chapter two

NEW ENGLAND SALT MARSHES: ECOLOGY, IMPORTANCE, AND CONSERVATION

Salt marshes are one of the most productive natural ecosystems on Earth, and support a rich **diversity** of plants and animals that are uniquely adapted to inhabit **wetlands** that constantly change with the ebb and flow of the tide. Today, salt marshes are treasured for the biodiversity they support, their contribution to marine productivity and commercial fisheries, their ability to anchor sediments and protect shorelines from erosion and flood damage, and their capacity to improve water quality.

Despite their importance, New England salt marshes have been mistreated ever since the Colonial period because they were perceived as barren, unproductive, mosquito-filled wetlands that could only be improved by filling, draining, or dredging. In the last 350 years, humans have converted countless acres of salt marshes to roads, farms, parking lots, neighborhoods, and even cities. Large areas of Boston were once productive salt marshes! Our understanding of the importance of salt marshes has increased in the last few decades, and today there are strict laws and regulations designed to protect salt marshes from destruction and pollution. Yet, coastal development continues throughout New England and natural resources face increasing pressure as communities try to find a balance between development and healthy natural ecosystems.

This chapter introduces some important concepts of salt marsh biology and ecology, including their formation and succession, characteristic plant communities, **food webs**, and importance as nursery areas and wildlife **habitat**. This chapter also covers why salt marshes are important to humans, and the many ways that humans have destroyed, degraded, and polluted these valuable ecosystems. An understanding of salt marsh biology and ecology is imperative for anyone who is conducting environmental impact studies or basic **monitoring** in these habitats. The current condition of salt marshes is the product of ever changing natural processes and **human disturbances**, and any successful monitoring program needs to be mindful of both.

"*…There are at present about 3240 acres of city real estate in an area that contains old Boston, Roxbury and Back Bay… When the Puritans arrived to settle this area, there existed only 1185 acres of dry land on which to build. Four hundred eighty-five acres of the present 3240 acres were salt marsh and 1570 acres were shallow water which was part marsh, part mud and sand flat, and part open water even at low tide. There was a gain of 2055 acres of dry land made by filling the marshes and lowlands.*"

John and Mildred Teal, 1969
From *Life and Death of the Salt Marsh*

BIOLOGY AND ECOLOGY OF NEW ENGLAND SALT MARSHES

Life in coastal wetlands is characterized by extreme fluctuations on a daily and seasonal basis. In general, New England coastal wetlands experience regular patterns of flooding and exposure with the ebb and flow of the tide. Wetlands associated with **estuaries** also contend with daily and seasonal fluctuations in salinity. In a single day, a crab in a coastal wetland might be covered with seawater, exposed to the atmosphere, and experience salinities of 10 to 35 parts per thousand (ppt)! Normal seawater has a salinity of 35 ppt. Clearly, plants and animals must be highly specialized to deal with such extremes.

Salt Marsh Development

Coastal wetlands exist in areas that are periodically flooded by tidal waters. They develop along embayments, **barrier beaches**, islands, and especially estuaries that form the link between the ocean and non-tidal freshwater habitats. While this manual focuses on salt marshes, tidal mud flats and rocky shores are examples of other coastal wetlands whose conditions are less hospitable to the establishment of plant communities.

Salt marshes develop in sheltered coastal areas where the absence of severe winds and waves allows fine sediments to settle and accumulate and for plants to eventually take root. Salt marshes form along barrier landforms and islands, coastal ponds, and tidal creeks or rivers. Salt marshes are common along the Atlantic seaboard as far north as mid-coast Maine. In Massachusetts, there are some very large salt marshes along the North Shore and throughout Cape Cod.

Two other types of marshes are influenced by tides yet support different plant communities. Brackish marshes exist further inland along estuarine systems and have salinities ranging from 0.5 to 18 ppt. Brackish marshes can support typical salt marsh plants along the seaward edge of the marsh, but also support a high diversity of freshwater and slightly salt-tolerant wetland plants. Tidal freshwater marshes occur at the inland limit of estuaries where tides continue to cause fluctuating water levels but seawater fails to penetrate. Tidal freshwater marshes support a high diversity of wetland plants that are intolerant of salinity. Being able to identify plant and animal **species** from brackish and freshwater marshes is an important component to studying salt marshes because tide restrictions frequently cut off salt marshes from their tidal influence, causing salt-**tolerant** organisms to be out-competed and replaced by brackish and freshwater organisms.

