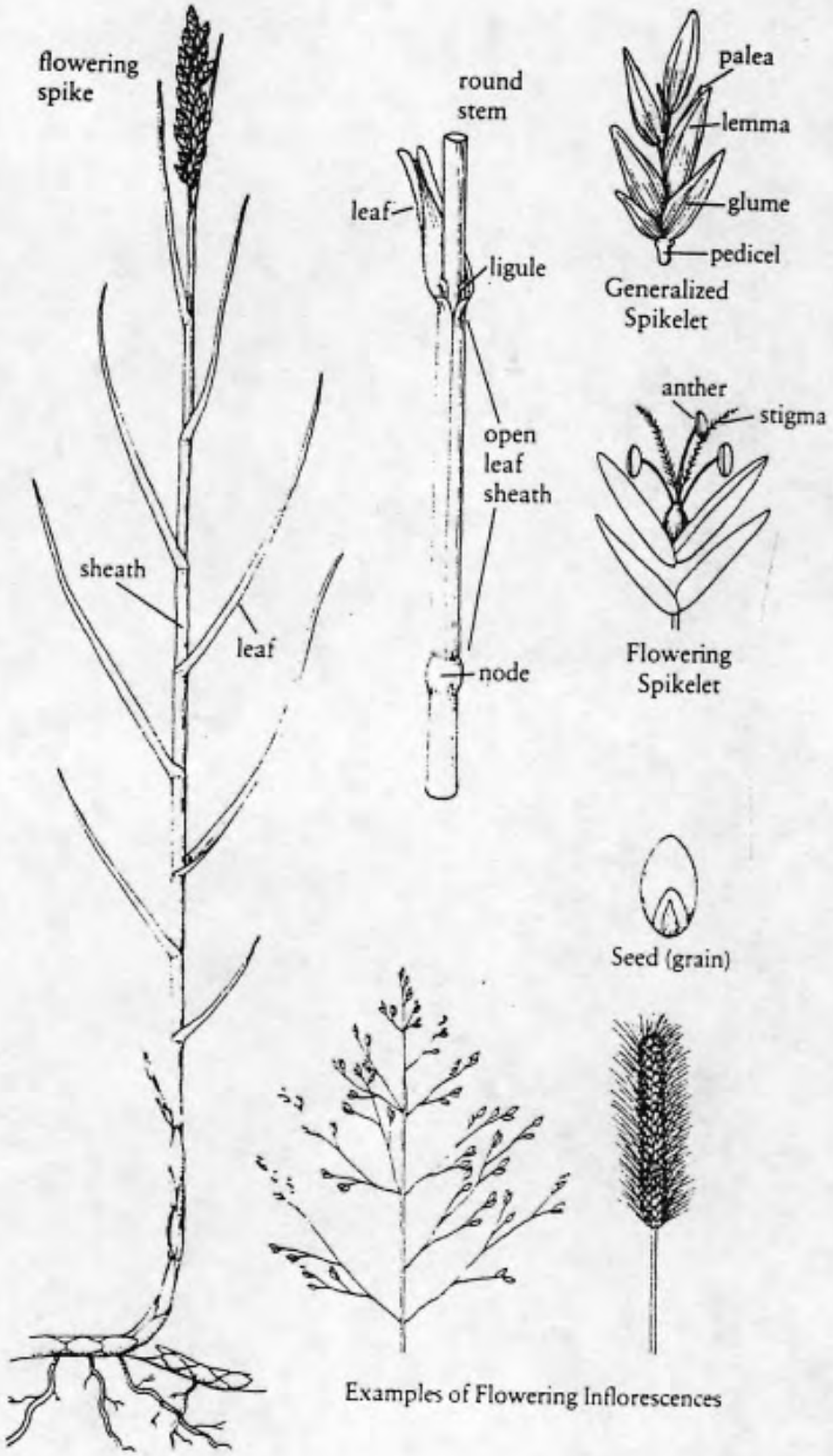
Narrow-leaved Cattail (*Typha angustifolia*)
Tall grasslike perennial herb up to 10 feet high with narrow leaves (to ½ inch wide) and inconspicuous flowers borne in terminal spike (persistent through the winter) composed of two separate parts (male flowers above and female flowers below): May to July; coastal marshes mostly in brackish waters, but also along edges of salt marshes and inland marshes.-

Broad-leaved Cattail (*Typha latifolia*)
Has wider leaves (up to one inch wide) and a continuous terminal spike separated into two distinct parts.

Distinguishing among Grasses, Sedges, and Rushes

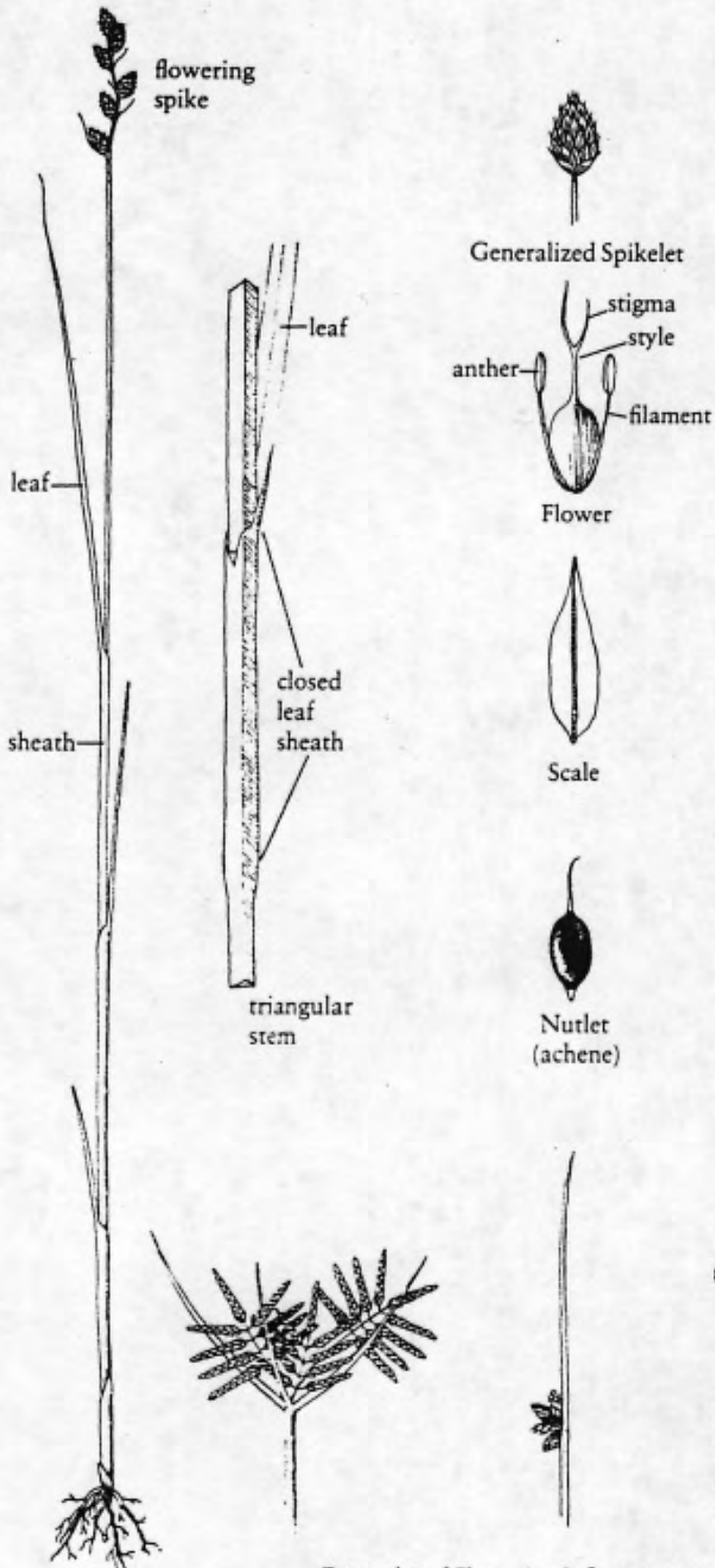
Many people have difficulty separating grasses, sedges, and rushes from one another. It is, therefore, useful to review the general differences between them.

