4. HABITAT

Habitat is the place where an organism is found (Ricklefs 1990), and is often characterized by a dominant plant (*e.g.,* salt marsh or seagrass) or physical characteristic (*e.g.,* cobble fields, reefs, wrecks). While one typically thinks of habitat as these types of biotic or abiotic structures, it is important to recognize that the ocean water itself, throughout the water column, is habitat for countless organisms. Likewise, the air above the ocean, and the sediments beneath it, provide important habitat in the form of shelter, forage opportunities, breeding locations, migration corridors, and other ecological services.

Describing habitat involves issues of scale and the inherent variability of natural resources. For example, whale habitat is described in terms of thousands of kilometers (hundreds of miles) of ocean, while juvenile fish habitat is described by unique seafloor characteristics or microhabitats on the scale of centimeters to meters (inches to feet). In addition to these spatial ranges, in the temperate northeast, there are large variations in the physical properties of the ocean and coastal environment that can affect the temporal nature of habitats. The most obvious change within the planning area is the temperature shift from summer to winter, but there are also seasonal changes in salinity, dissolved oxygen, sediment grain size, the depth of stratification of the water column, the presence or absence of certain plant species, and the concentration of nutrients and minerals in the water column. Owing to these spatial and temporal variations, the ocean environment in Massachusetts contains a diverse suite of habitats that support many resident and migratory organisms and their life history stages.

Changes to ocean habitats through the addition of man-made structures, the disturbance of sediments, or the addition of pollutants, can have profound effects upon how an organism fulfills its life history and can cause the weakening or breakage of vital food web links. There is scientific evidence to suggest that as food webs become weakened, either through disturbance (Altman and Whitlatch 2007, Didham *et al.* 2007) or the addition of non-native species (Cohen and Carlton 1993), native species are more likely to be replaced by non-native species, further changing ecosystem dynamics. In some cases, mitigation efforts may restore habitat, but experience has shown that these efforts are expensive and often fail to replicate the original habitat.

Within and outside of the planning area, pollution, coastal alteration, and fishing practices have already dramatically altered the extent and quality of estuarine and marine habitats. For example, many estuaries on the south side of Cape Cod and in Buzzards Bay, are eutrophied (*i.e.,* have high nutrient content and low bottom dissolved oxygen) and have seen the replacement of native eelgrass (*Zostera marina*) beds by macroalgae that provide relatively less habitat. In deeper waters, much of the bottom has been scoured by trawling gear, greatly changing the complexity and habitat quality of the seafloor. Any future uses of the planning area should consider existing habitat and ecological services that are provided by the ocean and whether the new uses will diminish the existing habitat quality (which is often already affected by human alterations). This section of the baseline assessment documents the various uses of the planning area as habitat for plants and animals across the marine food web, discusses the identification of important habitats, and describes measures that may be used to mitigate for habitat conversion or fragmentation.

PRIMARY AND SECONDARY PRODUCERS

Primary and secondary productivity is a measure of the abundance or mass of photosynthesizers and the organisms that graze upon them, respectively. Primary producers perform the important role of capturing the sun's energy and transforming it to a form that other organisms can utilize. For the most part, primary producers are plants or cyanobacteria, either attached or free-floating; although, it should also be noted that there are some primary producers, called chemosynthesizers, that do not photosynthesize, but they are relatively rare and are not considered further in this document. Within the planning area, there are some areas that are shallow enough to support attached plant life. For example, eelgrass has been observed near Great Misery and Bakers Islands in Salem Sound, Great Island in Wellfleet, the Weepecket Islands in Gosnold, and in the shoals of Cape Cod Bay off of Brewster and Orleans. In addition, macroalgae can be found on sand, cobble, ledges, and man-made structures throughout the planning area, wherever there is enough light on the bottom to support photosynthesis. One important macroalgae is kelp, a brown alga represented by three genera (*Agarum, Alaria, Laminaria*) in Massachusetts.