Salt Marsh Plants and Zones

Salt marshes are comprised of three distinct zones called the **low marsh**, the **high marsh**, and the **marsh border** community. Scientists use vegetation to define these zones because the composition of the plant community reflects **hydrology**, salinity, and **substrate** conditions. Salt marsh zones and dominant plant species are illustrated in Figure 1; only the most common species are mentioned here and those interested in a complete description of salt marsh plant communities should consult Tiner (1987), Mitsch and Gosselink (1993), or Bertness (1999).

Low Marsh: The low marsh is located along the seaward edge of a salt marsh. The low marsh is usually flooded at every high tide and exposed during low tide. It tends to occur as a narrow band along creeks and ditches, whereas the high marsh is much more expansive and is flooded less frequently. The predominant plant species found in the low

A salt marsh that has developed on the landward side of a barrier beach.
Photo: Paul Godfrey

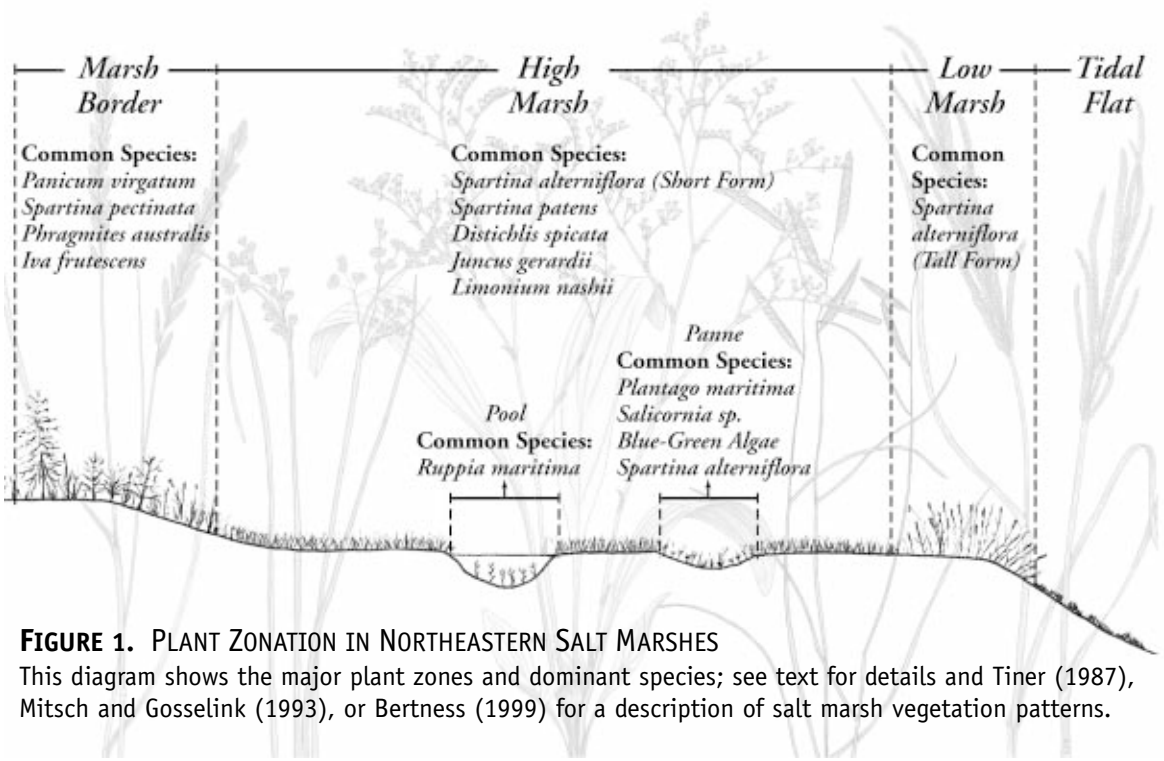

FIGURE 1. PLANT ZONATION IN NORTHEASTERN SALT MARSHES
This diagram shows the major plant zones and dominant species; see text for details and Tiner (1987), Mitsch and Gosselink (1993), or Bertness (1999) for a description of salt marsh vegetation patterns.

marsh is the tall form of *Spartina alterniflora* (smooth cordgrass). This species can reach a height of six feet and is very tolerant of daily flooding and exposure.