Grasses. Grasses have jointed, hollow stems that are round in cross-section. Leaves are distinctly two-ranked and connected to the stem by open sheaths. Leaves possess a ligule (membranous or hairy appendage) at the junction of the leaf and leaf sheath. Flowers are born in spikelets, and each flower consists of two glumes (bracts) and one or more florets (each of which has two different bracts, the lemma and the palea, and a flower). Fruits are grainlike seeds.



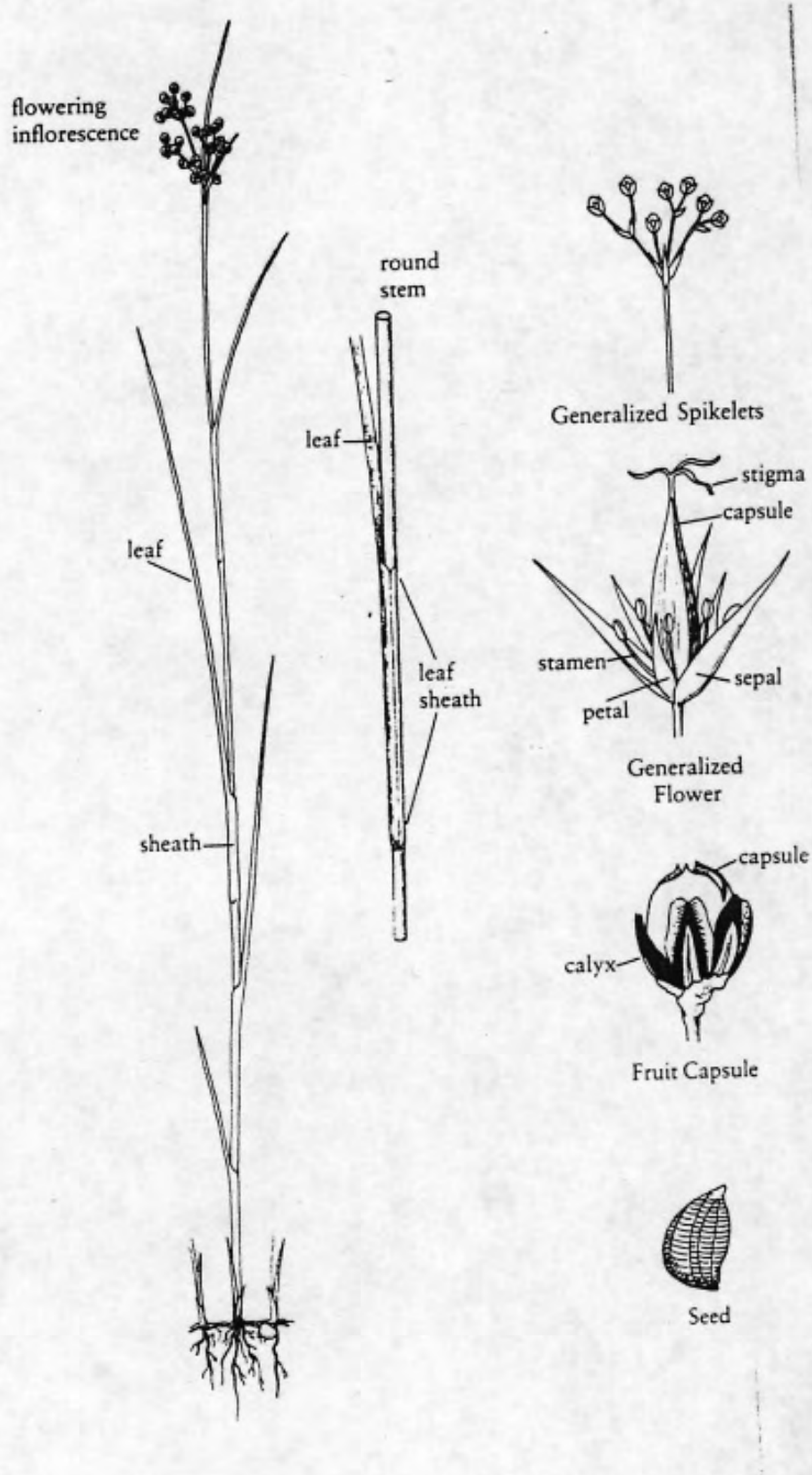
Characteristics of grasses.

Sedges. Sedges have solid, triangular stems for the most part. Leaves are three-ranked with closed sheaths. Flowers are born in the axils of overlapping scales, which may collectively resemble a bud. Each flower consists of a single pistil with two to three stigmas and one to three stamens. Fruits are lens-shaped or three-angled nutlets called *achenes*.



Characteristics of sedges.

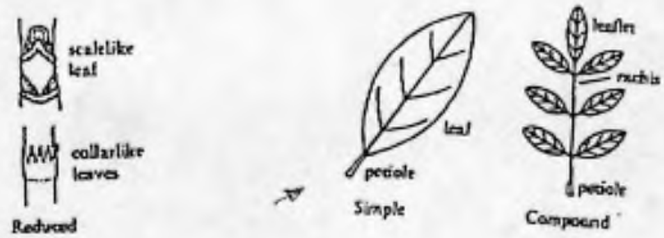
Rushes. Rushes have solid stems, mostly round in cross-section. No ligule is present. They have regular flowers with three sepals, three petals, three or six stamens, and a fruit capsule. Fruit capsules are usually three-valved but sometimes one-celled. Rushes can be easily separated from grasses and sedges by their multiseeded capsules, because grasses and sedges have only one seed per flowering scale.