While seagrasses and macroalgae may be the most obvious primary producers, the major contributors to primary production in the ocean are free-floating phytoplankton. Zooplankton are the organisms (*e.g.,* copepods) and larvae (*e.g.,* fish and crustaceans) that graze upon phytoplankton, and each other, while actively or passively moving through the water column. Together the two types of plankton form the foundation of most marine food webs. For more information on primary producers such as kelp and seagrass, see Donovan and Tyrrell 2004.

Monitoring by the Massachusetts Water Resources Authority (MWRA) has demonstrated that there are distinct peaks ("blooms") in phytoplankton abundance in early spring (April), summer (June), and fall (October) in Massachusetts Bay. The phytoplankton species assemblage in Massachusetts Bay includes microflagellates and cryptomonads, which are numerically dominant throughout the year, but reach peak abundances in summer (Werme *et al.* 2008). Diatoms are another major phytoplankton species that are abundant in fall, winter, and spring. Early spring blooms of the toxic alga *Phaeocystic pouchetti* occur annually and are apparently not related to the MWRA outfall in Massachusetts Bay. There is some evidence to suggest that the length of the *P. pouchetti* bloom is related to the day of year at which ocean temperatures first reach 14 C° (57° F)—with bloom durations around 100 days when temperatures warm to 14° C in June, while blooms last only about 10 days when temperatures warm to 14° C in April (Werme *et al.* 2008). There have also been regular blooms of the toxic dynoflagellates *Alexandrium fundyense* and *A. tamarense* in the late spring and summer. *Alexandrium* densities typically range from 1-100 cells per liter (cells/l or cells/1.1 quart) in Massachusetts Bay when they are present, but cell densities were as high as 8,000 cells/l in 2005 and 600 cells/l in 2006. Anderson *et al.* (2007) have suggested that the 2005 bloom was a result of a high abundance of *Alexandrium* cysts in Gulf of Maine sediments in 2004. Winds from the northeast also assisted in maintaining the bloom by driving *Alexandrium* patches toward the shore and into Massachusetts Bay. *Alexandrium* blooms are monitored closely and have led to large seasonal closures of shellfish harvesting areas along the Massachusetts coast, from the border with New Hampshire to Cape Cod.

Zooplankton graze on phytoplankton and are, in part, responsible for the periodic subsidence of phytoplankton blooms (changing climatological patterns and cycles of nutrients and other resources affect cycles as well). The zooplankton community in Massachusetts Bay in 2006 was dominated by the copepods *Oithona similis* and *Pseudocalanus spp.* Other copepod species typical of the Gulf of Maine include: *Calanus* *finmarchius*, *Paracalanus parvus*, *Centropages typicus*, and *Centropages hamatus* (Libby *et al.* 2007). Early life stages of bivalves, gastropods, barnacles, polychaetes, crustaceans, and fish are also important components of the zooplankton community. From 2001-2006, MWRA documented a decrease in total zooplankton abundance over the 1992-2000 period. Copepod abundance in particular was found to be lower in Massachusetts Bay and offshore, with the most abundant species, *O. similes*, showing the most dramatic decrease. Notably, the relatively larger copepod *C. finmarchius* has not decreased in abundance and in fact has increased in abundance since 2000 (Libby *et al.* 2007). While it is not the most abundant, the size of *C. finmarchius* relative to other zooplankton makes it the most important contributor to the zooplankton biomass cycle (Bourne 1987). There have been suggestions across the globe that zooplankton abundances may be lower due to an increase in filter feeders, especially ctenophores (comb jellies) and jellyfish.

BENTHIC COMMUNITIES

Benthic communities are defined by the dominant species and a variety of community indices such as species richness, diversity, and evenness. The species that typify the benthic communities in Massachusetts include polycheate worms and amphipods (*e.g.*, *Eucone incolor, Aricidea quadrilobata, Levinsenia gracilus, Exogenes spp,* and *Crassicorophium crassicorne*), sand dollars, bivalves, and sea anemones. Hard bottom communities include algae, sponges, and sea anemones (Auster and Langton 1999). It is known that areas of soft coral and kelp, both important benthic communities, exist within the planning area, but they have not been mapped (Comm. of Mass. 2004). The most robust dataset examining benthic community temporal trends in the planning area has been collected by the Massachusetts Water Resources Authority during impact assessment and environmental quality monitoring for the Boston Harbor outfall (MWRA 2006). There are smaller studies with benthic infaunal information in Buzzards Bay and associated with construction projects. However, Massachusetts is lacking a comprehensive map of benthic communities.

