CHAPTER 8.

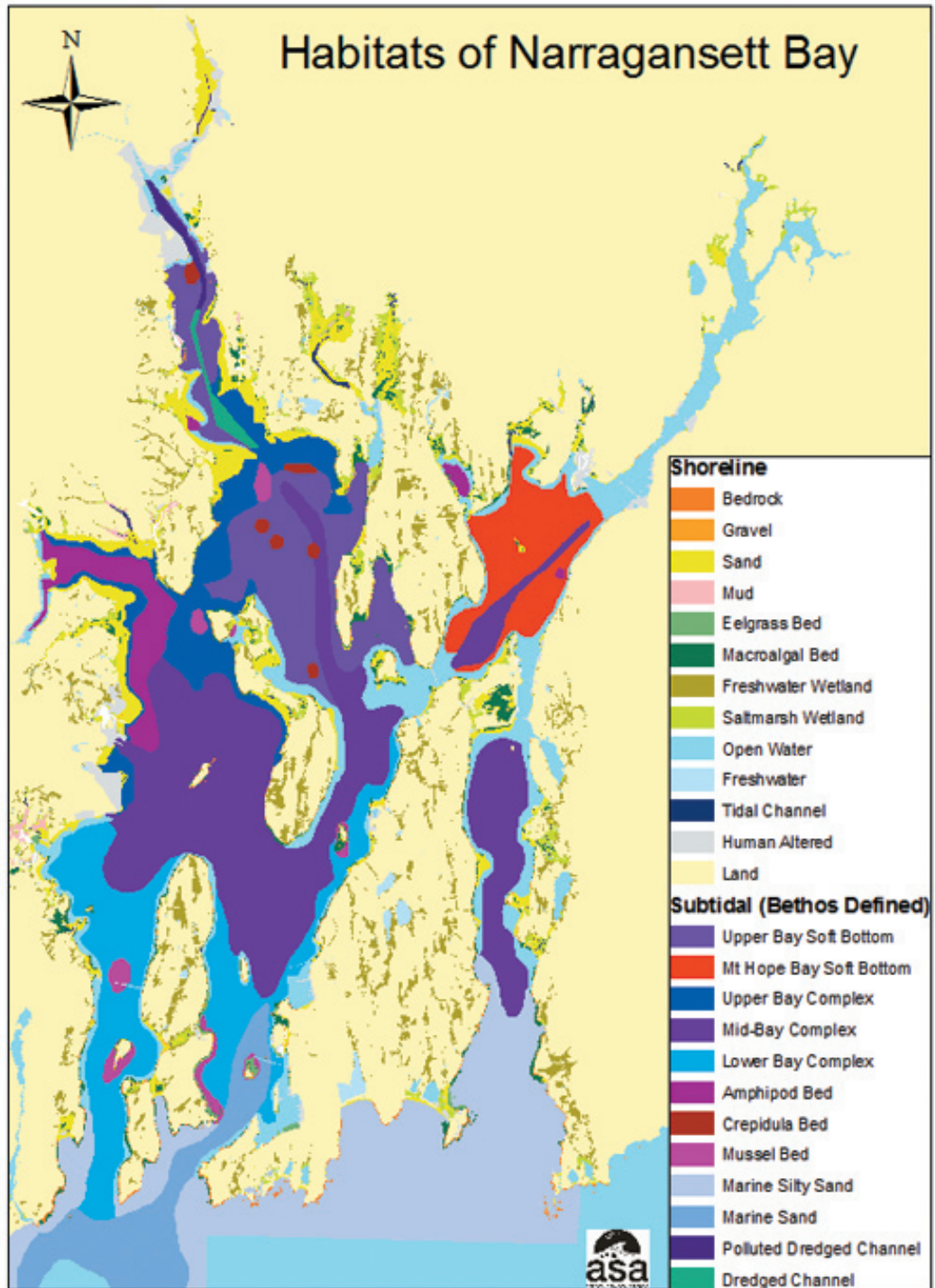# Estuarine Habitats of Narragansett Bay

Malia L. Schwartz

Figure 8.1. Estuarine habitats of Narragansett Bay. *Source: French et al., 1992. Image courtesy Applied Science Associates.*

Estuarine Habitats of Narragansett Bay

Introduction

Estuarine habitats support some of the most productive floral and faunal communities on Earth, and the habitats of Narragansett Bay are no exception. Many different habitat types are found in and around the Bay, including open water, salt marshes, subtidal bottom habitat, brackish waters, a complex intertidal zone of sandy beaches, mud and sand flats, and rocky intertidal areas, submerged aquatic vegetation with macroalgal and eelgrass beds, and human-modified shorelines (Fig. 8.1).

The productivity and variety of estuarine habitats foster an abundance and diversity of wildlife. Shorebirds, fish, crabs and lobsters, marine mammals, clams and other shellfish, marine worms, sea birds, and reptiles are just some of the animals that make their homes in and around estuaries. These animals are linked to one another, and to an assortment of specialized plants and microscopic organisms, through complex food webs and other interactions (EPA, 1998).

In addition to serving as important habitat for wildlife, fringing estuarine wetlands also perform other valuable services. Water draining from the uplands carries sediments, nutrients, and other pollutants. As the water flows through wetlands such as swamps and salt marshes, much of the sediments and pollutants are filtered out. This filtration process creates cleaner and clearer water, which benefits both people and marine life. Wetland plants and soils also act as a natural buffer between the land and ocean, absorbing floodwaters and dissipating storm surges. This protects upland habitats as well as economically valuable real estate from storm and flood damage. Salt marsh grasses and other estuarine plants also help prevent erosion and stabilize the shoreline (EPA, 1998).

Narragansett Bay is one of the best-studied estuaries in the world (Ely and Crist, 2001), and its habitats have been the subject of in-depth research for over 30 years.

Figure 8.2. Salt marshes, such as Round Marsh in Jamestown, R.I., are some of the most ecologically valuable habitats in Narragansett Bay. *Photo by Malia Schwartz.*

This chapter provides an overview of the major habitat types of Narragansett Bay and, where appropriate, makes specific reference to those habitats found on and around the islands of the NBNERR. It also delves into the basic life histories and ecology of the organisms found in these habitats that are then expanded on in subsequent chapters. And finally, it gives examples of habitat restoration efforts ongoing in several Bay habitats.

Open Water

The open water, or pelagic, habitat is the dominant habitat in Narragansett Bay, based on area. The Bay itself is a phytoplankton-based ecosystem with relatively little salt marsh or macroalgae. The pelagic habitat is a dynamic environment with tidally and wind-driven circulation and freshwater inputs (French et al., 1992). A wide variety of plankton, benthic communities (Chapter 9), and nekton (Chapter 10) are found in and under the open water habitat of Narragansett Bay. In turn, this habitat provides food for a diverse assemblage of birds, as well as for marine mammals and occasional sea turtles (Chapter 11). The pelagic habitat also supports a number of commercial and recreational fisheries and shellfisheries.

Salt Marshes

While only covering a small surface area in Narragansett Bay, estuarine emergent wetlands, or salt marshes, are some of the most ecologically valuable habitats in the Bay (Fig. 8.2). Salt marshes protect coastal areas from erosion, remove nutrients from overenriched waters, provide sheltered habitat for key resource species, serve as nursery grounds for fish and shellfish, and are a major food source for the organisms that live there (Tiner, 1984).

