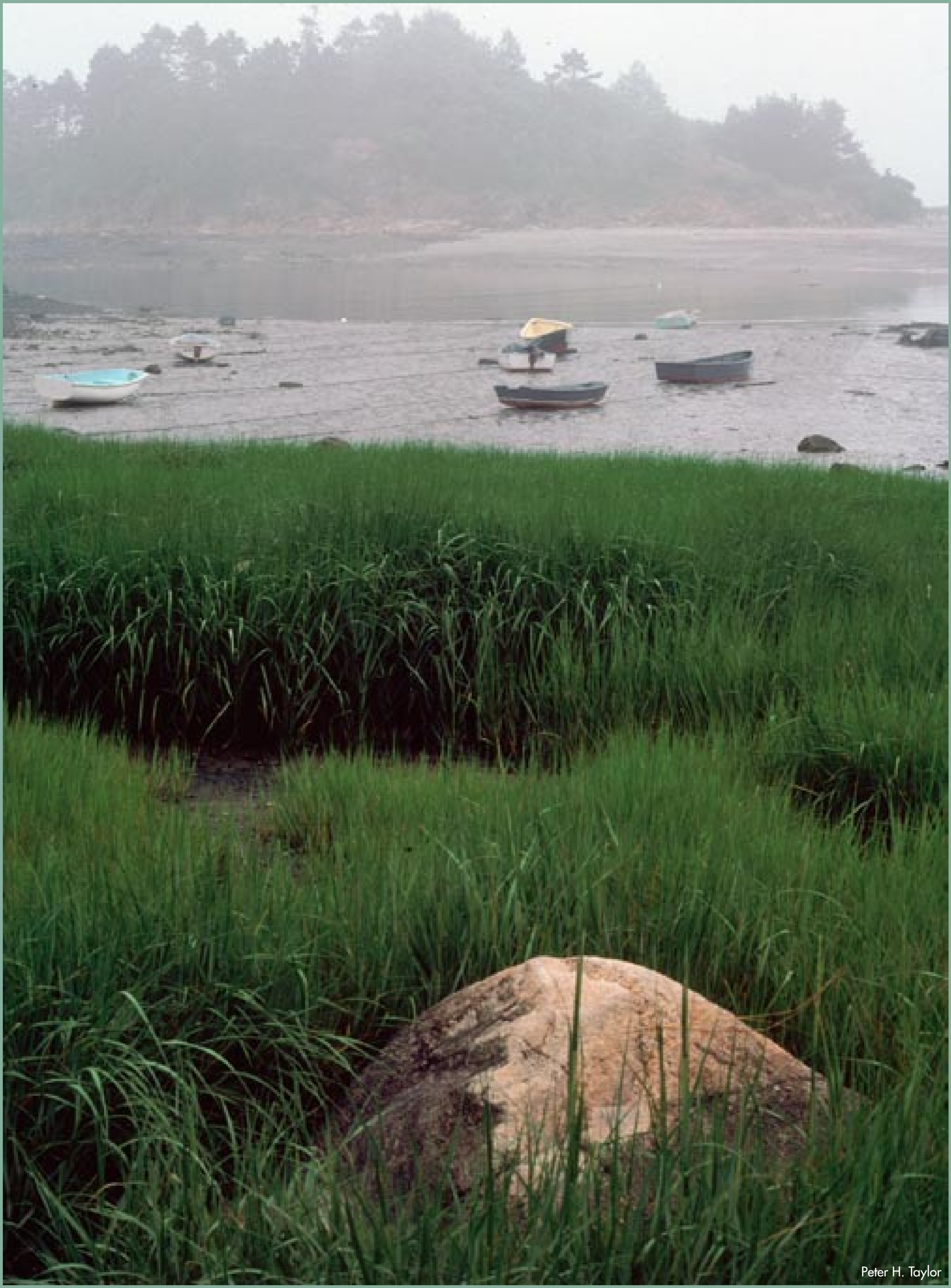

Peter H. Taylor

Biogenic Habitats

Certain plants and animals grow in such a manner that they provide a unique environment and physical structure for other organisms. Habitats created by plants or animals are called biogenic. Biogenic habitats may offer space for attachment, hiding places from predators, and shelter from harsh environmental conditions. Examples of biogenic habitats in the Gulf of Maine include salt marshes, seagrass beds, kelp beds, shellfish beds, and cold-water corals. Each type can occur in a range of physical substrates and environmental conditions. For example, salt marshes develop primarily in muddy intertidal areas, but they also exist in some rocky and sandy intertidal areas. The biogenic character of a habitat depends on how dense the species are. Usually a sufficient density must be reached before an area is considered a true biogenic habitat. For example, a dense oyster bed is a biogenic habitat, but sparse oysters do not provide the same function and are not considered biogenic habitat.