Benthic communities are highly correlated to major physical parameters including depth, water flow, oxygen penetration, and grain size (Biles *et al.* 2003; Diaz and Rosenberg 1995). Therefore, preliminary work was conducted to characterize the physical parameters in the planning area. Benthic terrain modeling (BTM) was utilized to map major depth and slope features in the planning area. Five seafloor classes were mapped (crests, depressions, flats, and areas of low and high slope). The BTM was then combined with sediment composition and seafloor roughness and the analysis defined 56 unique combinations of seafloor habitat classes within the planning area (Figure 4.1). Because the correlation of benthic community to grain size is strong, it should be relatively straightforward to stratify the existing acoustic data and set up a series of benthic stations both for characterizing the planning area and examining long term trends. More than half of the planning area still remains to be mapped using high resolution acoustic methods coupled with groundtruthing as part of the USGS-CZM Seafloor Mapping Cooperative. The importance of such mapping cannot be overstated. Seafloor mapping is the cornerstone of any habitat assessment, and is similar to topography and soils mapping on land. Complete mapping of the seafloor communities in Massachusetts will also enable assessments of ecosystem uniqueness, vulnerability, and resiliency.

There is conflicting research regarding the recovery rates of different benthic community types. Ranges for hard bottom communities (gravel, cobble, rocky, and ledge) are thought to be as long as 10 years (reference) and soft bottom communities (mud) are typically shorter (Bruce Estrella pers comm. – find better reference).

FISHERIES RESOURCES, SHELLFISH, AND HABITAT

There are over 200 species of fish that utilize the planning area, and all of state waters are important to marine fisheries in some manner, by either directly or indirectly supporting a species. Massachusetts is a relatively data-rich coastal state, and we are fortunate to have a consistent multi-season, multi-year, stratified-random trawl survey dataset with which to examine trends in fisheries abundance and distribution. The federal stock assessment survey utilizes the results of the state survey. There are important caveats to the analysis of fisheries resources. First, only species vulnerable to the survey method (an otter trawl towed at 4.6 km/h or 2.5 knots) are captured. Many pelagic species and shellfish species, as well as some ecosystem indicator species such as forage fish, are not vulnerable to capture. Second, the survey was designed to examine relative abundance of species, not spatial distribution. Third, the survey occurs only in May and September during daylight hours, so important seasonal fisheries and habitat use is not captured. Fourth, portions of the planning area are undersampled due to the inability of the sampling gear to sample in complex topography. These areas likely represent some of the more critical habitat types for population bottlenecks of some species. Fifth, there is no statewide survey of the distribution of shellfish species.

With an end goal of determining what areas of the planning area are important to marine fisheries as a whole, the dataset was used to map the relative importance of different parts of the planning area to 22 species of commercial or recreational value vulnerable to the survey method. In general, the major areas of importance are inner Massachusetts Bay, Ipswich Bay, Nantucket Sound, and outer Vineyard Sound.

This is an oversimplification of the areas "important" to fisheries resources, and the analysis by necessity eliminated considerable detail. Even areas of "low importance" can have resources not found elsewhere and that have particular vulnerability to impact. Therefore, it is worth identifying other analyses that could be conducted with this dataset. Greater detail regarding spatial distribution, such as the identification of biological "hot spots" and species with highly homogenous distributions could be done. The data as analyzed consolidated 30 years of data, and therefore ignored temporal trends in both abundance and distribution. Species shifts due to climate events such as the North Atlantic Oscillation or warming temperatures would be worthwhile to identify. Lastly, examining additional biological indicators such as community composition, abundance, and diversity (including species richness and evenness) should be considered as potential analyses with the MarineFisheries data.