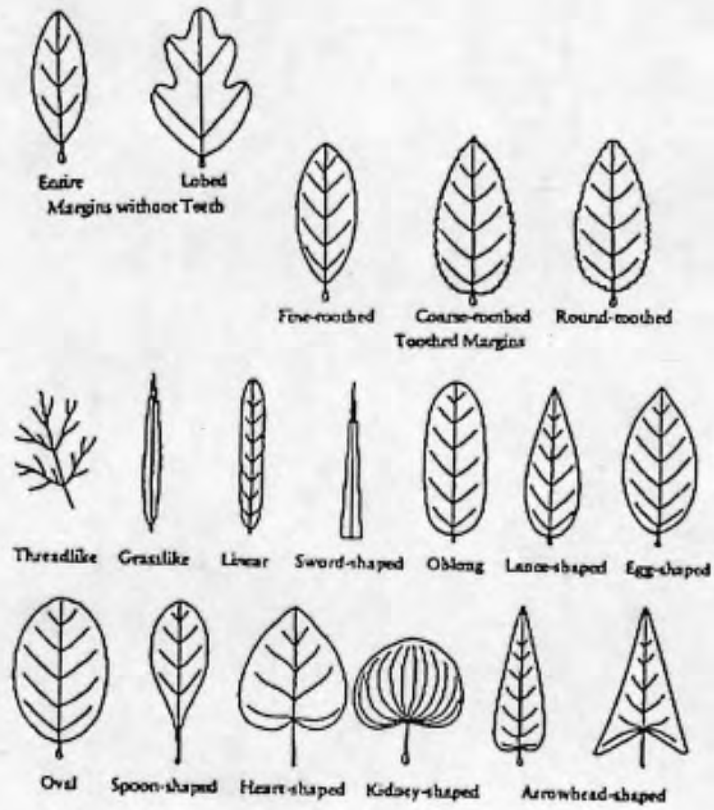


Characteristics of rushes.

Leaf Types

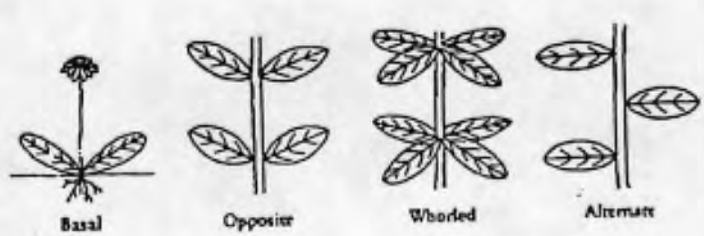
Leaves may be conspicuous as in most wetland plants or reduced to spines or scales as in saltwort and glassworts, respectively. Simple leaves are leaves that are not divided into more than one part, whereas compound leaves are divided into two or more distinct and separate parts called leaflets. Lobed leaves are simple leaves that have shallow or deep indentations forming lobes but are not divided into separate parts. Entire leaves are leaves with smooth margins, unbroken by indentations. Toothed leaves have margins indented by fine or coarse teeth or have scalloped edges. Leaves also take on a variety of shapes, including threadlike, grasslike, linear, lance-shaped, egg-shaped, spoon-shaped, heart-shaped, arrowhead-shaped, and sword-shaped. Fleshy-leaved plants have succulent leaves that are fleshy in texture. Leaves are attached to the stem in different ways. Sessile leaves are leaves that are directly joined to the stem, without a stalk (petiole). Petioled leaves are connected to the stem by a stalk (petiole).





Leaf Arrangements

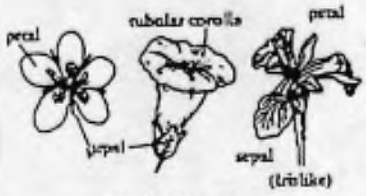
Leaves are arranged on plants in four basic ways: (1) basal, (2) opposite, (3) whorled, and (4) alternate. Basal leaves grow directly from the roots of the plant; they do not arise from the stem. When leaves grow in pairs across from each other along a stem, the leaves are oppositely arranged. If the leaves grow in clusters of three or more around the stem, they are whorled. When leaves grow singly on the stem and vary in position from one side to the next up the stem, they are alternately arranged.



Flower Types and Arrangements

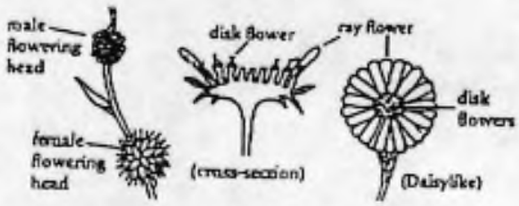
At first glance, flowers are either regularly or irregularly shaped. Regular flowers are radially symmetrical with distinct petals or petallike parts surrounding the center of the flower. Each petal or petallike part is alike in shape, size, and color. Irregular flowers are not radially symmetrical, and their petals or petallike parts are not alike but differ in shape, size, and/or color. Tubular flowers have petals fused into lobes that are joined at the base forming a tube. Some tubular flowers have distinct upper and lower lobes called lips. Inconspicuous flowers do not have petals, or their petals or petallike parts are so small that they cannot be readily observed.

Flowers are arranged in several ways—many grow singly along the stem, whereas others occur in clusters of various types. The latter include heads, panicles, racemes, spikes, and umbels among others. A head is a rounded or flat-topped cluster of sessile flowers, as found in many asters. A panicle is a branched inflorescence with a central axis, as present in many grasses. A raceme is an unbranched elongated inflorescence with lateral flowers. A spike is a type of raceme with sessile flowers. Some plants possess a single terminal spike, and others have numerous small spikes called spikelets branching from a central axis or side branches. An umbel is an inflorescence with several branches arising from the end of a peduncle (flowering stalk), as found in water parsnip.



Regular Flowers

Irregular Flowers



Heads

Raceme
(flowers stalked)

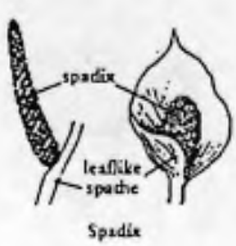
Spike
(flowers not stalked)

Panicle

Simple Umbel

Compound Umbel

Catkin



Spadix

Life Form

Life form relates to the growth form of a plant. Five life forms are generally recognized in tidal wetlands: (1) aquatic plants, (2) emergent plants, (3) shrubs, (4) trees, and (5) vines. Aquatic plants grow in permanently flooded waters, either free-floating, submerged (underwater), or with floating leaves at the surface and stems rooted to the underlying substrate. Emergent plants are erect, herbaceous (nonwoody) plants that have all or part of their stems and leaves standing above the water's surface or grow on the surface of intertidal areas. Shrubs are woody plants less than 20 feet in height, usually with multiple stems, but also including saplings of tree species. Trees are woody plants 20 feet or greater in height, having a single main stem (trunk). Vines are woody or herbaceous plants that climb or twine around the stems of other plants.

SALT AND BRACKISH MARSH PLANTS OF MAINE

The following list of plants contains those species found in Maine salt and brackish marshes. This list should be used in conjunction with *Coastal Wetland Plants of Northeastern United States* by Ralph Tiner to help in the identification of plant species needed to complete the *Maine Citizens Tidal Marsh Guide.*