Salt Marshes

Seagrass Beds

Kelp Beds

Shellfish Beds

Cold-water Corals

CHAPTER SIX

Salt Marshes

Peter H. Taylor

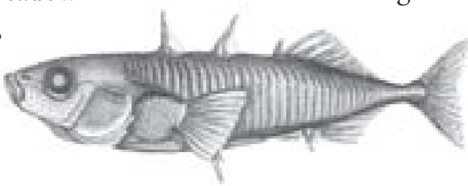
General Description

Salt marshes are grass-dominated habitats that extend from the low intertidal zone to the upper limits of the highest high tides. Salt marshes have gradients in elevation and soil salinity, with areas near inputs of surface water or groundwater being less saline. Salt marshes may grade into brackish and fresh tidal marshes along their upland and upriver edges.

Salt marshes generally have three distinct zones: low marsh, high marsh, and marsh fringe or border. Tall forms of salt marsh cordgrass (*Spartina alterniflora*) dominate the low marsh, which includes areas typically flooded by tides twice in a 24-hour period. The high marsh is flooded less often by tides, and dominant plants are saltmeadow hay (*Spartina patens*), black grass or rush, spike grass, and the short form of salt marsh cordgrass (Tiner 1987). The transition between salt marsh cordgrass and saltmeadow hay generally corresponds to the mean elevation of high tide. At the salt marsh upland border, plant diversity increases, and common species include marsh elder, seaside goldenrod, and switch grass. A non-native form of the common reed (*Phragmites australis*) is invading salt marshes throughout the northeastern United States, and drastically alters the habitat. Chapter eleven of this primer discusses *Phragmites* marshes as a distinct biogenic habitat.

Animals living in salt marshes of the Gulf of Maine include fish (mummichog, stickleback, Atlantic silverside, sheepshead minnow), ribbed mussels, snails, and fiddler crabs.

The two basic types of salt marsh in the Gulf of Maine region differ in their relative abundance of low- and high-marsh grasses. Fringing marshes form narrow bands along shorelines where protection from waves and winds is adequate but steep slopes and coarse sediments constrain the development of marsh peat and



Three-spine stickleback
Ethan Nedeau

sediment accretion. These narrow marshes can grow in areas of muddy, sandy, or rocky substrates and are dominated by the tall form of salt marsh cordgrass. They are more susceptible to erosion from waves and ice, and therefore the narrow bands of fringing marsh are more ephemeral than extensive marsh meadows.

As their name implies, salt marsh meadows are broad expanses of vegetation that form in calm areas along the coastline, such as behind barrier beaches, where they are protected from waves and strong winds. Inhabited mostly by high-marsh plants, meadow marshes typically have a greater variety of topography and ecological communities than fringing marshes. They have areas of high-marsh plants; border plants; marsh pannes and pools; low-marsh plants; and intertidal and subtidal creeks with muddy bottoms. Meadow marshes usually have a deep base of organic peat.

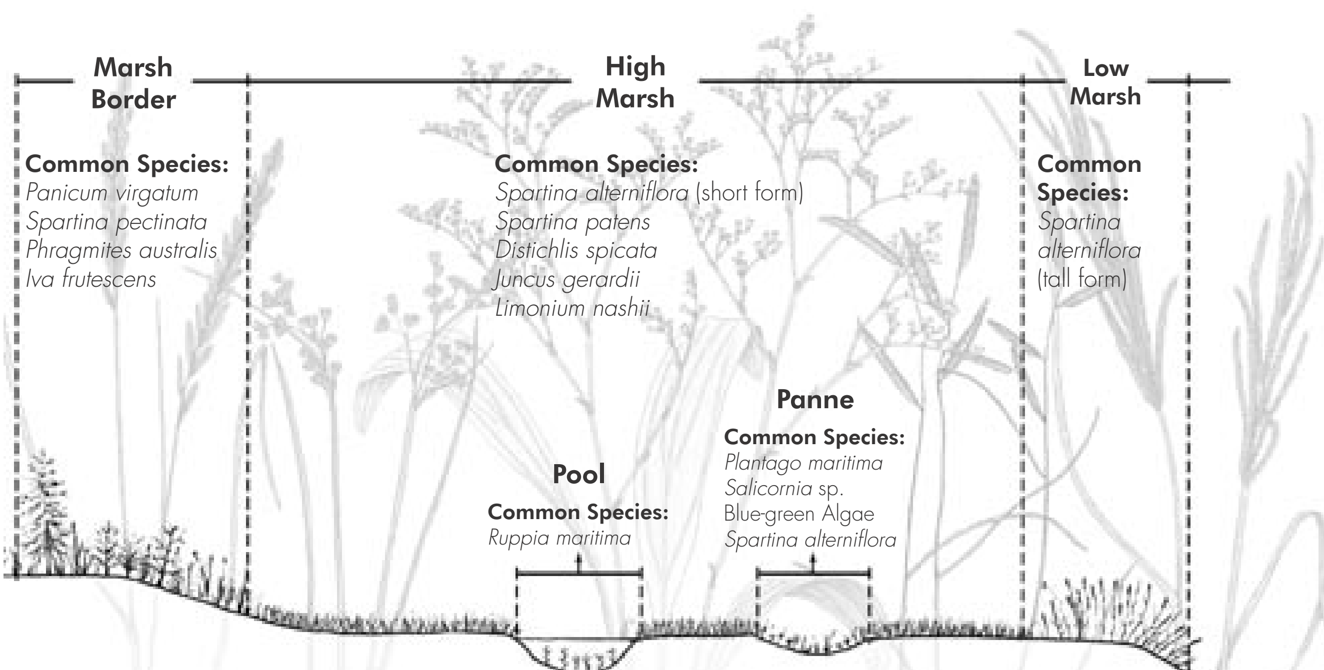
Distribution

Meadow and fringing salt marshes are found in bays and tidal rivers along the Gulf of Maine coastline. Some examples of expansive salt marshes are at the head of the Bay of Fundy; at the mouths of the Penobscot and Kennebec rivers and in Scarborough, Wells, and Ogunquit, Maine; in New Hampshire's Piscataqua River; on the north shore of Massachusetts and on the perimeter of Cape Cod.