High Marsh: The high marsh lies between the low marsh and the marsh's upland border. The high marsh can be very expansive in some areas, sometimes extending hundreds of yards inland from the low marsh. Soils in the high marsh are mostly saturated, and the high marsh is generally flooded only during higher than average tides. Plant diversity is low (usually less than 25 species), with the dominant species being the grasses and rushes such as *Spartina patens* (salt hay grass), *Distichlis spicata* (spike grass), *Juncus gerardii* (black grass), and the short form of *Spartina alterniflora*. Other plant species commonly encountered on the high marsh are *Aster tenufolius* (perennial salt marsh aster), *Limonium nashii* (sea lavender), and *Agalinus maritima* (seaside gerardii). Within the high marsh are depressions, called **pannes**, that hold standing water and can dry out during extended dry periods. Salinity can reach extremely high concentrations in pannes and only the most salt-tolerant species can exist at panne edges including *Salicornia* sp. (glassworts), *Plantago maritima* (seaside plantain), and the short form of *Spartina alterniflora*, as well as some blue-green **algae**. There are some deeper and more permanent pools in the high marsh that can be vegetated with submerged aquatic species such as *Ruppia maritima* (widgeon grass).

Marsh Border: The marsh border is located at the salt marsh's upland edge and other isolated areas on the marsh where elevations are slightly above the high marsh. The marsh border is usually only flooded at extreme astronomical tides and under irregular conditions such as storm surges or wind-driven tidal inundations, and does not experience waterlogged conditions or severe salt stress. A high diversity of herbs, shrubs, and even trees exists in the marsh border. *Iva frutescens* (high tide bush), *Baccharis halimifolia* (sea myrtle), *Agropyren pungens* (stiff-leaved quackgrass), *Solidago sempirvirens* (seaside goldenrod), and *Panicum virgatum* (switchgrass) are just some of the many marsh border plants.

Salt Marsh Succession

Salt marshes develop in sheltered coastal areas that are protected from severe wind and wave action, where the combination of low energy and deposition of fine sediments (sand and silt) favors the establishment of plant communities. One of the first plants to take hold in these areas is *Spartina alterniflora*, whose seeds are dispersed by wind and water. *Spartina alterniflora* is a perennial plant that develops an extensive root system, called **rhizomes**, that stabilize sediments and reduce erosion. As this plant establishes itself, it forms dense stands that buffer wave energy and trap sediments, promoting further development of the infant salt marsh.

Bacteria and fungi slowly decay organic matter trapped by a growing stand of *Spartina alterniflora*. Over time, the accumulation of dead and decaying matter results in the formation of peat. Peat accumulation occurs for many years and raises the elevation of the marsh enough to reduce flooding frequency. Once this occurs high marsh plants such as *Spartina patens* and *Distichlis spicata* can become established, which in turn accelerates peat accumulation and eventually allows a greater diversity of salt marsh plants to exist there. A mature salt marsh has a well-defined low marsh and high marsh that continue to expand seaward and landward over time. The landward migration of the salt marsh occurs as the marsh keeps pace with sea level rise. As the height of the sea increases very gradually, so too does the surface of the marsh. Unfortunately, coastal development at the marsh's edge prohibits this landward migration, and over [a long] time, sea level rise and hardened shorelines may become a major cause of salt marsh loss.