Agalinis maritima	Seaside Gerardia
Agropyron repens	Quackgrass
Agrostis gigantea Roth, Agrostis alba	Creeping Bent Grass, Redtop
Amaranthus scanabinus	Water Hemp
Ammophila breviligulata	Marramor Beachgrass
Arenaira peploides	Seabeach Sandwort
Artemesia stelleriana	Dusty Miller
Artemisia caudata	Tall Wormwood
Aster subulatus	Annual Salt Marsh Aster
Aster tenuifolius	Perennial Salt Marsh Aster
Atriplex glabriuscula	Orach
Atriplex patula	Orach
Bassia hirsuta	Hairy Smotherweed
Cakile edentula	Sea-Rocket
Carex paleacea	Salt marsh Sedge, Chaffy Sedge
Carex scoparia	Pointed Broom Sedge
Carex hormathodes	Marsh Straw Sedge
Cladium mariscoides	Twig-Rush
Distichlis spicata	Spike Grass
Eleocharis halophila	Salt Marsh Spike-Rush
Eleocharis parvula	Dwarf Spike-Rush
Eleocharis smallii	Small's Spike-Rush
Elymus virginicus	Virginia Rye Grass
Euphorbia polygonifolia	Seaside Spurge
Festuca rubra	Red Fescue
Glaux maritima	Sea Milkwort
Hordeum jubatum	Squirrel-Tail Grass
Hudsonia tomentosa	Beach Heather
Iva frutescens	Marsh Elder of High-Tide Bush
Juncus balticus	Baltic Rush
Juncus canadensis	Canada Rush
Juncus gerardii	Black Grass
Juncis greenei	Green's Rush
Lathyrus japonicus	Beach Pea
Leachea maritima	Pinweed
Limonium nashii	Sea Lavender or Marsh Rosemary
Lythrum salicaria	Purple Loosestrife
Myrica pensylvanica	Northern Bayberry
Panicum virgatum	Switchgrass
Phragmites australis	Common Reed
Pinus rigida	Pitch Pine
Plantago maritima	Seaside Plantain
Polygonella articulata	Sand Jointweed
Polygonum aviculare	Common Knotgrass
Polygonum ramosissium	Bushy Knotweed
Potamogeton pectinatus	Sago Pondweed
Potentialla anserina	Silverweed
Prunus maritima	Beach Plum
Puccinellia maritima	Seaside Alkali Grass

Quercus alba	White Oak
Quercus bicolor	Swamp White Oak
Ranunculus cymbalaria	Seaside Crowfoot
Rosa palustris	Swamp Rose
Rosa rugosa	Salt Spray Rose or Rugosa Rose
Rosa virginiana	Virginia Rose
Ruppia maritima	Dtich or Widgeon Grass
Salicornia bigelovii	Bigelow's Glasswort
Salicornia europaea	Common Glasswort or Samphire
Salicornia virginica	Perennial or Woody Glasswort
Sanguisorba canadensis	Canadian Burnet
Scirpus	Bulrushes
Scirpus acutus	Hard-Stemmed Bulrush
Scirpus americanus	Three-Square
Scirpus atrovirens	Green Bulrush
Scirpus cyperinus	Wool Grass
Scirpus maritimus	Salt Marsh Bulrush
Scirpus paludosus	Bayonet-Grass
Scirpus robustus	Salt Marsh Bulrush
Scirpus validus	Gerater Soft-Stemmed Bulrush
Smilax rotundifolia	Common Greenbriar
Solidago sempervirens	Seaside Goldenrod
Spartina alterniflora	Saltwater Cordgrass, Smooth Cordgrass
Spartina patens	Salt Meadow Grass, Salt-Hay Grass
Spartina pectinata	Prairie Cordgrass or Slough Grass
Spergularia canadensis	Canada Sand Spurrey
Spergularia marina	Salt Marsh Sand Spurrey
Suaeda linearis	Sea Blite
Suaeda maritima	Sea Blite
Suaeda richii	Sea Blite
Toxicodendron radicans	Poison Ivy
Triglochin maritima	Seaside Arrow Grass
Typha angustifolia	Narrow-Leaved Cattail
Typha latifolia	Borad-Leaved or Common Cattail
Zannichellia palustris	Horned Pondweed
Zostera marina	Eelgrass

Analyzing Your Data

Once the data has been collected, it is entered into a spreadsheet template which computes the peak-to-peak (maximum of the six measurements minus minimum measurement) water-level change for each reference point. This water-level change is the tidal range. The spreadsheet should be set up to compute the tidal range as well as the ratio of the upstream to downstream tidal ranges.

The data can be visualized by graphing both upstream and downstream water-level changes for each crossing on the same axes. To do this, compute the mean distance to the water surface for both the upstream and downstream data sets, then subtract the mean from each data set, and then plot the resulting values as a function of time of day.

If the crossing creates no restriction, then the upstream and downstream curves should lay over each other and the measured peak-to-peak upstream and downstream level changes will be within 1-2 inches of each other (Figure 16). If there are significant differences between the curves of the upstream and downstream tidal ranges, then the crossing is altering the tidal flow (Figure 17).

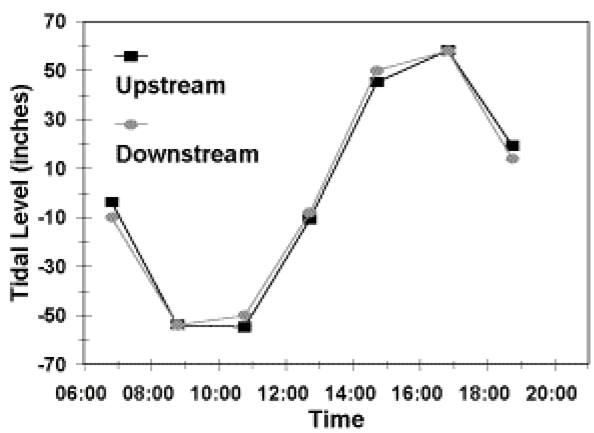


Figure 16. *Example tidal data from an unrestricted site. Note that the upstream and downstream curves are almost identical. Tidal level at each time point for the upstream curve is computed as the difference between the measured value and the average value for the upstream data and likewise for the downstream data.*

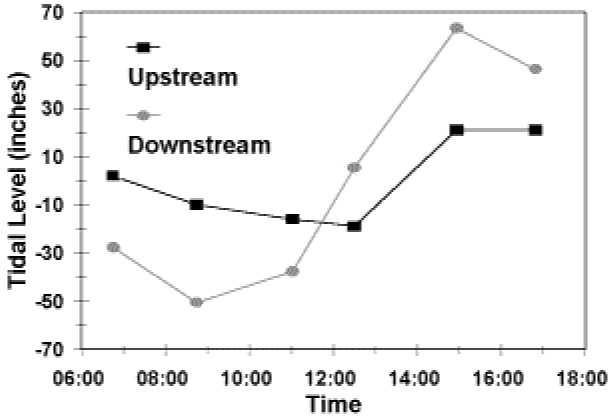


Figure 17. *Example tidal data from a restricted site. The large difference between the upstream and downstream curves is the result of a severe restriction due to the collapse of a culvert.*

Notice in Figure 17 that the upstream tide cycle is delayed somewhat with respect to the downstream data. This is typical of an extremely restricted site and is due to the fact that the upstream high tide is so much lower than the downstream tide that water is still moving through the restriction to the upstream tide, even when the downstream tide is starting to go out.

We chose to define a crossing as being significantly restricted if the difference between the upstream and downstream tidal range was more than 5 inches. This may or may not mean that the marshes are suffering because of the reduction of tidal now. To determine the effects on the salt-marsh habitat may take years of research, but it is likely that, if a culvert or bridge is limiting the amount of salt water entering a marsh, marsh productivity will be diminished or the salt-marsh habitat will change to brackish or fresh marsh and in some cases upland species may invade the former marsh. Also, the alteration of salt-water flow will increase the chances that invasive species such as phragmites will take hold.

The most common type of restriction in our study area was the case where the culvert was located too high. At these sites, water becomes trapped on the upstream side of the crossing, once the tide drops below the bottom of the culvert. The result is a tidal curve on the upstream side that has a narrow peak at high tide and is flat over much of the rest of the tidal cycle (Figure 18).