Ecological Functions

Salt marshes are among the most biologically productive ecosystems in the world. In the Gulf of Maine, they help support rich coastal and estuarine food webs. Canada geese, deer, snow geese, voles, insects, snails, and crustaceans directly consume vegetation in the marsh, and farmers historically grazed their livestock on salt marsh grasses. However, most of the plant matter that grows in salt marshes enters the food web after it dies, rather than being eaten while alive. Microbes and worms break down the decaying plant material, or detritus, producing food particles that are swept away by the tides, transporting nutrients to other habitats. The detritus is eaten by crabs and shellfish and several species of fish that feed, breed, and find refuge in tidal channels or on the flooded marsh surface.

Salt marshes provide critical resting and feeding grounds for migratory birds and serve as nurseries for some young fish, shellfish, crabs, and shrimp because the physical structure of the grasses offers hiding places from predators. Some juvenile fish that live in salt marshes include menhaden, tomcod, and tautog. By laying eggs in the marsh before larvae enter



Salt marshes around the Gulf of Maine host distinct communities of plants. Species inhabit different areas of the marsh according to elevation, salinity, and other factors. Figure by Ethan Nedeau

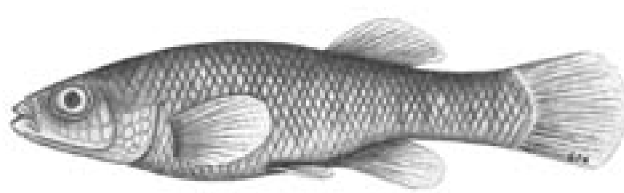
A clapper rail looks for food in a salt marsh.
Derek and Frances Richardson

Salt marshes serve as natural classrooms for students.
Peter H. Taylor

the water column, mummichogs and Atlantic silversides rely on salt marsh habitats for important parts of their life cycles. Many large predators rely on the small fish that are produced in salt marshes. Birds such as the clapper rail and salt marsh sparrow nest in salt marshes. Raptors hunt for small mammals among the grasses, while the American black duck and other waterfowl feed on invertebrates.

As they grow, salt marsh plants absorb atmospheric carbon dioxide, which is a major greenhouse gas. The carbon can be stored in the soil for thousands of years as the vegetation dies and is transformed into peat. The roots and stems of marsh plants improve water clarity by slowing water flow and trapping waterborne sediments, which block sunlight penetration, clog filter-feeding animals and fish gills, and may contain toxins or heavy metals. In addition, the grasses absorb excess nutrients that enter groundwater and surface water from fertilizers and sewage discharge. This reduces the risk of eutrophication in estuaries and nearby coastal waters.

Salt marshes protect uplands and prevent property damage by absorbing storm surge. Historically, marshes typically were able to accrete sediment fast enough to keep pace with rising sea levels. Old, buried tree stumps that are occasionally unearthed in salt marshes provide evidence of this accretion. However, increases in sea level could drown some marshes, causing the loss of productive habitat and protection of the uplands from storm surge.



Mummichog. Ethan Nedeau

Economic and Recreational Value

From an economic perspective, salt marsh habitats have enormous indirect value because commercial species depend on them during parts of their lives. These species find refuge in marshes as young, they feed in marshes as adults, and they depend on coastal food webs that are fueled by salt marsh detritus.

Salt marsh hay historically was used as livestock feed and for insulation, and today it is more commonly sold as high-grade mulch. A salt-marsh view can raise the value of residential or commercial real estate. Bird watching is a popular recreational activity in salt marshes, while kayakers and canoeists paddle the tidal channels, and recreational anglers catch fish that rely on salt marsh habitats. Educational programs for children and adults often visit salt marshes, which are convenient, accessible, and attention-grabbing natural classrooms for lessons in estuarine and coastal ecology.

Management Considerations

For centuries, salt marshes around the Gulf of Maine were filled, dredged, and drained for agriculture, urban and port development, and mosquito control. In Boston, for example, nearly four thousand acres of salt marsh were filled between 1643 and 1988 (Dalia 1998). Historically, materials from harbor dredging were disposed directly on the marsh surface, burying the vegetation and eventually transforming the marsh to upland. In practical terms, filled marshes are lost forever. However, the effects of some other human impacts, such as drainage ditches, can be countered through habitat restoration. In the 1600s, farmers dug ditches in

Road crossings and human-made ditches (visible as straight lines) intended for mosquito control and draining harm the health of many salt marshes around the Gulf of Maine. Massachusetts ACEC Program

salt marshes to increase drainage, promoting the growth of salt marsh hay that fed herds of livestock. This practice is no longer common, partly because people recognize the value of natural marsh habitats. People also dug ditches to drain the upper portions of the salt marsh—believed to be mosquito nurseries—in an attempt to reduce mosquito populations. This practice climaxed in the 1930s. Yet these "mosquito-control" ditches usually led to increased mosquito populations because draining the marsh forced minnows, which normally ate larval and adult mosquitoes, to leave. Ditches also lowered the water table and altered soil salinity, which shifted vegetation patterns and ultimately altered the quality of salt marsh habitat for birds, wildlife, and invertebrates (Roman *et al*. 2000).