A primary source of food in salt marshes is in the form of decomposing

plant material, or detritus. Detritus is the base of an aquatic food web supporting higher consumers and commercial species. Animals such as shrimp, snails, clams, worms, and killifish consume plant breakdown products, graze on microscopic organisms growing on the surface of the detritus (Beck and Beck, 1998), or scour epibenthic algae off the sediments. To illustrate the interwoven nature of this food web, research by Nixon and Oviatt (1973a) in Bissel Cove reported that excretion and fecal pellets produced by foraging grass shrimp provided nutrients for enhanced development of bacteria and algae on the detritus. In turn, forage fish (e.g., anchovies, silversides, sticklebacks, mummichogs) and small invertebrates (e.g., grass shrimp and worms) are then consumed by commercial and recreational fish species, including winter flounder (*Pseudopleuronectes americanus*), striped bass (*Morone saxatilis*), and bluefish (*Pomatomus saltatrix*) (Beck and Beck, 1998).

Salt marshes are characterized by two general vegetative zones based on differences in tidal flooding—regularly flooded low marsh and irregularly flooded high marsh. In the low marsh—the area covered by each day's high tides—vegetation is dominated by a single plant, the tall form of smooth cordgrass, *Spartina alterniflora*, which typically grows 90–180 cm (3–6 feet) high (Beck and Beck, 1998). In addition, filamentous algae and diatoms are found at the base of the grasses growing in the flooded part of the marsh (Donaldson, 1995). Where the tall cordgrass meets the water's edge, the mud is home to densely packed beds of ribbed mussels, and around the plants' roots, one can find small holes that form the openings to fiddler crab burrows. Moving away from the water, at the edge of the border marked by the high-tide line, the cordgrass is short, less than 30 cm tall (Bertness, 1992).

In addition to providing food and shelter to the organisms that inhabit the low marsh, *S. alterniflora* has also been shown to be an effective nutrient sink, able to capture and hold available inorganic nutrients, such as nitrogen and phosphorus and trace elements, then slowly release them as the plants die, decay, and are carried into the estuary to serve as a rich source of detrital food (Nixon and Oviatt, 1973b).

In contrast to the low marsh, the high marsh is a mosaic of species, the occurrence of each being precisely determined by the elevation and resultant amount of tidal flooding. The high marsh is characterized by salt-marsh hay (*S. patens*), spike grass (*Distichlis spicata*), glassworts (*Salicornia spp.*), sea lavender (*Limonium nashii*), salt marsh aster (*Aster tenuifolius*), black grass (*Juncus gerardii*), and hightide bush (*Iva frutescens*). Salt marsh pools and tidal creeks can also be vegetated with widgeon grass (*Ruppia martima*), sea lettuce (*Ulva lactuca*), and other macroalgae (Beck and Beck, 1998).

In Narragansett Bay, salt marshes cover about 1,120 ha (2,800 acres). There are also roughly 80 km of narrow, fringing marshes—marshes that line the edge of rocky shores or developed areas. French et al. (1992) reported on the species composition and relative abundance of salt marsh plants in eight salt marshes around Narragansett Bay. The surveyed marshes included: 1) Watchemoket Cove, East Providence; 2) Hundred Acre Cove, Barrington; 3) Chase Cove, Warren; 4) Common Fence Point, Portsmouth; 5) Bissel Cove, North Kingstown; 6) Round Swamp, Jamestown; 7) Weaver Cove (Melville), Portsmouth; and 8) Emily Ruecker Wildlife Marsh, Tiverton. At the seven sites that could be sampled (Weaver Cove was too degraded), *S. alterniflora* dominated the low marsh and *S. patens*, the high marsh. Both species are perennial grasses, annually producing large amounts of organic matter that are exported from the marshes into the detrital

Table 8.1. Relative coverage (%) of dominant high and low marsh species for seven salt marshes within Narragansett Bay. Sp = *Spartina patens*, Ds = *Distichlis spicata*, Ap = *Atriplex patula*, Sa (t) = *Spartina alterniflora* (tall), Sa (s) = *Spartina alterniflora* (short), Jg = *Juncus gerardii*, If = *Iva frutescens*, Se = *Salicornia europea*, Ss = *Solidago sempervirens*, Lc = *Limonium carolinianum*, At = *Aster tenuifolius*, Pm = *Plantago maritima*. Data from French et al., 1992.

High marsh	Sp	Ds	Ap	Sa (t)	Sa (s)	Jg	If	Se	Ss	Lc	At	Pm
Bissel Cove	53.6	14.2	0.6	0	0	17.2	0.6	0	11.2	0	0.6	1
Ruecker Wildlife Marsh	47.8	34.8	0	2.7	6.7	0.4	0.4	7.2	0	0	0	0
Round Swamp	82.7	12.5	0	2.0	0	0	0	0	0	2.0	0	0.8
Watchemoket Cove	94.1	4.7	0.6	0	0	0	0	0	0.6	0	0	0
Hundred Acre Cove	57.1	40.8	0	0	0	2.1	0	0	0	0	0	0
Common Fence Point	81.3	18.1	0.6	0	0	0	0	0	0	0	0	0
Chase Cove	72.2	27.8	0	0	0	0	0	0	0	0	0	0

Low marsh	Sa (t)	Ds	Sp	Se	Sa (s)	Ap
Bissel Cove	7.9	4.2	18.5	0	68.8	0.6
Ruecker Wildlife Marsh	100	0	0	0	0	0
Round Swamp	76.2	0	21.9	1.9	0	0
Watchemoket Cove	97.3	0.9	0	0	0	1.8
Hundred Acre Cove	80.1	8.3	9.3	2.3	0	0
Common Fence Point	98.4	0.8	0	0.8	0	0
Chase Cove	89.6	7.8	1.9	0.7	0	0

food web or deposited within the marshes, contributing to the underlying peat (Nixon, 1982; Teal and Teal, 1962). Table 8.1 shows the relative coverage of species found in the seven study sites that were examined.

Within the boundaries of the NBNERR, salt marshes are found in the North Prudence Unit (102 acres) and Barre and Little units (48 acres), on the east shore of Patience Island (13 acres), and in a small area on Dyer Island (3 acres) (see Table 4.3, page 36; Fig. 4.11, page 34). As with the previous examples, the salt marshes of the Reserve are dominated by *S. alterniflora* and *S. patens*, and are influenced by the adjoining Bay rather than landward processes. They are laced with irregular creeks, ponds, potholes, and man-made drainage ditches (Beck and Beck, 1998). Seventy-six percent of the salt marshes occurring on the islands of the Reserve are protected within NBNERR boundaries (Rosenzweig et al., 2002).

Salt Marsh Restoration

Despite their documented ecological and societal importance, over half the estuarine wetlands originally occurring in the continental United States have been destroyed, largely as a result of urbanization (Tiner, 1984; Tiner et al., 2004). But public concern, coupled with increased public awareness of the functions and values of estuarine wetlands, has provided the impetus for salt marsh restoration (Shisler, 1990). In Rhode Island, recent attempts have been made to restore once-productive salt marsh habitats.

Within Narragansett Bay, a salt marsh restoration effort was undertaken at Sachuest Point salt marsh on Aquidneck Island. In March 1998, tidal flow to the formally restricted portion of the marsh was reestablished with the construction of additional culverts, marsh pools, creeks, and ditches (Roman et al., 2002) (Fig. 8.4). One year after tidal restoration, the tidal range was equivalent to that of the unrestricted portion of the marsh, and vegetation composition had begun to return to normal unrestricted salt marsh conditions, most notably an increase in the abundance of *S. alterniflora* and *S. patens*, and decrease in the height of *Phragmites australis*. An increase in the nekton density and species richness of the restoring marsh also occurred (Roman et al., 2002). Sachuest Point is a prominent example of salt marsh restoration in Narragansett Bay; however, many other similar examples exist, including Potter Pond (Prudence Island) in the NBNERR, Gooseneck Marsh (Newport), Walker Farm (Barrington), and Silver Creek (Bristol).