The seaward edge of a salt marsh is subject to intense wind and wave energy. **Photo: Paul Godfrey**

Higher than normal tides deposit large amounts of dead plant material or other **debris** on the marsh, creating bare or open areas by shading and killing the plants below and often slightly lowering the marsh elevation underneath. These depressions may become pannes or pools. **Opportunistic** plants like *Salicornia* sp. and *Distichlis spicata* quickly colonize these open areas. Over time, typical high marsh plants may outcompete and replace opportunistic species.

The important thing to remember about salt marsh succession is that the appearance, productivity, and biological diversity of a salt marsh constantly change due to natural processes. Human disturbance and pollution certainly affect salt marshes, but the distinction between natural processes and human impacts is sometimes fuzzy, and can lead to uncertainty in environmental impact studies.

A pool located in the high marsh zone. **Photo: Ethan Nedeau**

Salt Marsh Food Web

Salt marshes support one of the most productive natural plant communities on Earth, rivaling productivity of some of the most fertile farmland in North America. With that much plant production, you might think that **herbivores** would be the most important consumers in salt marshes…not true! Salt marsh plants are too tough, salty, and nutrient-poor to support most herbivores. Flowers and seeds are more palatable, but regardless scientists estimate that only 10% of the plant productivity in salt marshes is consumed as living material. Insects, snails, crabs, and some vertebrates are common salt marsh herbivores. Some food web interactions in a typical salt marsh in northeastern North America are illustrated in Figure 2.