Highways, roads, and railroads currently divide many salt marshes. These barriers fragment the habitat and reduce the natural tidal flushing of the marsh. Culverts allow for some flooding and draining, but many culverts are undersized, creating tidal restrictions and facilitating invasion by less salt-tolerant plants such as the common reed *Phragmites* (see Chapter 11). This hardy plant spreads rapidly when salinity is reduced, and it can out-compete other plants such as salt marsh hay. Stands of *Phragmites* lower biodiversity and degrade habitat quality for many species.

Salt marshes incur indirect and cumulative effects of human activities, such as non-point source pollution from upland development and sea-level rise due to climate change. Constructing roads, seawalls, and buildings along the upland border of salt marshes prevents the natural landward migration of the marsh and reduces the species diversity of upland plant communities (Bozek and Burdick 2003). Construction of seawalls or groins has led to erosion of salt marshes because the structures interrupt the natural sediment-transport processes that had supplied sediments to marshes. Dock and pier construction can shade and kill salt marsh plants if the structures do not allow enough light to reach the marsh surface. If erosion-prevention measures are not properly implemented in upland construction projects, excessive sedimentation can smother marsh flora and fauna and provide favorable conditions for invasion by *Phragmites*.

Tidal creek straightened to drain marsh and control mosquitoes. Ethan Nedeau

CHAPTER SEVEN

Seagrass Beds

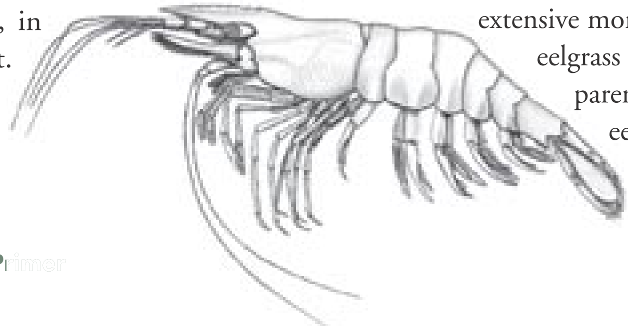
Seagrass beds grow in shallow, clear waters because they need plenty of sunlight. Seth Barker

General Description

Seagrass is a general term for flowering plants that live in low intertidal and subtidal marine environments. Roots anchor seagrass to the sediment, but unlike terrestrial plants, seagrass also absorbs nutrients from the water along the entire length of its blades, which can reach ten feet. Similar to horizontal stems, rhizomes connect the upright shoots.

Two species of seagrass live along the Gulf of Maine coast. Eelgrass (*Zostera marina*) is the dominant seagrass throughout the region, while widgeon grass (*Ruppia maritima)* is limited to low-salinity waters. Eelgrass tolerates a wide range of temperature (0–30°C) and salinity regimes (10–30 parts per thousand) and takes root on substrates from coarse sand to mud (Thayer *et al*. 1984). It even thrives among cobbles and boulders, in small patches of soft sediment. Eelgrass can live everywhere from tide pools along the shoreline to subtidal areas of several meters depth, as long as the water is relatively clear and allows sufficient light for growth. The most important factor in eelgrass survival and growth is light limitation.

Eelgrass beds are a critical habitat in the Gulf of Maine. Their connection to fisheries is especially valuable. Eelgrass also provides vital services to improve water quality by filtering suspended sediment and excess nutrients. The ecological importance of eelgrass beds along the Atlantic coast became clear after an outbreak of wasting disease in the 1930s. Caused by a slime mold that infects the leaves, the disease killed an estimated 90 percent of eelgrass in the region (Burdick *et al*. 1993). The die-off led to massive erosion and dramatic changes in water quality (Thayer *et al*. 1984). Scallops, American brant, and other animals that relied on eelgrass beds for food and shelter suffered extensive mortality (Thayer *et al*. 1984). The eelgrass limpet (*Lottia alveus*) even apparently went extinct due to the eelgrass die-off, which is the only documented extinction



Grass shrimp. Ethan Nedeau

Seagrass beds slow the movement of water. They provide shelter and hiding places for many species, such as scallops (lower left) and needlefish (far right). Top left: Fred Short, University of New Hampshire. All others: U.S. Geological Survey

of a marine invertebrate in North America (Carlton *et al.* 1991). Some commercially valuable species, such as scallops, also reportedly declined as eelgrass disappeared.