Benthic Habitat

Occurring below the low-tide line, the subtidal, benthic (bottom) habitat of Narragansett Bay is composed of soft, unvegetated sediments, predominantly clayey silt and sand-silt-clay. This habitat is found throughout the mid- and upper Bay and in protected coves and embayments. Coarser, sandy sediments are found in the lower Bay (see Fig. 7.6, page 84). Sub-tidal waters support a diverse benthic community of molluscs, crabs, and worms that live in and on the sediments (Fig. 8.5). The northern quahog (*Mercenaria mercenaria*) is the most commercially important species with a smaller fishery in the Bay for the American lobster (*Homarus americanus*). Blue mussels (*Mytilus edulis*) are abundant intertidally, in shallows with hard substrates (French et al., 1992), and in two big commercial beds in the lower West Passage at depths of 12–18 m (40–60 feet) (S. Nixon, personal communication).

There are 13 benthic habitat types found in the waters of Narragansett Bay (Table 8.2, Fig. 8.1). Organisms found in the lower Bay and at depths greater than 12 m (40 feet) in the mid-Bay are adapted to true marine conditions. Evidence of this historically could be seen in sea scallop beds off Gould Island, ocean quahogs in the East Passage, and populations of surf clams off Bonnet Shores in the West Passage and in the lower reaches of the Sakonnet River. In the lower reaches of the East and West passages, much of the bottom is composed of empty oyster and quahog shells, on which live large numbers of blue mussels and slipper shells (*Crepidula fornicata*) found in densities high enough to affect the distribution of other species and sediment characteristics. (Olsen et al., 1984; French et al., 1992).

In areas of deep water in the mid-Bay, where sediments are soft and salinities high, a deposit-feeding community flourishes that is dominated by two species of small clams, *Yoldia limatula* and *Nucula annulata,* and the catworm, *Nephtys incisa,* as well as the coot clam, *Mulinia lateralis*, and a polychete worm, *Mediomastus ambiseta*. This community is widespread on soft bottom and is also found at the bottom of dredged channels. These deposit-feeding organisms constantly rework the top few centimeters as they sift organic matter from between the sediment grains and excrete it in packets called pseudofeces. This produces a soft, pelletized

surface. Since the pellets clog the feeding mechanism of filter feeders, they are largely excluded from such areas. Currents occasionally sweep these nutrient-rich pellets into suspension, thus enriching the water. (Olsen et al., 1984; French et al., 1992).

Historically, the upper Bay was rich in oysters (*Crossostrea virginica*), quahogs, and soft-shelled clams (*Mya arenaria*) (Olsen et al., 1984). While quahogs are still abundant, some of the most productive shellfishing grounds, including the Providence River and Greenwich Bay (see Fig. 7.2, page 79), are often conditionally or permanently closed to harvesting due to bacterial pollution.

Parts of the "upper Bay complex" (Table 8.2, BUB), such as the habitat surrounding North Prudence and Patience Island, are characterized by various sandy sediment types. The tube-dwelling amphipod crustacean, *Ampelisca abdita*, can be found in dense mats in this habitat, as are quahog beds, which sustain lucrative commercial and recreational shellfish harvests (Fig. 8.6). In addition, the *Ampelisca* themselves are an important food source for fish, notably winter flounder (French et al., 1992; Olsen et al., 1984).

Rocky Reefs

Narragansett Bay has few natural rocky reefs (e.g., off Hope Island), but the West Passage of Narragansett Bay near Dutch Island is home to six small artificial rocky reefs. Constructed by NOAA Fisheries with settlement money from the 1989 *World Prodigy* oil spill, the reefs—made of two different sizes of quarried cobble—were built to enhance lobster stocks in the Bay by providing new shelters created by the artificial reefs (Schwartz, 1996).

Castro (2003) examined the effects of habitat enhancement and stock enhancement on the abundance of American lobster inhabiting the artificial reefs. Reefs were monitored for six months pre-construction and five years post-construction using a combination of visual surveys by scuba divers, trap sampling, a tag-recapture program, and airlift sampling for young-of-the-year. Castro (2003) found an approximate population size of 1,250 lobsters at the reef sites, calculated from tag-recapture and visual survey information. In addition, a significant increase in the number of naturally settling young-of-the-year was noted at the reef sites compared to pre-reef conditions. While the addition of hatchery-reared lobsters (stock enhancement) did not contribute to enhancement at the reef sites, the addition of the reefs (habitat enhancement) did significantly increase the numbers of lobsters in Dutch Harbor

through increased settlement and migration (Castro, 2003).

In addition to the Dutch Harbor reefs, an artificial reef-site was constructed in Mount Hope Bay as part of a Rhode Island Experimental Program to Stimulate Competitive Research (EPSCoR) project to study the role of artificial reefs in oyster enhancement and finfish habitat restoration in Narragansett Bay (EPSCoR, 2007; *www.riepscor. org/summer2007/project34.html*). And when the R.I. Department of Transportation and Federal Highway Administration approved the demolition of the old Jamestown Bridge, artificial reefs were created with the concrete rubble from the bridge at several deep-water sites at the bottom of Rhode Island Sound (Berman, 2006).

Brackish Habitat

Portions of Narragansett Bay where salinity levels are reduced by freshwater dilution are important for supporting important resource species such as oyster, soft-shell clam, and blue crab (*Callinectes sapidus*) (Fig. 8.7). However, the value of these brackish habitats can be compromised by their location at river mouths and within coves that are often subjected to intense physical disturbance from dredging and filling, and which serve as sinks for local and watershed contaminants. Brackish areas in Narragansett Bay tend to be small since many streams enter the water from steeply sloping shores or over dams; the Tauton River is an exception, having a long tidal reach (French et al., 1992).

All brackish areas studied in Narragansett Bay supported species adapted to shallow water with low and variable salinity, extremes in temperature, and high concentrations of organic detritus. These include molluscs (*Hydrobia totteni, Illyanassa obsoleta, Macoma balthica,* and *Mya arenaria*) and polychaetes (*Neanthes succinea, Polydora ligni, Scolecolepides viridis*, and *Streblospio benedicti*). The brackish fauna of the Kickemuit River, which empties into Mount Hope Bay, R.I., included a number of species not found, or rare, in other brackish areas, such as the gastropods *Sayella fusca* and *Odostomia trifida* and the amphipod *Paraphoxus spinosus*. These may be sensitive species that have been eliminated from polluted areas (French et al., 1992).