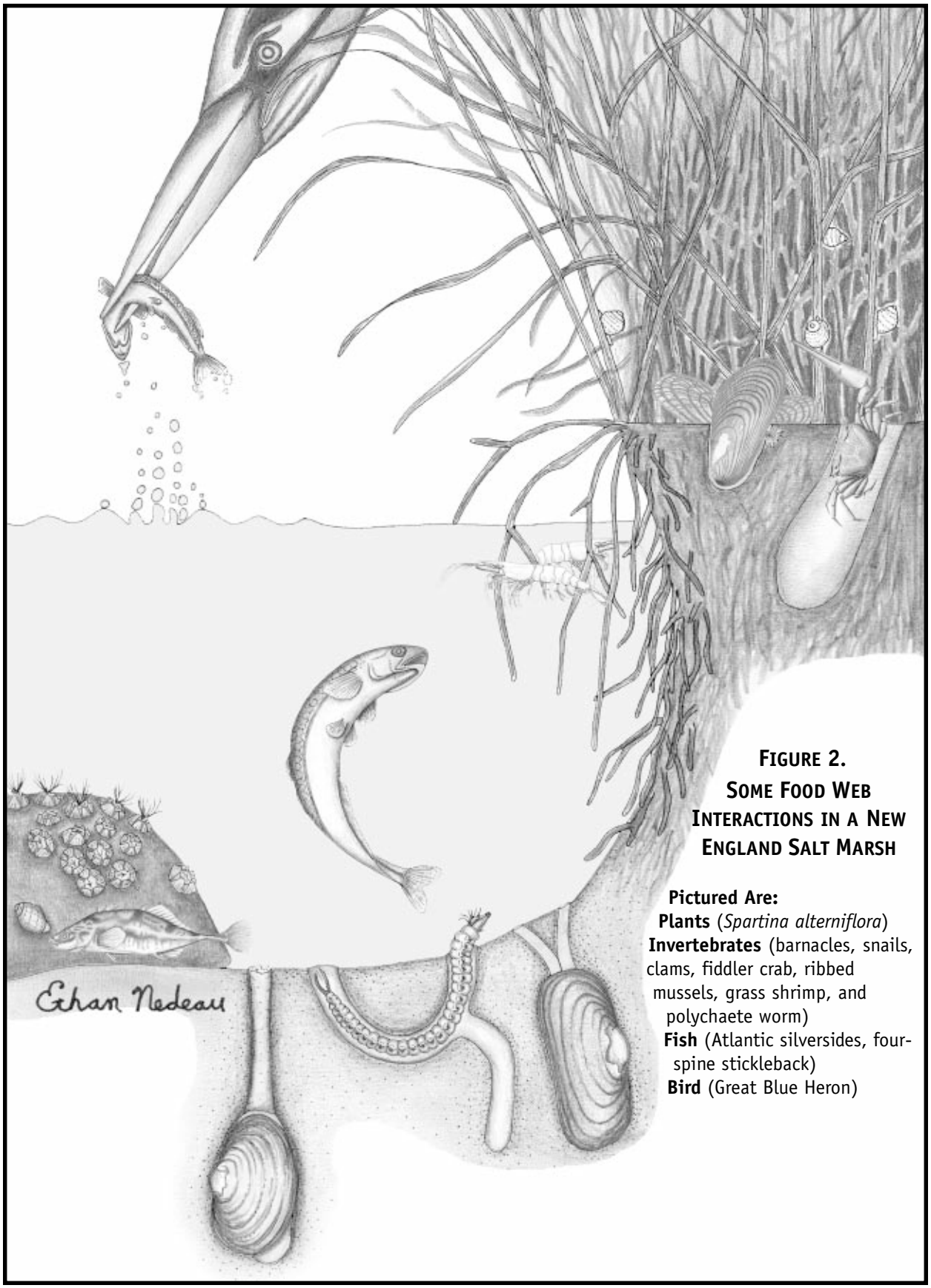

FIGURE 2.
SOME FOOD WEB INTERACTIONS IN A NEW ENGLAND SALT MARSH

Pictured Are:
Plants (*Spartina alterniflora*)
Invertebrates (barnacles, snails, clams, fiddler crab, ribbed mussels, grass shrimp, and polychaete worm)
Fish (Atlantic silversides, four-spine stickleback)
Bird (Great Blue Heron)

Salt marshes are **detritus**-based ecosystems. Scientists define detritus as decomposing plant and animal material. Bacteria, fungi, microscopic plants and animals, and some larger animals all contribute to the decomposition of dead plants, resulting in detritus. Many **invertebrates** eat detritus and associated decomposers (think of detritus as a cracker and decomposers as peanut butter — its hard to eat one without the other); these invertebrates are called **detritivores**. Some detritivores eat detritus directly (some snails, crabs, and amphipods) whereas others eat sediment that contains detritus (fiddler crabs, snails, shrimp, and worms).

A nesting tern. **Photo: CZM Staff Photo**

A third group of consumers are **filter feeders**, which include clams, mussels, and some worms. Filter feeders actively filter food (**phytoplankton**, zooplankton, detritus) from the water column. A fourth group of consumers are **predators**, which includes a wide variety of invertebrate and vertebrate animals. Terrestrial insects and spiders are important predators in the high marsh vegetation. Killifish, grass shrimp, and blue crabs are three common predators in the low marsh. There are also many birds that prey upon salt marsh animals, such as terns, plovers, egrets, and herons.

IMPORTANCE OF NEW ENGLAND SALT MARSHES

Salt marshes are dynamic and productive ecosystems that provide important benefits to humans and wildlife alike. Most notably, salt marshes are important nursery grounds and wildlife habitat, provide flood and erosion control, improve water quality, and offer recreational retreats.

Nursery Grounds and Wildlife Habitat

A rich diversity of invertebrate and vertebrate animals depends on salt marshes to one degree or another. Many invertebrates are well adapted to daily cycles of exposure and flooding, and the benefit of this adaptation is that they can spend their entire lives in a very productive ecosystem.

Many animals are not adapted to live in salt marshes all the time, yet have found ways to capitalize on the food and safety that salt marshes provide during essential times of their life cycle. Many marine fish use salt marshes as breeding grounds or nursery habitats for juveniles, where they find an abundant supply of prey (such as worms, molluscs, and crustaceans) and few predators. Menhaden, flounder, sea trout, spot, and striped bass are just a few examples of game fish that use salt marshes at some point in their lives. Non-game fish such as killifish and mummichogs also rely on salt marshes and are key forage species for game fish such as striped bass and bluefish. Blue crabs forage for prey in the low marsh during high tide but move offshore during low tide; unlike green crabs and fiddler crabs, blue crabs cannot tolerate long periods of exposure.