Distribution

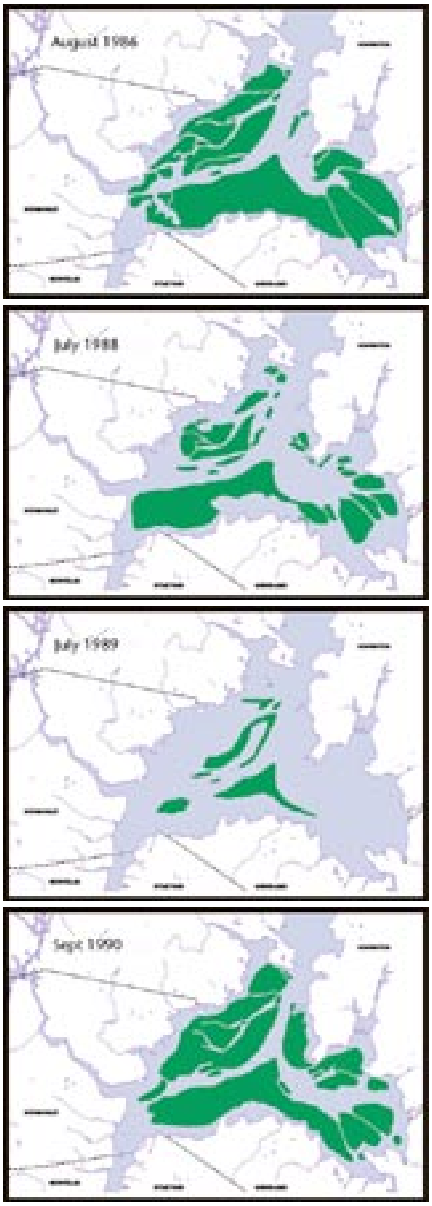
Seagrass usually lives in shallow (to a depth of 35 feet), clear waters where it receives ample sunlight. The beds often lie next to salt marshes or in harbors and inlets where they are protected from storms. Declining water clarity has caused eelgrass to disappear from many urban harbors. For example, eelgrass has been lost from Boston Harbor, Massachusetts; Portland Harbor, Maine; and Little Bay and much of the Piscataqua River in New Hampshire. In Maine, fishing practices impact eelgrass in many bays. These are losses of great ecological magnitude. Widgeon grass lives in salt marsh pools and shallow areas of brackish coves. Massachusetts, New Hampshire, and Maine conduct mapping programs to assess changes in the distribution of seagrass beds.

Ecological Functions

Seagrass beds are highly productive with photosynthetic rates approaching that of intensively farmed agricultural fields (Thayer *et al.* 1984). However, most of the productivity enters the food web as detritus, not as living plant tissue. Some suspension-feeding animals grow faster in seagrass beds compared to unvegetated habitats because of the greater availability of food particles (Lenihan and Micheli 2001). Seagrass blades make it difficult for predators to find and track their prey, so the beds act as refuges for small animals. The blades also slow the water, providing inhabitants a respite from currents and promoting sediment deposition. Seagrass produces oxygen through photosynthesis, which benefits the animals that inhabit the beds.

While the persistence of seagrass beds depends on clear water to ensure light penetration, the beds also help improve water quality by trapping suspended sediments and absorbing nutrients. In addition, seagrass beds stabilize sediments, which reduces erosion and maintains deeper channels. Like cobble beds and other structurally complex habitats, eelgrass beds support a greater diversity of bottom-dwelling animals than flat, open habitats (Deegan and Buchsbaum 1997). Seagrass beds are especially notable for their role as nurseries. Commercially valuable species such as bay scallop, cod, blue mussel, and winter flounder use seagrass habitats as juveniles, though not exclusively. Many algal and invertebrate species attach themselves to seagrass blades, including encrusting and upright bryozoans, tunicates, hydroids, and red and green epiphytic algae. Atlantic silversides and other species spawn in eelgrass beds. Other species that occur commonly

American brant feed in seagrass beds. U.S. Fish and Wildlife Service



Mapping of seagrass beds (green area) in Great Bay, New Hampshire, revealed contraction caused by an outbreak of the eelgrass wasting disease. Source: Fred Short, University of New Hampshire; http://ciceet.unh.edu/GBdata/

in seagrass beds are lobster, pipefish, tomcod, American brant, and European green crab.

Economic and Recreational Value

Seagrass beds can reduce property damage from coastal storms by absorbing waves and preventing erosion. These habitats are nurseries for commercially valuable species such as bay scallop, cod, and winter flounder, providing economic benefits for humans. Seagrass beds also provide recreational value for hunters and bird watchers by attracting waterfowl.

Management Considerations

Impaired water clarity due to turbidity, algal blooms, and improper disposal of dredged material present some of the biggest threats to seagrass beds. Water quality can degrade due to particulate matter in the runoff from areas of coastal deforestation or industrial development (Roman *et al.* 2000). Other factors that diminish water clarity include pollution from land use, dredging, boating, and turbid runoff from streets and exposed soil. Seagrass generally needs more light than phytoplankton, but water quality standards often are set at levels more amenable for phytoplankton.