Figure 8.4. Tidal flow was restored to a previously restricted portion of Sachuest Marsh by constructing a new culvert (*top*) as well as marsh pools, creeks, and ditches (*bottom*). *Photos by John Catena, NOAA Restoration Center.*

Figure 8.5. A benthic community. Illustration by S.P. Silvia. (A) Tube-dwelling amphipods, *Ampelisca*. (B) Benthic amphipod in filter-feeding position, *Leptocheirus pinguis*. (C) Ice cream cone worm, *Pectinaria gouldii*. (D) Coot clams, *Mulinia lateralis*. (E) Hermit crab, *Pagurus longicarpus*. (F) Quahog, *Mercenaria mercenaria*. (G) Shimmy worm, *Nephtys incisa*. (H) Mantis shrimp, *Squilla empusa*. (I) Mud snail, *Ilyanassa trivittatus*. (J) Worm casting. (K) Macoma clam, *Macoma balthica*. (L) Nematodes. (M) Nut clams, *Nucula proxima*. *Source: Olsen et al., 1984*.
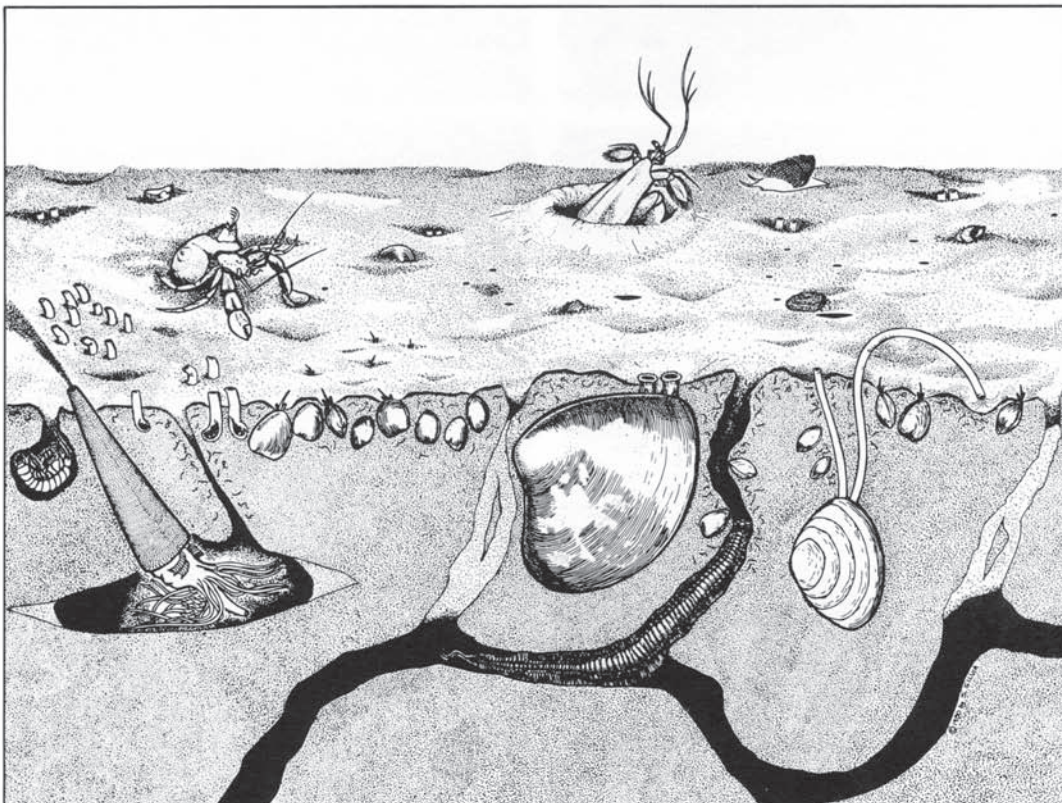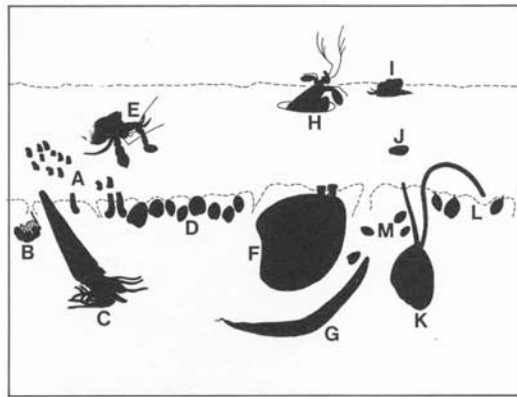

Table 8.2. Thirteen benthic habitat types indicated on the Narragansett Bay map of habitats (Fig. 8.1). *Data from French et al., 1992*.

Name	Abbrev.	Description
Marine sand	BSA	Silty sand typical of Rhode Island Sound and extending up into the East Passage. Fauna characterized by marine spp. such as *Astarte, Cyclocardium, Byblis serrata*, and *Arctica islandica*
Marine silty sand	BSS	Habitat found at the mouth of the Bay and in Rhode Island Sound. Characterized by fine sands with marine spp. such as *Spisula, Echinarachnius*, and *Spiophanes bambyx*
Lower Bay complex	BLB	Composed of a variety of mixed sediments containing sand. *Mytilus* and *Crepidula* shells may be locally abundant. Mid-estuarine and estuarine-offshore spp. found here include *Pherusa affinis, Aricidea* and *Ampelisca vadorum*
Mid-Bay complex	BMB	Habitat found in the deeper water of the mid-Bay, channels of Mt. Hope Bay, and the upper Bay on clayey silt and sand-silt-clay. The fauna are mid-estuarine and estuarine-offshore and include *Mulina, Mediomastus, Nucula annulata, Nephtys*, and *Yoldia*
Upper-Bay complex	BUB	Composed of various sediment types containing sand, with tidal current features and *Mytilus* and *Crepidula* beds
Mussel (*Mytilus edulis*) beds	BME	
Crepidula beds	BCF	
Amphipod beds	BAA	
Mt. Hope Bay soft bottom	BMH	Clayey-silt and sand-silt-clay habitat found in the non-channel areas of Mt. Hope Bay. Mid-estuarine spp. include *Spiochaetopterus*, while *Nucula, Nephtys, Yoldia*, and *Ampelisca abdita* are of lesser importance
Upper Bay soft bottom	BUS	Softer sediments of the upper Bay and lower Providence River. Its low diversity fauna includes mid-estuarine spp. and high levels of eutrophication indicators such as *Streblospio* and *Mediomastus*
Estuarine dredged channel	BLP	Habitat on the soft sediments of the lower Providence River channel includes a low density of mid-estuarine species, much like BMB, but fewer in number
Polluted dredged channel	BUP	Upper channel of the Providence River and Seekonk River have a fluid, non-cohesive bottom low in oxygen. Fauna consists of greatly reduced diversity and density of pollution-resistant spp.
Shallow undredged brackish	BSU	Undredged areas of the Seekonk River and other shallow brackish areas with fine sand and silt bottoms with brackish water spp. such as *Macoma balthica, Scolecoleipides, Cyathura*, and *Mya*

Intertidal Zone

The intertidal, or littoral, zone—the area above the low-water mark and below the high-tide line—of Narragansett Bay is composed largely of narrow cobble beaches. Within the NBNERR, beaches (some sand, mostly cobble) are found on Prudence, Patience, Hope, and Dyer islands; mud or sand flats can be seen in the North Prudence Unit; and rocky intertidal areas are found on Hope Island and at the southern end of Prudence Island (Beck and Beck, 1998).

Organisms that live in the intertidal zone are adapted to an environment of harsh extremes. Temperature, dessication, salinity, and wave action can vary widely depending on the area inhabited. One easily visible feature of intertidal communities is "vertical zonation," where the community is divided into distinct vertical bands of specific species going up the shore. Typically, species' ability to cope with dessication determines their upper limits, while competition with other species sets their lower limits.

In the "upper littoral" subzone, which is flooded only during the day's high tides, the environmental fluctuations are most dramatic. The duration of submersion is not long enough to sustain large amounts of vegetation, but some do survive. In Narragansett Bay, the predominant organisms in this subzone are barnacles, small gastropods, isopods, mussels, sea stars, and whelks. The upper littoral can also contain rock pools inhabited by small fish Fig. 8.8).