Animals do not need to enter salt marshes to benefit from their productivity. Every ebb tide carries a flush of nutrients and detritus into offshore areas, where it is eaten by a variety of consumers and helps fuel marine food webs. In addition, fish and crustaceans that feed in salt marshes and then move into offshore areas are essentially transferring salt marsh-derived nutrients into marine food webs.

Many birds use salt marshes to nest, breed, feed, or rest during migration. Some of these birds are rare and protected, such as the Northern Harrier, Least Tern, King Rail, and American Bittern. Salt marshes are also critical habitat for the Massachusetts-listed Diamond-backed Terrapin and Eastern Box Turtle. Deer, muskrats, otters, foxes, and coyotes may also forage in or near salt marshes.

Erosion Control and Flood Protection

Salt marshes are very effective at reducing shoreline erosion. The roots and stems of salt marsh vegetation hold sediment — without vegetation, sediment could easily be transported away by wind and waves, and storms would cause severe erosion. Vegetation also absorbs waves and storm surges, temporarily stores floodwaters, and slows river currents. Waterfront homeowners and business owners that have marshes between their property and the ocean should feel fortunate because marshes provide a great line of defense against storm damage. Some states are even sponsoring costly salt marsh restoration projects because it is a cost-effective way of protecting coastal communities from storm surges, tropical storms, and Nor'easters.

Water Quality

Streams, rivers, surface runoff, and subsurface flow all transport pollutants from uplands to marine environments. Salt marshes perform a natural filtration process that can help purify water that passes through before reaching the ocean. Salt marshes trap sediments, take up nutrients such as nitrogen and phosphorus, and break down or bind a variety of organic and inorganic pollutants. Although salt marshes are capable of coping with small amounts of pollution, excess amounts of certain pollutants such as nitrogen may have adverse effects on marsh productivity and food chains. Humans should not take the purification value of salt marshes for granted, and should try to minimize inputs of pollutants to maintain healthy marshes.

Recreation and Education

Salt marshes offer a wide variety of educational and recreational opportunities. They are unique "outdoor classrooms" well suited for coastal ecology lessons, and allow easy access to a rich diversity of plants and animals for natural history and marine biology study. They are perfect areas for wildlife viewing, and photographers and artists have long sought solace in their natural beauty. Salt marshes also provide opportunities for subsistence and recreational hunting and fishing, whether it is shellfish, fish, or waterfowl. Many kayakers and canoeists enjoy exploring bays, rivers, and creeks during high tide.

THREATS TO NEW ENGLAND SALT MARSHES

The outright destruction of salt marshes has been virtually halted in Massachusetts since 1963 when Massachusetts adopted the state's Wetlands Protection Act to protect inland wetlands and coastal salt marshes. Since then there has been other important state and federal legislation aimed at protecting salt marshes and other wetlands. However, 350 years of wetland destruction and pollution have left a lasting legacy on New England salt marshes. Today, some of the challenges facing wetland managers and scientists include the identification of imperiled salt marshes, the prioritization of sites for restoration, and the development of ways to measure the effectiveness of restoration efforts. Three current threats to salt marshes are changes to natural hydrology, pollution, and coastal development.

Coastal wetlands provide great opportunities for environmental education!
Photo: Paul Godfrey

Road crossings and ditching have had a dramatic effect on the hydrology of salt marshes along the Atlantic seaboard. **Photo: Ethan Nedeau**

Changes to Natural Hydrology

Throughout coastal New England, there are vast areas of wetlands that were productive salt marshes until roads or railroads severed their connection to the sea. Humans built transportation routes on salt marshes because they were open and flat. Horses and carts were the first to use these routes, followed by steam locomotives in the latter half of the 19th century. In the 20th century, humans continued to create and pave roadways on some of our most valuable wetlands to accommodate automobiles. These roadbeds divided salt marshes into two sections — one with direct unlimited tidal connection to the ocean, and one with restricted or in some cases no access to the ocean. Called tidal restrictions, these road and railroad crossings have had enormous impacts on landward salt marshes by reducing or eliminating tidal flooding — the force that drives salt marsh ecosystems. Tidal restrictions led to the disruption of natural flooding regimes, alterations to soil and water chemistry, and changes to natural plant and animal communities. These changes led to the establishment and proliferation of **invasive species** such as *Phragmites australis* (common reed) or *Lythrum salicaria* (purple loosestrife).