Excessive nutrients and disease present two more threats to seagrass. Elevated nitrogen levels stemming from increased commercial and residential development leads to a decline in the relative abundance of seagrass compared to phytoplankton and macroalgae, including epiphytes (Roman *et al.* 2000). Phytoplankton blooms can shade seagrass beds, while growth of algae on the seagrass blades can render the plants more vulnerable to wave damage. High nutrient levels also make eelgrass more susceptible to disease. An especially severe outbreak of the naturally occurring slime mold wasting disease in the 1930s led to the decline of 90 percent of eelgrass along the Atlantic coast (Roman *et al.* 2000).

Fishing, boating, and dredging harms seagrass blades and roots. For example, turbid water from a propeller or dredging equipment can block transmission of sunlight (Deegan and Buchsbaum 1997). Docks, piers, and other structures shade seagrass and can fragment the beds (Burdick and Short 1999). Mussel dredging, trawling, and mooring chains scrape gaps in seagrass beds that heal slowly because of physical damage to the roots. Bare patches created by boat groundings and propeller scars recover slowly because of the sediment displaced by propeller wash. Dredging in harbors and navigation channels can bury or remove seagrass beds.

Several non-native species threaten seagrass beds. For example, the lacy crust bryozoan (*Membranipora membranacea*) and the orange colonial tunicate *Botrylloides violaceus* both attach to seagrass blades, while the green alga *Codium fragile* ssp. *tomentosoides* attaches to eelgrass blades and may compete for nutrients. The overgrowth by these and other attached organisms blocks light transmission and increases drag on the blade, potentially increasing its susceptibility to wave damage (Lambert *et al.* 1992).

CHAPTER EIGHT

Kelp Beds

Kelp beds provide habitat for many fish, invertebrates, and algae. Ian Skipworth

Kelp blade. Ethan Nedeau

General Description

Kelp beds form a distinct type of underwater habitat. While many different seaweeds live on rocky substrates in the Gulf of Maine, kelps are noteworthy because they are large and create underwater forests with physical structure and layering similar to that of a terrestrial forest.

Kelps in the Gulf of Maine tend to be much smaller than kelps found on the Pacific coast of North America, but they nonetheless form a very important habitat type. Kelps are brown algae that use root-like holdfasts to attach to hard substrates. Although their general morphology resembles terrestrial plants, kelps are quite different. For example, nutrient absorption occurs throughout the whole organism, not just through the holdfast. Kelp beds resemble forests on land in that the kelp blades form a canopy layer, fleshy algae such as Irish moss form an understory layer, and the crustose red algae that live on rocks are comparable to a forest's herb layer. This complex structure creates homes for many different species. Different species of kelp generally dominate at different water depths and wave-exposure conditions. For example, the strap-shaped blades of oarweed (*Laminaria digitata*) help to dissipate wave energy, while species with wide blades are common in wave-sheltered conditions.

Distribution

The most common species in this region are sugar kelp (*Laminaria saccharina*), oarweed, edible kelp (*Alaria esculenta*), and shotgun kelp (*Agarum clathratum*). The precise distribution and abundance of kelp beds in the Gulf of Maine are poorly known. In general, kelps require clear, cold water and a firm substrate for attachment. As a result, they are more common north of Cape Cod than to the south, where the water is warmer and soft sediment more widespread. Kelps can be found attached to rocks from the lower intertidal zone to about 40 meters depth if the water is very clear. Kelps also attach to human-made structures such as docks and piers.

Large kelp found washed ashore in Maine. Peter H. Taylor

Kelp holdfast attached to mussel. Ethan Nedeau

Ecological Functions

Kelp beds support higher species diversity than adjacent unvegetated habitats because of the structure provided by these large algae. Invertebrates and fish, especially juvenile fish such as cunner, find protection from predators and harsh environmental conditions, including ultraviolet radiation and strong currents, by inhabiting kelp beds. The holdfasts provide microhabitats for small invertebrates such as brittle stars, polychaete worms, snails, and juvenile mussels. Lobsters hide in kelp beds while molting (Harvey *et al*. 1995). Some invertebrates such as sea slugs, snails, bryozoans, and hydroids, as well as other algae, live attached to kelp blades and stipes.

Both living and dead kelp are important foods for echinoderms, mollusks, and crustaceans. When storms rip kelp from the rocks, the decaying algae may be deposited on nearby beaches, providing food and shelter for crustaceans and insects. In turn, shorebirds feed on these organisms. Kelp is also significant because its rate of primary productivity is among the highest in the world. It contributes to nutrient cycling by absorbing inorganic nutrients and then entering the food web as dead tissue, or detritus.

Economic and Recreational Value

Kelp beds provide habitat for many commercially valuable fish and invertebrates, as well as their prey. Kelp is the preferred food of green sea urchins, which began supporting an important commercial fishery in the late 1980s and 1990s. Extensive kelp beds reduce current speeds and buffer upland areas from erosion or storm damage.