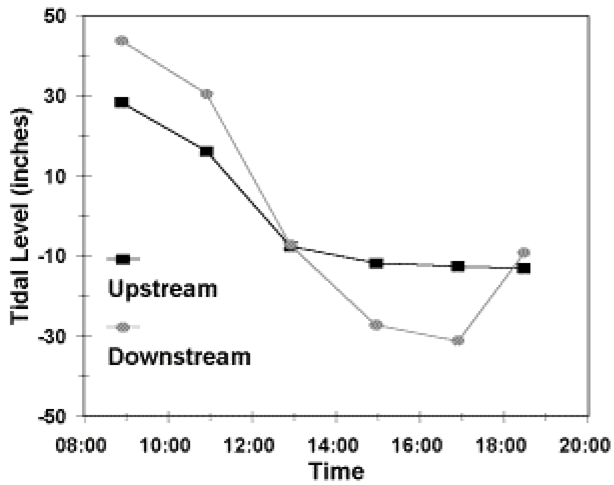


Figure 18. *Example tidal data from a site where the culvert was located too high. The upstream curve exhibits little tidal change during the four afternoon data points due to water trapped behind the culvert.*

The rise and fall of the tide should progress gradually on both sides of the crossing as shown in Figure 16. If any of the curves have more than one peak or otherwise look irregular, the data should be questioned. The most common error we found was that, on a few occasions, volunteers would switch their upstream and downstream measurements when they recorded them on the data sheets. This error can usually be spotted as irregularity in both curves at the same time point.

RETURN THE TIDES PROJECT: Tidal Crossing Data Sheet- Phase I (circle one): **MEASURED ESTIMATED**

IMPORTANT: before filling out this form review the instructions sheet and list of codes and abbreviations

Location Information			
Topo Name/ID # (copy from preliminary list)		Unique no. (assigned by GIS)	
Town		Topo quadrant (NW,NE,SW,SE)	
Water Body/Stream Name (From Topo, if not named, get local info and enter in quotes)		Marsh Ownership (P/T/S/F + cons)	
Street/Road Name (From Topo, if not named, get local info and enter in quotes)		Road Jurisdiction (P/T/S/F)	
Landmark/Location Description (From Topo, only if road or stream not named on topo)		LOCATION MARKED ON TOPO (check)	

Field visit Information	
Date/time/volunteer name(s)	
Weather (circle one)	Sunny Partly Cloudy Overcast Rain
Tide (circle height and direction)	HIGH/MID/ LOW Incoming/Outgoing/Change/Slack
	Enter Location and Description (e.g. "from crossing looking upstream")
A Photo #1 - Reference #:	
B Photo #2- Reference #:	
C Photo #3- Reference #:	
D Photo #4- Reference #:	
E Photo #5- Reference #:	

Crossing Information	**Remarks**
Type (circle one choice)	Bridge / Culvert / Dam/Other (describe in detail):
Fill (circle one choice)	Road on Marsh / Headland to Headland
Road runoff (circle one choice)	Onto Marsh / Into Creek
Shape (circle one choice)	Round/oval / Rectangular / other (sketch):
Material (circle one choice)	Iron/Aluminum/concrete / plastic /masonry / other (describe):
Dimensions of opening (Ho, Wo)	Height: ft in. Width: ft in
Nature of crossing: (circle all applicable) Upstream Downstream	 Perched culvert/ pooling/ scour/ bank slumping/ rubble in stream perched culvert/ pooling/ scour/ bank slumping/ rubble in stream
Upstream Channel Width (UchW)	Ft Distance from Crossing (DC): Ft
Downstream Channel Width (DChW)	Ft Distance from Crossing (DC): Ft
Height from Channel bottom to culvert bottom: Upstream (UchH,)	Ft
Height from Channel bottom to culvert bottom: Downstream (DchH)	Ft
Length of fill over marsh (LF)	Ft
Channel Length at crossing (In middle) (CL)	Ft
Road Description (circle all applicable)	Lanes: 1 2 3 4/ curbs / paved sidewalks
Road Surface Material (circle one)	Asphalt/Concrete/Gravel/Dirt/Other (describe):
Condition (1-5*) of Bridge or culvert	1 2 3 4 5
Condition (1-5*) of Road	1 2 3 4 5

*1. Excellent 2. Good 3. Fair 4. Poor 5. Need of Immediate Repair

PHASE I DATA SHEET (PAGE 2/2) Topo Name/ID #: Crossing name:

Circle the Most Appropriate Response

Restriction Classification Scheme		
Classification	**Evidence of Flow Restriction/Erosion**	**Notes**
1 Upstream	Unrestricted/ No Pooling	
2 Upstream	Flow Detained/ Slight Erosion	
3 Upstream	Minor Pooling/Erosion Present	
4 Upstream	Significant Pooling/Significant Erosion Present	
5 Upstream	Major Pooling/Major Erosion Present	
Classification	**Evidence of Flow Restriction/Erosion**	
1 Downstream	Unrestricted/ No Pooling	
2 Downstream	Flow Detained/ Slight Erosion	
3 Downstream	Minor Pooling/Erosion Present	
4 Downstream	Significant Pooling/Significant Erosion Present	
5 Downstream	Major Pooling/Major Erosion Present	
Classification	**Channel vs. Crossing/ Opening**	
1 Upstream	Channel Width < Opening Width	
2 Upstream	Channel Width = Opening Width	
3 Upstream	Channel Width 1.1 to 2.0x Opening Width	
4 Upstream	Channel Width 2.1 to 5.0x Opening Width	
5 Upstream	Channel Width 5.1x + Opening Width	
Classification	**Channel vs. Crossing/ Opening**	
1 Downstream	Channel Width < Opening Width	
2 Downstream	Channel Width = Opening Width	
3 Downstream	Channel Width 1.1 to 2.0x Opening Width	
4 Downstream	Channel Width 2.1 to 5.0x Opening Width	
5 Downstream	Channel Width 5.1x + Opening Width	
Classification	**Vegetation Comparison**	
1	Upstream = Downstream	
2	Upstream Slightly Different Than Downstream	
3	Upstream Different From Downstream	
4	Upstream Much Different Than Downstream	
5	Upstream Completely Different Than Downstream	
Classification	**Flood Potential**	
1- Low	Flooding unlikely	
2- Med	Need detailed survey to determine flooding risk	
3- High	Structures likely to be flooded if restriction removed	

ADD SKETCH PAGE FOR EACH SIGNIFICANT RESTRICTION (circle) **SKETCH ATTACHED**

Narrative Description and General Notes: (attach additional pages as needed)

Volunteer signature(s):

rev November 13, 2000

RETURN THE TIDES PROJECT: Phase I Tidal Crossing Data Sheet, SKETCH PAGE

Location	
Topo Name/ID # (copy from preliminary list)	
Field visit Information	
Date/time	
Weather	Sunny Partly Cloudy Overcast Rain
Tide	High / Low Incoming / Outgoing Change (Slack)

Plan View Sketch

1"=

North Approximate Scale (Feet)

General Notes: (attach additional pages as needed)

Volunteer Signature(s):

Casco Bay Return the Tides
Instructions for Tidal Crossing Data Sheet, Phase I

EQUIPMENT: Field map, Preliminary phase crossing listing, Phase One data sheets (one per crossing), blank paper, copies of Topo map quadrants, RTT fact sheets, pencils, measuring tape, rubber boots or mud sneakers, camera, film, clipboard, orange vest.