In contrast, the "lower littoral" subzone is mostly submerged—it is only exposed during low tides. This area is teeming with life—the most notable difference in this subzone is that there is much more marine vegetation, especially seaweeds, or macroalgae. Organisms in this subzone generally are not well adapted to periods of dryness and temperature extremes. Some of the organisms in this area include anemones, crabs, green algae, hydroids, isopods, mussels, nudibranchs, sculpins, sea cucumber, sea lettuce, sea stars, sea urchins, shrimp, snails, sponges, tube worms, and whelks. Creatures living in this subzone can grow to larger sizes because there is more productivity in the lower littoral and because marine vegetation can grow to much greater sizes due to the better water coverage—the water is shallow enough to allow light to reach the vegetation, nutrients are supplied on a regular basis, and the salinity is close to that of full seawater. This area is also protected from large predators such as large fish because of the wave action and the water still being relatively shallow (Bertness et al., 2001).

Submerged Aquatic Vegetation

Eelgrass

Eelgrass, *Zostera marina*, is a rooted, submerged flowering plant typically found in coastal and marine habitats (Fig. 8.9). Eelgrass contributes significantly to the health and productivity of these habitats (Keller et al., 1996). It plays an important role in the life cycles of scallops, crabs, finfish, geese, and ducks. The dense meadows of eelgrass provide breeding and nursery areas for young finfish and shellfish as well as a substratum for attachment in the water column and protection from predators (Thayer et al., 1984). In fact, recent studies in Rhode Island (Harris et al., 2004) have documented that eelgrass beds—even those of modest density—increase survivorship of tautog (*Tautoga onitis*), cunner (*Tautogolabrus adspersus*), and silversides (*Menidia menidia*), but do not affect predation by bluefish (*Pomatomas saltatrix*) on Atlantic menhaden *(Brevoortia tyrranus)*. These findings suggest that eelgrass habitats indeed serve a functional role as refuges from predation for some prey fish.

During its life cycle, eelgrass typically breaks away from the base shoots and becomes an important component of the detrital pathway. Detritovores begin to break down the leaves into smaller particles which are then consumed by bacteria and fungi. Many invertebrates also consume the decaying eelgrass and then become food for larger life forms, such as fish and crabs (Keller et al., 1996).

Eelgrass communities are also valuable sediment traps and help stabilize bottom sediments

Figure 8.7. Brackish water habitats, such as at the mouth of the Narrow River in Narragansett, support important resource species, but are also often compromised because they serve as sinks for local and watershed contaminants. *Photo by Malia Schwartz.*
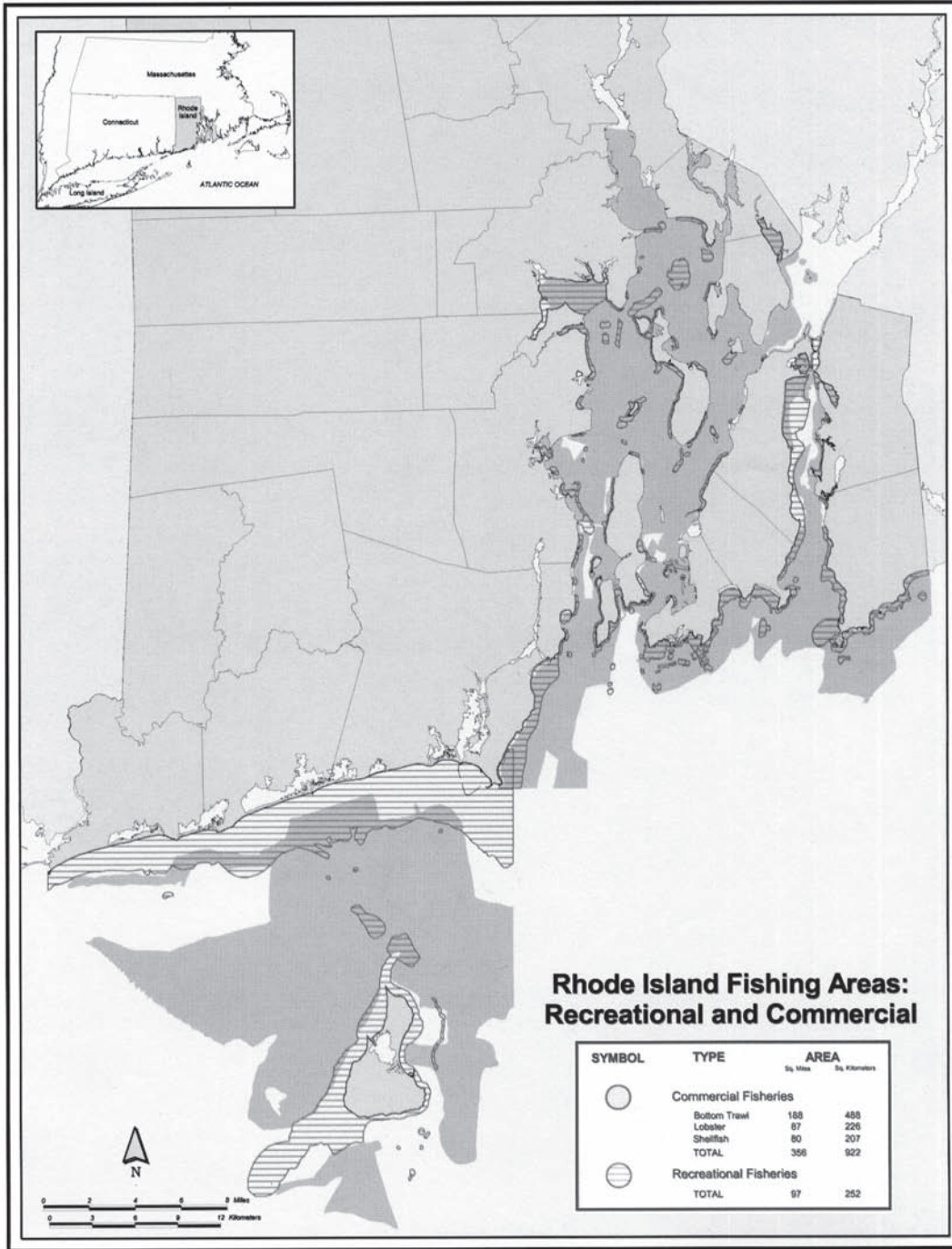
Rhode Island Fishing Areas: Recreational and Commercial

SYMBOL	TYPE	AREA	
		Sq. Miles	Sq. Kilometers
○	Commercial Fisheries		
	Bottom Trawl	188	488
	Lobster	87	226
	Shellfish	80	207
	TOTAL	356	922
○	Recreational Fisheries		
	TOTAL	97	252

Figure 8.6. Narragansett Bay provides ideal habitat for commercial and recreational fisheries. *Source: Rhode Island Marine Resource Uses Project*.

(Thayer et al., 1975). Their leaves act as dampers in the water and reduce wave motion. Eelgrass meadows remove both suspended sediments and nutrients from the water column. High levels of nutrients entering a system from developed areas are taken up by eelgrass rather than being passed downstream where they might add to the level of pollution in a system (Keller et al., 1996). Historically, eelgrass beds could be found throughout the Bay and thrived even in the more polluted areas of the upper Bay and Providence River (Nixon et al., 2007).