Management Considerations

Herbivory can have a major effect on kelp beds. In the late 1980s and 1990s, population explosions of green sea urchins destroyed kelp beds in many parts of the Gulf of Maine (Witman 1987, Taylor 2004). Kelp is susceptible to overgrowth by several non-native species, including the lacy crust bryozoan and several introduced tunicates (e.g., *Botryllus schlosseri* and *Botrylloides violaceus*) that attach to kelp blades. Overgrowth by the lacy crust bryozoan slows kelp's growth rate by reducing light penetration and may make the kelp prone to dislodgement during storms by increasing drag on the blade (Lambert *et al*. 1992). In some areas in the Gulf of Maine, kelp beds are being replaced by beds of the non-native green alga *Codium fragile* ssp. *tomentosoides* (see Chapter 11) (Harris and Tyrrell 2001).

Coastal construction, boat anchors, and mobile fishing gear can damage kelp beds. Because kelp spores need hard substrates for settlement, construction projects on shore or underwater that cause excessive sedimentation may inhibit the successful establishment of young kelp. Turbidity also blocks light penetration and reduces growth rates of kelp.

If the frequency and intensity of storms increase because of climate change, the persistence of kelp beds could be threatened. Storms frequently dislodge kelp, especially kelp with holdfasts attached to mussel shells rather than solid rock surfaces. In addition, warmer waters caused by climate change might favor the growth of *Codium* beds rather than kelp beds.

CHAPTER NINE

Shellfish Beds

General Description

Some bivalve mollusks form large, dense aggregations called shellfish beds that function as distinct biogenic habitats. Small animals find refuge in the crevices among the shellfish, while others attach to the shells. Each species that forms shellfish beds has different environmental requirements, and therefore shellfish beds can be found in the intertidal and subtidal zone and from estuaries to far offshore.

The Gulf of Maine has three types of shellfish beds that are especially noteworthy as biogenic habitats. Mussels secrete strong, flexible threads that bind individuals together in clumps. Oysters settle onto the seabed in clusters, and as they grow, their shells attach permanently to the substrate, leading to formation of a calcareous reef. Scallops do not attach to each other or the substrate, but their dense aggregations are nevertheless referred to as shellfish beds. In some places, currents arrange the empty shells of dead shellfish into long rows, called windrows, on the seafloor, where fish hide to ambush prey, avoid predators, or escape currents.

A small bed of blue mussels in the intertidal zone. Albert E. Theberge, NOAA Photo Library

Distribution

Blue mussels and oysters inhabit the intertidal to shallow subtidal zone, while scallops and horse mussels only live

Blue mussels (left), oysters (center), and bay scallops (right) can grow dense enough to create biogenic habitats. Ethan Nedeau

Oyster harvest. Gilles Daigle

in the deeper subtidal zone. Eastern oysters are largely restricted to estuaries, where they tolerate brackish water with relatively low salinities from 20 to 27 parts per thousand.

Ecological Functions

Shellfish are filter feeders that improve water quality by removing suspended material and particulate pollutants (Gili and Coma 1998). They are such effective filter feeders that sometimes they are stocked specifically to improve water quality. Large oyster reefs alter local flow conditions, and the slower flows promote deposition of particulates from the water. The improved water quality associated with shellfish beds benefits seagrass and seaweed. Mussel beds harbor greater biodiversity than adjacent bare substrates because many species of small animals live in the crevices among mussel shells. Calcareous oyster reefs provide protection for small reef-dependent fish, mollusks, polychaete worms, decapods, and other crustaceans.

Humans, crabs, lobsters, fish, predatory snails, and diving seabirds all consume large quantities of shellfish. Flocks of sea ducks such as common eider, long-tailed duck, and black scoter dive for shellfish near the coast, especially during the winter. Their feeding forays can leave large gaps in subtidal mussel beds, rendering the remaining mussels vulnerable to dislodgement by currents and waves.

Shellfish also provide an important function in the food web by transferring food from the water column to benthic habitats. These filter feeders convert water column productivity in the form of phytoplankton and zooplankton into their tissues, which then becomes available as food to animals higher in the food web, such as the birds, crabs, and fish that eat filter feeders.

The filter feeding of dense aggregations of shellfish can concentrate contaminants from the water column. Similarly, deposit-feeding bivalve shellfish accumulate pollutants in their tissues when feeding in contaminated sediments. Resource managers routinely use shellfish as bioindicators because the concentration of contaminants and toxins in their tissues can be monitored as indicators of water quality.

Economic and Recreational Value

Blue mussels, oysters, and scallops are harvested commercially and recreationally in the Gulf of Maine. Aquaculture businesses grow blue mussels and oysters in some locations along the coast. Many commercially valuable fish and invertebrates inhabit shellfish beds. Finally, large mussel or oyster reefs can help protect upland areas from storm damage.

Management Considerations

Shellfish beds face numerous threats. Declining water quality due to eutrophication, sedimentation, toxics, and rising water temperature is the biggest problem. Dredging, disposal of dredge materials, and increased freshwater runoff to coastal waters because of land development all can threaten shellfish beds.

Dense aggregations of shellfish are susceptible to outbreaks of disease, such as the parasites MSX and Dermo. Some non-native species threaten shellfish by attaching to their shells. For example, colonial tunicates can smother them, while the alga *Codium fragile* raises the risk of dislodgement by increasing drag on the shellfish.

Overharvesting can reduce or eliminate the filtering function of shellfish beds, which may lead to more turbid water and less light penetration for growth of seaweed and seagrass. Trawling gear can destroy the biogenic habitat that shellfish beds and reefs add to otherwise featureless bottoms. The gear can also resuspend sediments and contaminants into the water, potentially smothering the shellfish beds.