Part 1 is a preliminary assessment of the crossing to record its basic characteristics and determine if it is apparently restrictive. If the crossing is clearly restrictive, you should gather Measured information and make a sketch of the site. If a site appears from the outset to be either very small or not significantly restricted dimensions may be ESTIMATED be estimated by pacing or armspan in the interest of time. and a site sketch need not be made. The most restrictive crossings will be selected for Phase II tidal curve measurements.

DATA POINTS:

LOCATION INFORMATION

Topo Name/ID number: Topo/sequential number by topo. (Copy from Crossing List)

Unique number: leave blank, the GIS program assigns this number automatically when the record is entered in the system.

Town name: **Town**, city or other minor civil division**.** (Copy from Preliminary List)

Topo Quadrant:: quadrant of topographic quadrangle map- e.g.: NW, NE, SW, SE. (Copy from Preliminary List)

Water body/stream name: From topo map or from local knowledge/information if not named on topo map (indicate local names not printed on topo map by using quotation marks). (Copy from Preliminary List)

Marsh ownership: If known, insert one or more of following as appropriate: private, town, state, federal. Add qualifier "cons" (for conservationif land is held for conservation. Include detailed ownership information in comment section if known.

Road/Street Name: Name of the street or road crossing the water body/stream as printed on the Topo map. If not a street, insert other identification such as "Guilford Rail line." (Indicate local names not printed on topo map by using quotation marks). (Copy from Preliminary Phase Crossing List)

Road/Street Jurisdiction: if known, insert one of following: private, town, state, federal.

Landmark/Location Description: Complete this item only if stream and road names are not printed on Topo map. If necessary, record distance and direction from an identified landmark on the topo map (e.g., 0.6 miles east of US HWY. 1 on Blue Point Road). (Copy from Preliminary Phase Crossing List)

Location Marked on Topo Map: the exact location of each crossing on a copy of the Topo map using shis symbol:

|
– • –
|

with the bullet over the exact crossing location. Indicate the map has been marked by checking the data sheet box. This information will be used by the GIS system to enter the position of the crossing in the data base.

Instructions for Tidal Crossing Data Sheet, Phase I, page 2

FIELD VISIT INFORMATION:

Date/time/volunteer name(s): record date and time of site visit (important for tide info) and full names of all volunteers

Weather: circle applicable description

Tidal Conditions: Circle approximate tide level (low, mid, high) and tidal current flow direction (incoming, outgoing, change/slack). You may consult the tide table for general reference, but record local conditions at crossing by observing water level and flow directions.

Photographs: Take at least 5 photos as follows:

#1,2: Standing on the creek bank, photograph the crossing from the upland ("upstream") and seaward ("downstream") sides.

#3,4: Standing at the crossing, photograph the marsh looking upstream and downstream.

#5: Finally take at least one overview photograph of the marsh and crossing to show the entire setting, this may be from a nearby high point where the road emerges onto the marsh.

Record a description of the locations where the photos were taken. Record roll and photo number, mark and label printed photos as follows. Example: "SPO/FR 2 A: Anthoine Creek /Broadway. View from upland side".

Crossing type: Indicate Bridge/Culvert/Dam/Other. (Copy from Preliminary Phase Crossing List)

Road on Marsh: **Does** the road approach the crossing on fill placed on the marsh surface, or does the crossing go from headland to headland (no fill on marsh)? Circle appropriate choice.

Road Runoff: Note and describe how road runoff is directed at the crossing and approaches. Freshwater runoff directed onto the marsh can damage it. If runoff is carried to the center of the crossing and drains directly into the tidal creek, there is less freshwater impact on the marsh vegetation.

S**hape**: Circle appropriate choice or make sketch

Material: Circle appropriate choice or describe

Dimensions of opening: BRIDGES: Record height and width of opening (smallest dimension for water flow). Height is measured from lowest horizontal object under bridge to channel bottom at center, width is measured at narrowest horizontal opening perpendicular to channel centerline.

CULVERTS: Record height and width of opening (smallest dimension for water flow). or diameter if round. If there are multiple structure at a single crossing, note number and describe each. Also note material for culverts.

Upstream/Downstream Channel Width: Restrictive bridges and culverts often cause substantial erosion of stream banks, especially near the restriction. Measure the channel width at a point beyond any erosion that may be due to increased current speed through the restriction. Except for very small channels (less than 10' wide), fifty feet from the crossing is a minimum distance. Note the distances, upstream and downstream, from the crossing where the measurements were taken and indicate location on sketch. If possible, measure at equal distances upstream and downstream from the crossing.

Instructions for Tidal Crossing Data Sheet, Phase I, page 3

Defining channel width: Many tidal creeks have gently sloping banks, making "channel width" hard to define. For this study, measure channel width from the high marsh/low marsh dividing line on each side of the creek. This is typically the upper limit of *Spartina alterniflora*. Note any difficulties in measuring width.

Nature of Crossing: Note and circle all applicable features separately for upstream and downstream (seaward) side of crossing.

Length of fill over marsh: Note the length of the fill from upland to upland along the centerline of the road or other feature.

Height from Channel bottom to culvert bottom: Culverts that are not flush with the channel bottom may cause tidal delays and pooling. Note the distance from the channel bottom to the bottom of the culvert.

Crossing width: **Note** the entire width of the fill on the marsh surface immediately adjacent to the crossing.

Culvert length/Bridge width: Pace off the total length of the crossing along the centerline of the stream and record approximate width.

Road description: **Circle** all applicable road features.

Road Surface Material: Note type of material such as asphalt, concrete, gravel, dirt, other (describe)

RESTRICTION CLASSIFICATION SCHEME

Evidence of Flow Restriction/Erosion: As you visually assess the crossing, characterize the bank erosion and pooling and circle an appropriate classification for upstream and downstream.

As with any ranking approach, objectivity is difficult to maintain, especially when first starting. When ranking the degree of bank erosion, the lowest scores should be given to those sites that most closely resemble natural stream conditions. This resemblance can be determined by studying the surrounding downstream conditions and similar streams that are not affected by road crossings. As you observe more, you will become familiar with typical conditions. Highly eroded sites will show bank failure or slumping; wide, rounded creek pools; and the build-up of rubble and riprap in the streambed.

Channel vs. Culvert Opening: Use the dimensions recorded above to compute the crossing ratio and circle an appropriate classification for upstream and downstream.

Vegetation Comparison: **Analyzing** the differences in vegetation from upstream to downstream can take a trained eye, especially since the differences may be subtle. Moreover, the differences may not be related to a restriction of salt water. Visually assess the habitat both upstream and downstream and record any difference in frequency of salt-tolerant and salt-intolerant plant such as common reed (*Phragmites australis*) or freshwater species such as cattails (*Typha sp*.) and common loosestrife *(Lythrum Salicaria*). In extreme cases, the habitat may evolve into shrub or forested swamp, and the former wetland may be invaded by upland species. Circle appropriate classification for upstream and downstream areas. Refer to the plant handouts for additional information.