The current distribution of eelgrass in Narragansett Bay is patchy (Fig. 8.10). It is limited to shallow embayments with mud-sand substrata since the rhizome is buried in the sediment and leafy shoots arise annually. Eelgrass beds have been reported in the southern East Passage around Newport (Brenton Cove and Coasters Harbor Island), on the east side of Conanicut Island (east of Beavertail State Park, Mackerel Cove, and Fort Wetherill State Park), and around Rose Island. Small patches have been reported in the West Passage north of Bonnet Point, on the east side of Dutch Island in Wickford, and in East Greenwich Cove (Keller et al., 1996). A 1989–1990 macroalgal survey (French et al., 1992) extended what was earlier limited to locations along the eastern shore of Conanicut Island to the eastern and western shores of the Sakonnet River. Within the NBNERR, lush eelgrass meadows could be found in the shallow waters of the Reserve until the 1930s. Today, only two healthy beds exist within the boundary of the NBNERR. The largest bed extends from the south end/ T-wharf area on Prudence for over 364 m (400 yards) north along the east shore. A much smaller bed exists south of Sheep Pen Cove (Beck and Beck, 1998).

Figure 8.8. Beavertail's rocky shores contain small tide pools that are home to creatures that can tolerate the extreme environmental fluctuations characteristic of the upper intertidal zone. *Photo by Malia Schwartz.*

Eelgrass Restoration

In the 1930s, a virulent fungal disease swept through eelgrass beds in North America and Europe and almost completely eliminated the plants from many areas (den Hartog, 1987). A slow recovery over the next 30 years renewed scientific interest in the ecology and reproduction of *Zostera,* and numerous studies began to reveal the importance of eelgrass habitats. Ironically, the recovery of eelgrass, at least along the U.S. East Coast, coincided with the migration of the human population to the coast, the increasing use of nitrogen fertilizer following World War II, and increasing atmospheric emissions of nitrogen from electric power generation and trans-
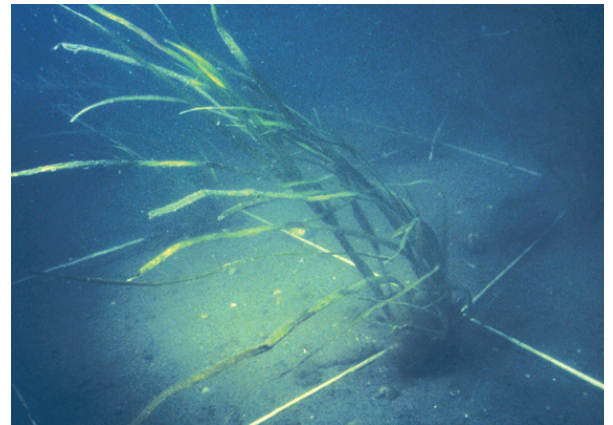

Figure 8.9. A plug of eelgrass, shown after transplant into one of 10 locations in Narragansett Bay as part of an eelgrass restoration effort. *Photo by Jerry Prezioso, NOAA.*

portation. The increasing inputs of sediment and nutrients combined to reduce coastal water clarity. As a result, the natural recovery of eelgrass largely stopped, and the plants were lost once again from many bays and estuaries. It is estimated that from one- to two-thirds or more of the once-recovered eelgrass has been lost (Fonseca et al., 1998; Hurley, 1992; Orth and Moore, 1983; Short et al., 1996).

However, this loss of eelgrass has stimulated growth in the area of eelgrass research, restoration, and recovery. Rhode Island Sea Grant researchers used mesocosm tanks, which replicated the coastal lagoons where eelgrass grows, to examine the effects of nutrients, temperature, shoot density, and ecosystem value of eelgrass (Bintz and Nixon, 2001; Harris et al., 2004). This led not only to new understanding of eelgrass ecology, but also to new approaches to restoring eelgrass beds through the use of seeds (Granger et al., 2002).
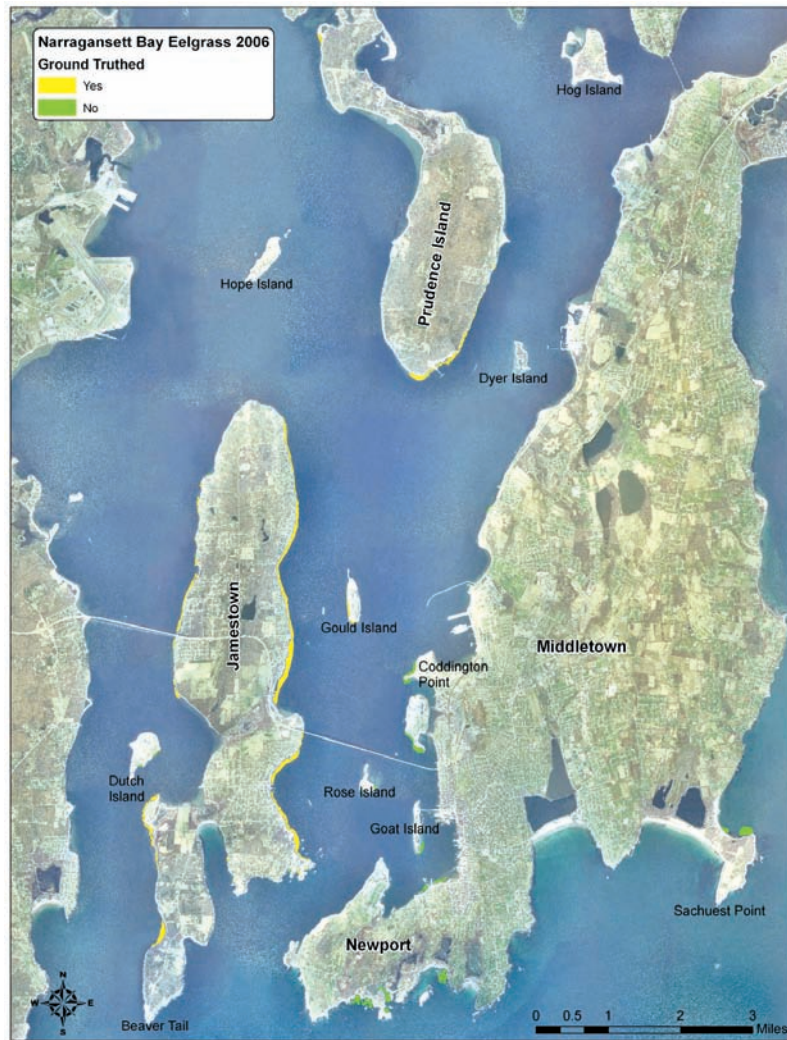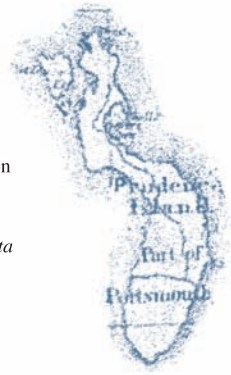
Figure 8.10. Eelgrass distribution (green/yellow) in Narragansett Bay. *Map courtesy Michael Bradley, URI Environmental Data Center.*

With funding from the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) and Rhode Island Sea Grant, Granger and colleagues developed techniques for harvesting, preparing, and storing eelgrass seed for later planting (Granger et al., 2002). The investigators went on to develop a "seeding sled"—a device towed under water that creates furrows, injects a seed-gelatin matrix into the sediments, and covers the seeds (Fig. 8.11). The researchers' mesocosm studies demonstrated 50 percent seed survival using these methods—unheard of success compared with past seed-based restoration efforts (Granger et al., 2002). This work was field-tested in Narragansett Bay in Reserve waters (see Chapter 13) and provided a link to the goals of the NBNERR to reestablish eelgrass in selected areas with a high potential for successful restoration (Beck and Beck, 1998).