Many local, state, and federal groups are working to address tidal restrictions and reclaim former salt marshes. The most common solution is to install larger culverts under roads and railways to restore tidal exchange. Mosquito control ditches also changed natural hydrology of salt marshes and efforts are underway to reverse these effects.

Increased surface runoff is another way that humans continue to alter the natural hydrology of salt marshes. In undisturbed coastal landscapes, rainfall and snowmelt are temporarily stored in wetlands and forests, or taken up by plants. In urban communities, much of the landscape has become rooftops and pavement, and rainfall and snowmelt flow rapidly over these surfaces into nearby streams and wetlands. Salt marshes in urban watersheds may receive enormous volumes of stormwater runoff, which can lead to increased erosion, sedimentation, altered salinity levels, and changes in soil saturation levels.

Environmental Pollution

Humans, their machines, and their animals release enormous amounts of pollution to the air, water, and soil. The list of pollutants is virtually endless, and their effect on

natural ecosystems is not well understood. Nutrients (such as nitrogen and phosphorus) from fertilizers, septic systems, and farm waste are common pollutants that in high enough concentrations can change the structure and function of natural ecosystems. Excess nutrients are a particular problem in salt marshes because they lead to **eutrophication** (see textbox on this page). Industries and combustible engines release a variety of heavy metals (such as mercury, lead, and aluminum) that pose lethal and chronic health risks to wildlife and humans. Herbicides and pesticides are applied to lawns, gardens, forests, and ponds to kill "nuisance" species, but often affect non-target species.

It is beyond the scope of this publication to detail all the types of pollutants and their effect on the environment, but consider this fact: every time it rains, stormwater picks up sediments, nutrients, chemicals, and heavy metals from the landscape and carries these pollutants into storm drains that may lead to streams, rivers, and salt marshes. Salt marshes are depositional areas and therefore are likely to store these pollutants for long periods.

Coastal Development

Coastal New England has witnessed unprecedented population growth and urban development over the past three decades. Real estate value has skyrocketed, increasing the pressure on landowners to sell or develop their land. Waterfront property is particularly valuable because of the great views, serenity, and access to the ocean that it can provide. The net effect of coastal development and land use change on salt marshes is the loss of upland buffers and new exposure to a wide variety of anthropogenic pollutants and disturbances.

The upland buffer and marsh border are important nesting, breeding, perching, or feeding areas for a variety of wildlife that also utilize the adjacent salt marsh, such as many species of songbirds and mammals. Elimination or alteration of upland buffers will indirectly alter wildlife use of the salt marsh. Noise pollution (from cars, airplanes, lawn mowers, etc.) and light pollution (from street lights, vehicle lights, etc.) can affect wildlife behavior. As covered above, the introduction of pollutants through stormwater runoff, leaky septic systems, lawn chemicals, and other human activities can affect wetland organisms. Human disturbance of the landscape may encourage potentially damaging native, **introduced**, or opportunistic species such as *Phragmites australis*, *Lythrum salicaria*, starlings, house sparrows, raccoons, and opossums. Domestic cats are often a problem for birds in marshes near residential areas.

Clearly, by virtue of their ecological importance as well as the widespread threats they face, salt marshes are worthy of continued monitoring and research to assess their ecological health, along with steps to improve or maintain their condition.

EUTROPHICATION

Eutrophication is the process of nutrient enrichment, typically by nitrogen and phosphorus. While some nutrients are essential to healthy ecosystems, excess nutrients that exceed the normal range for an ecosystem may have severe negative consequences. Among the adverse effects of eutrophication include an increased biomass of plants, proliferation of invasive species, loss of sensitive species, loss of biological diversity, and a reduction in the aesthetic and commercial value of a water body (Carpenter et al. 1998).

Garbage and bank erosion are two signs of a degraded marsh. **Photo: CZM Staff**

A barrier beach and its companion salt marsh converted to an urban landscape. **Photo: Paul Godfrey**

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