Instructions for Tidal Crossing Data Sheet, Phase I, page 4

Flood potential: Rank flood potential as follows:

1- LOW- there are no structures located near the marsh or the structures present are so high above the marsh that induced flooding is highly unlikely

2- MEDIUM- the potential for induced flooding can be ascertained only through detailed engineering field surveys.

3 HIGH- High probability that structures near the marsh will be flooded if the restriction is removed.

Sketch: Make a simple "bird's eye view" sketch of the site, with notable features labeled and upstream and downstream sides indicated. Indicate which direction is north and the approximate scale of the sketch. The sketch should show road, fill, crossing, scour pools, marsh, upland, road drainage and incorporate buildings, vegetation types, and crossing configuration.

Narrative comments: Write a brief narrative description of the crossing, the associated marsh and the surroundings. Try to capture the essence of the site, considering the following factors as they may be applicable: overall value and appeal of the site or extent of degradation ("a little gem of a marsh in an unexpected spot," "a sodden, stinking mess of putrid trash"), aesthetic value from a wildlife (birds, fish, shellfish, mammals) or landscape perspective (invasive plants, viewshed, etc.), public visibility, educational potential, nature of the surrounding area, potential for restoration and benefits of restoration, potential issues relating to restoration and anything else that may be of interest or helpful in describing the site and its restoration potential. Historic information and local knowledge about the site, its use (bird watching, hunting, harvesting, launching, etc.) and local value is very helpful. Comment on any special features not apparent from the data recorded above which might make this crossing or marsh a candidate for closer study or restoration or which may complicate a restoration effort. If you speak to any one at the site, explain the project, offer them a fact sheet and try to get their name and address (recruit them!)

APPENDIX J

RETURN THE TIDES PROJECT: Tidal Crossing Data Sheet- Phase II

REFER TO INSTRUCTION SHEET FOR DETAILED INSTRUCTIONS

Location	(copy from Phase I data sheet)		
Map Reference Number		Unique number:	
Town			
Water Body/Stream Name			
Street			
Landmark/Location Description			

Field visit Information	
Date/time/volunteer name(s)	
Weather (circle applicable terms)	Sunny Partly Cloudy Overcast Rain
Tide (from tide table)	High Low:

Water Levels : Time (Hours: Minutes)	Measure approx every 2 Height Upstream (Inches)	hours Height Downstream (Inches)

Sketch of Reference Points in Relation to Site
1”= ‘ North approximate scale (feet) 1”

General Notes (continue on back):

Casco Bay Return the Tides
Instructions for Tidal Crossing Data Sheet, Phase II

Phase II is a detailed measurement of the tidal heights at crossings that the Part I assessment indicated to be apparently restrictive.   It is important to get a set of measurements spread over 12 hours so, in order to do all the measurements in daylight you will need to start about 7 AM!

Field equipment: Phase 2 data sheet with site info, location map, Phase 1 data sheet, Return the Tides Fact sheets, clip board, sharp pencils, weighted tape measure, yardstick, bug juice, sturdy shoes

DETAILED INSTRUCTIONS FOR COMPLETING DATA SHEETS (see sample attached):

Location: If necessary, insert Map Reference Number, Town name and Water body/stream names from Part 1 data sheet, also insert Field visit information, note unusual weather conditions such as storm, heavy rain, or strong wind which might affect water level.

Determining Reference Points: Unless reference points have been pre marked, reference points need to be defined on both the upstream and the downstream side of the bridge or culvert. The reference points should be chosen near the middle of the channel, to ensure that your measurements will catch the low water. Reference points should be marked with a small spot of paint or colored chalk. It is important to mark the reference point clearly, for each successive measurement should be performed from the exact same point. A weighted tape measure or a carpenter's tape (for smaller sites) should be used to measure the distance between the water surface and the reference point for both upstream and downstream reference points at each crossing.

Sketch: Referring to the Phase 1 Sketch, make a simple "bird's eye view" sketch of the site, Showing the reference points used to measure the tidal heights, include enough detail so that the reference points can be relocated on a later occasion.

Measuring the Tide: The rise and fall of the tide is measured as the distance between the water surface and your reference points. The measurements need only be to the nearest inch, A total of 6 measurements timed approximately 2 hours apart need to be collected during one day. Timing your 6 measurements at 2-hour intervals allows you to record an entire tide cycle. It is not important that the measurements are taken exactly 2 hours apart, as 15 or 20 minutes either way will not effect the computation of the tidal range. It is important to **note the exact time** at which each measurement is taken, however. If there is not water at the crossing, measure to the bottom of the channel and describe where the water is in a note- such as “ no water on downstream side, water is out of sight across tide flats”

THINGS TO REMEMBER

Collect complete and ACCURATE data – it’s better to abort readings than to collect inaccurate data

Measure to nearest inch

Read measurements directly off tape

Record exact time of reading

Reference points need not be at same height

Measure with the bottom of the tape just touching the water (making ripples on surface)

Clean out trash to get a clear water surface

Describe any problems in a detailed comment on your data sheet; also include any other observations or comments about the site and your measurements that may be helpful.

When you are finished, please make copies of your data sheets and mail the original sheets to me in the envelope provided in your package. Save the copies in case the originals get lost in the mail.

Appendix H

RTT PRELIMINARY LIST Prepared by on , 2000

Topo Quad name [spell out] . page __ of __ .

ID # **Locate on Map**	**Use abbreviation from list**			**ROAD NAME** **From TOPO or field**	**WATERBODY NAME** **From TOPO or field**	**CLOSEST LANDMARK** **If there is no Stream Name**	**CROSSING TYPE** **Use code from list**	**REMARKS**
	TOPO NAME	**QUAD-RANT**	**TOWN NAME**					

RTT PRELIMINARY TIDAL CROSSING LIST INSTRUCTIONS AND ABBREVIATIONS

Use separate sheets for each Topo Quad. Compile initqal list form Topo map/GIS study, add additional sites as discovered.

ID # - This is a simple sequential number to tie in the entries on the preliminary list and the sites on the topo map.

TOPO NAME AND QUADRANT-[7 characters] Name abbreviated as below on List of Coastal Topo Names, plus quadrant, i.e. NW, NE, SW, SE]

e.g PTE- Portland East

TOWN NAME-[3 characters] abbreviated as on list of Town and city name Abbreviations

e.g.: CEL- Cape Elizabeth, THO- Thomaston, MAC,- Machias

ROAD NAME -[many characters] as printed on Topo map, or from local knowledge use the following abbreviations:

ST=Street,
LN=Lane,
STR=Stream,
BR- Brook;
CV=Cove,
R=River,
CR=Creek,
TR-Tributary,
PT- Point;
PD- Pond

WATER BODY/STREAM NAME-[many characters] use abbreviations above, insert name of nearest waterbody as printed on Topo map.

CROSSING TYPE: [1 character] Indicate crossing type as defined below, coded as follows:

B-Bridge;
C-culvert;
D-Dam
N-no crossing- unrestricted flow
O-other (Add explanatory remark)

BRIDGE - A structure that spans a stream between abutments on each side and which has **no hard bottom**. The stream flow and sediment load defines the height of the stream bottom under a bridge. Some structures that look like bridges actually are culverts because there is a solid bottom for the channel under the structure.