Figure 8.11. The eelgrass seeding sled, developed by URI researchers, was field-tested in NBNERR waters. *Photo by Stephen Granger, URI Graduate School of Oceanography (GSO).*

Macroalgal Beds

In shallow areas, macroalgae may contribute significantly to primary production particularly via contributions to detrital food chains (Mann, 1972; 1973) (Fig. 8.12). They provide habitat for a variety of organisms, such as bay scallop (*Argopecten irradians*) (Hicks, 1986), and when sessile, may integrate the history of a water mass. Consequently, rugged species such as *Ulva latuca, Fucus vesiculosus*, and *Chondrus crispus* serve as useful bioaccumulators of pollutants (Levine
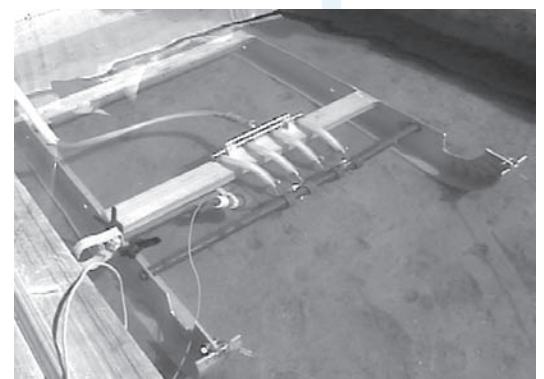
and Wilce, 1980; Sears and Battaglia, 1990), and therefore, changes in their abundance and distribution can be an indicator of degradation or recovery of an area.

But macroalgal proliferation can also cause degradation in an ecosystem. Increased nutrients, especially nitrogen and phosphorus, coming into an embayment from human sources can overstimulate plant growth—a process called eutrophication. If large amounts of seaweed accumulate, they may clog beaches and boating areas and cause odor problems when they decompose (Granger et al., 2000). More importantly, when the plants die and are decomposed by bacteria, oxygen in the water is depleted. Granger et al. (2000) conducted an assessment of eutrophication in Greenwich Bay in which they quantified the biomass of macroalgae at different times during the summer to predict the amount of oxygen consumption that might occur when the seaweeds died and decomposed in the bottom water. The major species they found were *U. lactuca* and *Gracilaria tikvahiae*, with lesser amounts of *U. linza* (Fig. 8.13). They determined that, while the macroalgae in the coves may have some impact on bottom-water dissolved oxygen if the coves became stratified, this impact was unlikely to be significant (Granger et al., 2000).

Seaweeds have been studied in Narragansett Bay since the mid-1800s (Fig. 8.14). Much of the published information as well as unpublished material was synthesized by French et al. (1992) and combined with a broad scale and semiquantitative sampling program to compile maps of macrophyte distributions within the Bay. Table 8.3 lists the macrophyte species collected during a 1989–1990 survey. Species diversity was highest where water from Rhode Island Sound entered the Bay through the East Passage and Sakonnet River. The number of macroalgal species found in the low intertidal was consistently higher than the upper subtidal. Red algae predominated in the subtidal zone (French et al., 1992).

According to the survey, the dominant species in the Bay were *Chondrus, Codium, Fucus, Ulva, Ascophyllum*, and *Laminaria. Chondrus, Codium, Fucus*, and *Ascophyllum* appeared throughout the Bay, while *Ulva* also extended into the tributaries. For the most part, *Fucus* and *Ascophyllum* were restricted to intertidal zones, while *Codium* and *Ulva* were a major component of both intertidal and subtidal zones. Compared with estuaries north of Cape Cod, Narragansett Bay

Figure 8.12. Seaweeds, or macroalgae, contribute significantly to primary production in estuarine habitats. *Photo by Malia Schwartz.*

has fewer species but a larger proportion that extend to the tropics (French et al., 1992).

Human-Modified Shorelines

Within Narragansett Bay, over half the shoreline has been "hardened" by human-made structures (RIGIS, 2006) (Fig. 8.15). These structures include bulkheads or seawalls that were designed to prevent erosion (Fig. 8.16). However, most coastal erosion in the Bay results from major storms, such as hurricanes and nor'easters. Sometimes these structures actually hasten erosion by concentrating the wave energy in the area of the barrier (Keller, et al., 1996). Under changing climate conditions and rising sea level, this effect will be intensified. The R.I. Coastal Resources Management Council's (CRMC) webpage on "Climate Change & Sea Level Rise" offers resources for information and related links on the topic. Visit *www.crmc.ri.gov/climatechange.html*. In addition, the CRMC had adopted new shoreline maps for Rhode Island's coast, detailing erosion rates for the shoreline. The maps are available at *www.crmc.ri.gov/maps/shoreline.html*.

Marinas as Habitat

Besides those structures built along the shore to prevent erosion, another type of human-modified structure along the shoreline is marinas (Fig. 8.17). A study by Nixon et al. (1973) provided one of the first attempts to look at marinas as habitat. They made basic ecological measurements of marina system production, respiration, species diversity, and major populations for comparison with those of estuarine salt marshes and other natural communities.

In their study, Nixon et al. (1973) compared two coves that both open into Wickford Harbor—Wickford Cove, which has three marinas and

Figure 8.14. Seaweeds provide habitat for a variety of organisms. Their ecology has been studied extensively in Narragansett Bay. *Photo by Malia Schwartz.*

numerous moorings, and Mill Creek, which is bordered by fringing *S. alterniflora* marsh with no boats, docks, or moorings. They found that the two ecosystems were strikingly similar in many respects. Fish species were similarly diverse in the marina and the marsh habitats, but abundance was greater in the marsh cove due to the presence of dense juvenile menhaden schools. Additionally, the fouling communities that grow on the undersurface of floats and wooden dock pilings of marinas appeared to be a food source for juvenile mummichogs (*Fundulus heteroclitus*) and likely serve as additional food sources to complement the detritus input from the salt marsh. Based on their findings, Nixon et al. (1973) concluded that in most respects, the marina cove and the marsh cove appeared not only to be similar, but also compatible ecological systems.