Many shellfish beds are closed to harvest because of high levels of fecal coliform bacteria resulting from inadequate sewage treatment. They are closed to protect human health, but contaminants of concern to humans may not harm the shellfish themselves. In fact, closures can benefit the shellfish by halting harvesting.

CHAPTER TEN

Cold-water Corals

A basket star wraps its arms around the soft coral *Gersemia*. Mike Strong and Maria-Ines Buzeta

General Description

Corals are suspension-feeding invertebrates with feathery tentacles that capture food particles from the water column. Corals living in the Gulf of Maine include horny corals (*Gorgonacea*), soft corals (*Alcyonacea*), and hard corals (*Scleractinia*). Horny corals have tree- or bush-like forms, soft corals resemble broccoli, and hard corals grow into a wide variety of shapes. The flexible skeletons of soft corals are composed mainly of proteins, unlike the fully calcified skeletons of hard corals. Many corals require a hard substrate for attachment, ranging from pebbles or boulders to solid rock outcrop. Some species can anchor in soft sediments, while others such as cup corals are free-living and do not attach to the substrate.

Historically, most people thought that reef-building corals only lived in the clear, warm waters of tropical oceans. However, recent deep-sea explorations have revealed important populations of hard corals off the coast of the northeastern United States and the Canadian Maritimes. Scientists already have discovered a *Lophelia* reef at the mouth of the Laurentian Channel off Nova Scotia and Newfoundland that qualifies as biogenic habitat; there are reports of *Lophelia* in the Jordan Basin, so perhaps such reefs exist in the Gulf of Maine, awaiting discovery (D. Gordon, personal communication). Gorgonians may grow densely enough in parts of the Northeast Channel to function as biogenic habitat (D. Gordon, personal communication).

In general, corals are long lived and slow growing. Studies of cold-water corals in Alaska indicate that some species grow only one centimeter per year (Krieger and Wing 2002), suggesting that corals may take centuries to attain several meters in height (Watling and Auster 2003). Fishermen in the Gulf of Maine who have found corals in their nets have referred to them as trees because of their large size.

The hard coral *Lophelia*. NOAA

The soft coral *Gersemia* (orange-yellow in center of photo), inhabiting a rocky ledge with urchins.
Mike Strong and Maria-Ines Buzeta

Distribution

Few data exist on the distribution of corals in the Gulf of Maine. Mortensen and Buhl-Mortensen (2004) recently published observations on the distribution and abundance of cold-water corals in the Northeast Channel between Georges Bank and Browns Bank. They reported finding three species of gorgonians that were more common along the shelf break and slope than on the inner part of the shelf. The highest densities of corals lived in areas less than 400 meters deep with a high proportion of cobble and boulder substrates and water temperature below 9.2° C. Other surveys in the Gulf of Maine have revealed soft corals at much shallower depths (MacKay *et al*. 1978) such as historical records of corals thirteen meters deep.

Ecological Functions

Cold-water corals can form a unique habitat that hosts a great diversity of species. Suspension-feeding invertebrates such as crinoids, basket stars, and anemones live on the corals, which improves their exposure to currents carrying food particles, protects them from some predators, and helps them avoid sedimentation. Fish, shrimp, and crabs swim or crawl among the corals, and some fish, sea stars, sea slugs, snails, and other invertebrates eat the soft tissues of corals.

Economic and Recreational Value

Although soft corals themselves currently have little direct economic value, scientists are exploring the potential for using them to produce pharmaceutical and cosmetic products. Deep-water coral habitats in the Gulf of Maine are not used for recreational activities such as scuba diving or ecotourism because they are inaccessible. However, some *Gersemia* and *Alcyonium* corals live in water shallow enough for recreational scuba divers to visit (L. Watling, personal communication).

Management Considerations

Cold-water corals in the Gulf of Maine are highly vulnerable to damage by fishing gear that scrapes the seafloor. Because of corals' slow growth rates, recovery from damage may take decades or centuries. In addition, because corals are non-mobile, larval dispersal is their only means of recolonizing after severe disturbance. Consequently, the abundance and distribution of coral habitats in the Gulf of Maine likely has declined because of damaging use of some types of fishing gear. Rising sea temperatures may further reduce the distribution and abundance of some cold-water corals. One study reported that the upper depth limit of three gorgonian corals was strongly influenced by high water temperatures (Mortensen and Buhl-Mortensen 2004). Non-native species also can pose a threat to corals. For example, populations of one octocoral species, *Alcyonium siderium*, in Massachusetts were severely threatened by predation by a non-native nudibranch, *Tritonia plebia* (Sebens 1999). Excessive sedimentation, pollution, and seafloor mining also can affect the persistence of corals as a habitat type.

The soft-coral *Gersemia* on a rock outcrop, among urchins and sponges.
Mike Strong and Maria-Ines Buzeta

Sponges in the Gulf of Maine can form biogenic habitat and provide similar ecological value as corals. This sponge has seastars and a basket star on it.
Mike Strong and Maria-Ines Buzeta