CULVERT - A structure to pass water under a road or other crossing which **has a bottom** as well as sides and a top. A culvert's bottom, unless it is set sufficiently deep so that the stream bed establishes equilibrium above the culvert bottom, artificially raises the stream bed height and restricts flow at lower tide levels. Culverts are commonly made of round or oval pipe, or of concrete, often in box section. Older culverts may be stone masonry. One or more pipes or boxes may be installed at a single crossing. Record shape, size, number and construction material for each pipe or structure forming the crossing.

OTHER- if the crossing is neither a culvert nor a bridge, (anything else such as a dam, flume, spillway, fish ladder, ditch, etc.) describe it in detail.

COASTAL TOPOGRAPHIC QUADRANGLE NAMES

Name	Abbreviation
Addison	ADD
Augusta	AUG
Baker Island	BKI
Bailey Island	BYI
Bangor	BGR
Bar Harbor	BRH
Bartlett I	BTI
Bass Harbor	BSH
Bath	BAT
Belfast	BFT
Biddeford	BID
Biddeford Pool	BDP
Blue Hill	BLH
Bois Bubert	BOB
Boothbay Harbor	BBH
Bowdoinham	BDH
Bristol	BRI
Brooklin	BRO
Brunswick	BRK
Bucksport	BPT
Calais	CAL
Camden	CAM
Cape Elizabeth	CEL
Cape Rosier	CRO
Castine	CAS
Cherryfield	CHD
Columbia Falls	CLF
Cross Island	CRI
Cutler	CUT
Damariscotta	DAM
Deer Isle	Dri
Devils Head	DVH
Dover East	DVE
Drisko Island	DRI
East Pittston	EPI
Eastport	EPT
Ellsworth	ELL
Freeport	FPT
Frenchboro	FRN
Friendship	FSP
Gardiner	GAR
Great Wass Island	GWI
Hampden	HAM
Hancock	HAN
Harrington	HAR
Hewett Island	HEI
Isle au Haut E	IHE
Isle au Haut W	IHW
Isles of Shoals	IOS
Islesboro	ISL

Johns Island	JNI
Jonesport	JPT
Kennebunk	KBK
Kennebunkport	KPT
Kittery	KIT
Leadbetter I	LBI
Lincolnville	LIN
Louds Island	LDI
Lubec	LUB
Machias	MAC
Machias Bay	MSB
Matinicus	MAT
Monhegan	MON
Moose River	MOR
Newbury Neck	NBN
New Harbor	NHB
North Haven E	NHE
North Haven W	NHW
Old Orchard Beach	OOB
Orland	ORL
Orrs Island	ORI
Pemaquid Point	PQP
Pembroke	PEM
Penobscot	PEN
Petit Manan	PTM
Phippsburg	PHI
Portland East	POE
Portland West	POW
Portsmouth	PTM
Prouts Neck	PRT
Red Beach	RDB
Richmond	RCH
Robbinston	ROB
Rockland	ROC
Roque Bluffs	ROQ
Salsbury Cove	SAL
Sargentville	SAR
Schoodic Head	SCH
Seal Harbor	SLH
Searsport	SPT
Small Point	SMP
South Harpswell	SHA
Stinson Neck	STN
Sullivan	SUL
South West Harbor	SWH
Swans I	SWI
Tenants Harbor	TEN
Thomaston	THO
Vassalboro	VAS
Veazie	VZE
Vinalhaven	VIN
Waldoboro East	WAE
Waldoboro West	WAW
Wells	WLS

West Lubec	WLU
Westport	WPT
Whiting	WHI
Whitneyville	WVL
Winter Harbor	WHB
Wiscasset	WIS
Yarmouth	YAR
York Beach	YKB
York Harbor	YKH

TOWN NAMES	
Addison	ADD
Alna	ALN
Arrowsic	ARC
Arundel	ARU
Augusta	AUG
Bangor	BGR
Bar Harbor	BRH
Bath	BAT
Beals	BLS
Belfast	BFT
Biddeford	BID
Blue Hill	BLH
Boothbay	BBY
Boothbay Harbor	BBH
Bowdoinham	BDH
Bremen	BRN
Brewer	BRE
Bristol	BRI
Brooklin	BRO
Brooksville	BVL
Brunswick	BRK
Bucksport	BPT
Calais	CAL
Camden	CAM
Cape Elizabeth	CEL
Castine	CAS
Centerville	CEN
Chelsea	CSE
Cherryfield	CHD
Columbia Falls	CLF
Cranberry Isles	CBI
Criehaven	CRI
Cumberland	CUM
Cushing	CUS
Cutler	CUT
Damariscotta	DAM
Deer Isle	DRI
Dennysville	DEN
Dresden	DRE
East Machias	EMA
Eastport	EPT
Eddington	EDD
Edgecumb	EDG
Edmunds TWP	EDM
Eliot	ELT
Ellsworth	ELL
Falmouth	FAL
Farmingdale	FAR
Frankfort	FFT
Franklin	FKN
Freeport	FPT
Frenchboro	FRN

Friendship	FSP
Gardiner	GAR
Georgetown	GEO
Gouldsboro	GOL
Hallowell	HAL
Hampden	HAM
Hancock	HAN
Harpswell	HWL
Harrington	HAR
Isle au Haut	IAH
Islesboro	ISL
Jonesboro	JNB
Jonesport	JPT
Kennebunk	KBK
Kennebunkport	KPT
Kittery	KIT
Lamoine	LAM
Lincolnville	LIN
Long Island	LGI
Lubec	LUB
Machias	MAC
Machiasport	MPT
Marion TWP	MAR
Marshfield	MFD
Matinicus Isle PLT	MAT
Milbridge	MIL
Monhegan PLT	MON
Mount Desert	MTD
Muscle Ridge TWP	MUS
Newcastle	NCL
Nobleboro	NOB
North Haven	NHN
Northport	NPT
Ogunquit	OGU
Old Orchard Beach	OOB
Orland	ORL
Orrington	ORI
Owls Head	OHD
Pembroke	PEM
Penobscot	PEN
Perkins TWP	PRK
Perry	PER
Phippsburg	PHI
Pittston	PIT
Pleasant Pt, Sipayik	PLP
Portland	POR
Prospect	PRO
Randolph	RAN
Richmond	RCH
Robbinston	ROB
Rockland	ROC
Rockport	RPT

Roque Bluffs	ROQ
Saco	SAC
Saint George	STG
Scarborough	SCA
Searsport	SPT
Sedgewick	SED
Sorrento	SOR
South Berwick	SBK
South Bristol	SBR
Southport	SPT
South Portland	SPO
South Thomaston	STH
Southwest Harbor	SWH
Steuben	STU
Stockton Springs	STS
Stonington	STN
Sullivan	SUL
Surry	SUR
Swans I	SWI
Thomaston	THO
Topsham	TOP
Tremont	TRE
Trenton	TNT
Trescotte TWP	TRE
Veazie	VZE
Verona	VER
Vinahaven	VIN
Waldoboro	WAL
Warren	WAR
Wells	WLS
West Bath	WBA
Westport	WPT
Whiting	WHI
Whitneyville	WVL
Winter Harbor	WHB
Winterport	WPT
Wiscasset	WIS
Woolwich	WLW
Yarmouth	YAR
York	YRK
T7 SD	T7S
T8 SD	T8S
T9 SD	T9S
T10 S	T10S