More recently, the concept of marinas as habitat has taken hold in the aquaculture industry. Innovative aquaculture techniques are using floating docks in marinas as platforms for the nursery culture of shellfish seed as a means to efficiently utilize valuable shoreline space (Scott et al., 2000). Shellfish seed, such as oyster, quahog, or scallop, are hung in bags on the underside of docks. There, they filter-feed on a variety of organisms in the water column, which, in addition to enhancing shellfisheries, also have the added benefit of removing excess nutrients from the Bay and improving water quality (Scott et al., 2000).
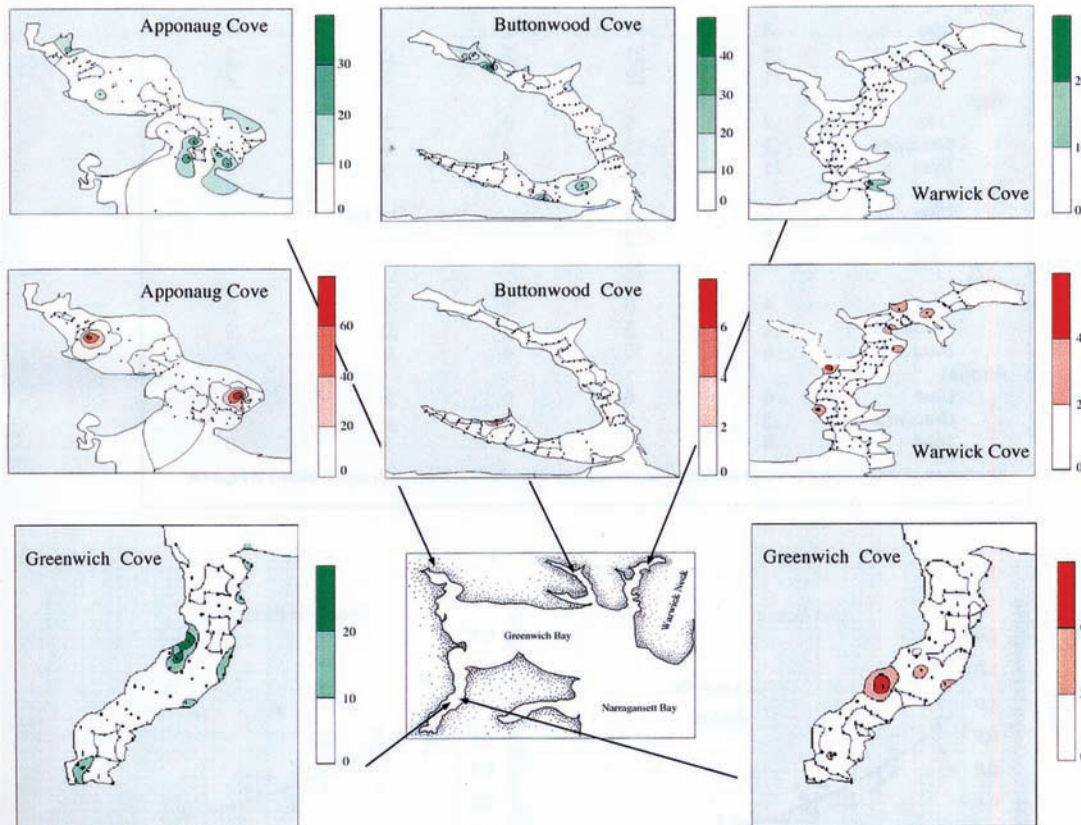

Figure 8.13. Biomass of *Ulva* (a green algae) and *Gracilaria* (a red algae) in the major coves of Greenwich Bay in July 1997. Units are in grams dry weight/m². Dots show sampling locations. *Source: Granger et al., 2000.*
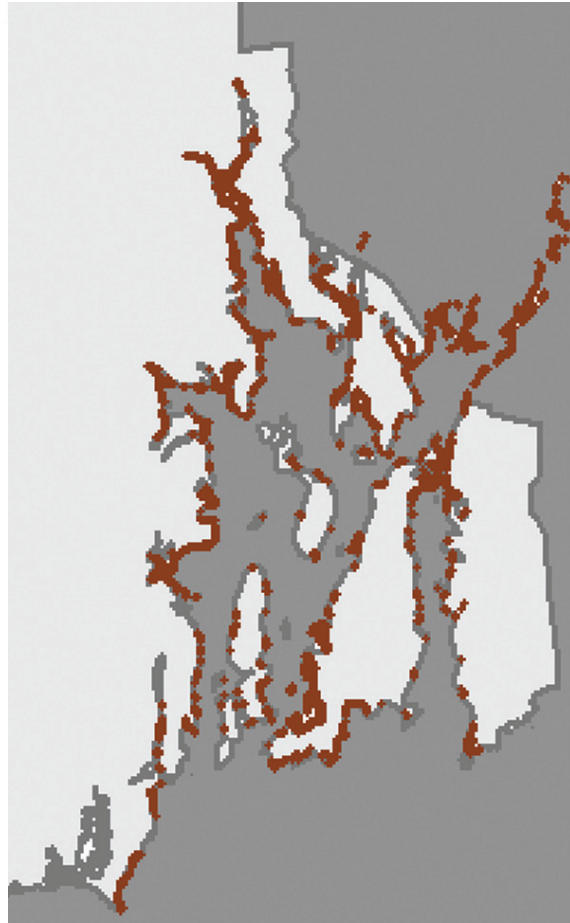
Figure 8.15. Within Narragansett Bay, over half of the shoreline is "hardened" with human-made structures (red areas). *Data source: RIGIS.*

Figure 8.17. This marina in Wickford Cove provided an ideal study site to explore the role of marinas as habitat. *Photo by Malia Schwartz.*

Figure 8.16. This bulkhead at State Pier #5 in Narragansett provides a sheltered cove to tie up, launch a boat, fish, or scuba dive. Human-made structures are designed to prevent erosion and provide sheltered areas for human use. *Photo by Malia Schwartz.*

Table 8.3. Macrophyte species collected during a 1989–1990 survey in Narragansett Bay. Species names read across, then down. *Data from French et al., 1992. Note: The genus* Enteromorpha *was recently reclassified as* Ulva.

Chlorophyta

Blidingia minima	*Bryopsis plumose*
Chaetomorpha aerea	*C. linum*
Cladophora albida	*C. sericea*
Codium fragile	*Enteromorpha compressa*
E. flexuosa	*E. intestinalis*
E. linza	*E. prolifera*
Kommannia leptoderma	*Monostroma grevillei*
M. oxyspermum	*Protomonostroma undulatum*
Rhizoclonium reparium	*Spongomorpha arcta*
S. lanosa	*Ulothrix flacca*
Ulva latuca	*Urospora penicilliformis*

Phaeophyta

Ascophyllum nodosum	*Chorda filum*
Cladosiphon zosterae	*Cladostephus spongiosus*
Desmarestia viridis	*Desmotrichum undulatum*
Dictyosiphon foeniculaceus	*Ectocarpus siliculosus*
Elaschista fucicola	*Fucus evanescens*
F. spiralis	*F. vesiculosus*
Giffordia granulosa	*Laminaria digitata*
L. saccharina	*Leathesia difformis*
Petalonia fascia	*Pilayella littoralis*
Punctaria latifolia	*Ralfsia verrucosa*
Scytosiphon lomentaria	

Rhodophyta

Agardhiella subulata	*Ahnfeltia plicata*
Antithamnion cruciatum	*Audouinella* sp.
Bangia atropurpurea	*Bonnemaisonia hamifera*
Callithamnion baileyi	*C. byssoides*
C. tetragonum	*Ceramium elegans*
C. rubrum	*Champia parvula*
Chondrus crispus	*Corallina officinalis*
Cystoclonium purpureum	*Dasya baillouviana*
Dumontia contorta	Encrusting corallines
Gelidium pusillium	*Gloiosiphonia capillaries*
Gracilaria tikvahiae	*Griffithsia globulifera*
Grinnellia Americana	*Hildenbrandia rubra*
Lomentaria baileyana	*Mastocarpus stellatus*
Palmaria palmata	*Phycodrys rubens*
Phyllophora pseudoceranoides	*P. truncata*
Plumaria elegans	*Pneophyllum lejolisii*
Polyides rotundus	*Polysiphonia denudata*
P. fibrillose	*P. harveyi*
P. lanosa	*P. nigra*
P. nigrescens	*P. novae-angliae*
P. urceolata	*P. umbrilicalis*
Porphyra umbilicalis	*Pterothamnion plumula*
Rhodomeia confervoides	*Scagelia pylaisaei*
Titanoderma pustulatum	

Cyanophyta

Callothrix sp.	*Microcoleus lyngbyaceus*

Chrysophyta

Berkeleya rutilens	*Grammatophora angula*
Licomorpha sp.	*Melosira* sp.
Vaucheria sp.	

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