In the planning area, the shellfish in order of highest abundance based on landings data are surf clams (*Spisula solidissima*), ocean quahogs (*Arctica islandica*), and sea scallops (*Plactopecten magellanicus).* Inshore of the planning area, in order of highest abundance are quahogs (*Mercenaria mercenaria*), soft shell clams (*Mya arenaria*), blue mussels (*Mytilus edulis*), razor clams (*Ensis directus*), oysters (*Crassostrea virginica*), and bay scallops (*Argopecten irradians*).

Although there is no statewide resource assessment for shellfish, shellfish suitability maps were updated this year to illustrate areas of known or anticipated shellfish resource. Some of the regions with shellfish resources that could be considered more vulnerable, or at greater risk of impact in general include: Nantucket Shoals (surf clams), Nantucket Sound (quahogs), Cape Cod Bay (ocean quahogs and sea scallops), and the North Shore (sea scallops).As with other resources, the risk of impact is highly dependent on the proposed use.

There are additional datasets that may be useful to examine in conjunction with the MarineFisheries datasets, in particular the Massachusetts Water Resources Authority dataset.

With the recent advances in oceanographic data collection and a push toward ecosystem based management, there is considerable interest in the fisheries research and management community to better couple biological and physical parameters. One way to describe this type of mapping is "potential habitat mapping." The idea is to define habitats using the life history characteristics of fish, and then model several physical parameters to predict where those habitats are, and by association, where particular species or species groups are located. The major habitat features of critical importance to marine fisheries resources in Massachusetts are listed in Table 4.1. (This list may be incomplete since some areas in the ocean may appear "featureless," but still be an important part of the ecosystem.)

Table 4.1. Habitat features of importance to fisheries resources.

Habitat Features	Species
3D Structure: Abiotic (Cobble/rocky/boulder/ledge bottom (not shell) often called "rock piles")	Many species utilize this type of bottom due to the 3D structure which provides shelter. Some species' life histories require this type of habitat. For example juvenile cod and lobster.
3D Structure: Biotic (SAV, Kelp, and structure-forming inverts)	Many species utilize this type of bottom due to the 3D structure which provides shelter. Some species' life histories require this type of habitat.
Upwelling	Important to driving productivity by bringing in nutrients; may not be a major feature in Massachusetts but could be important on a local scale
Deeper waters (channels, depressions)	Temperature and storm wave refugia
Estuaries, river mouths	Turbidity front at fresh-salt water interface can influence productivity
Shell Habitat	Settling habitat for invertebrates, may provide shelter
Shallow waters (<1.5 m or 5 ft) Mud Flats Salt Marshes	Critical nursery areas; mud flats are of high value to infauna.
Frontal boundaries	Represent important "edge" habitat for a wide variety of resident and migratory pelagic species.
Tide rips	Smaller frontal boundary features; sportfishing species; variety of species utilize these features and are popular fishing spots
Mud bottom	Has potential to provide abundant forage; lower resiliency to recurrent impacts in cold/deep mud

	bottom

In order to map these habitats, a variety of datasets are currently being assembled. These data include depth, sediment composition, biotic structure forming organisms, temperature, salinity, wave base, near bed sheer stress, light attenuation, primary and secondary productivity, frontal probability, and water column stratification. Most of these datasets exist but require compilation. It is anticipated that these variables will be used in a coupled bio-physical model to map fisheries habitats. There are several regional and federal efforts underway to collect data useful for the ocean planning process, and some of those efforts are attempting to create products (such as habitat models) that may benefit Massachusetts.

AVIFAUNA

The beaches, marshes, estuaries, rocky outcrops, and islands along the Massachusetts coastline, as well as the ocean waters themselves, provide valuable habitat for the reproduction and foraging of resident and migratory bird species. While most of these areas are outside the planning area, it is impossible for birds to access these important habitats without flying through the planning area, so the species that utilize them are considered in this baseline assessment. Furthermore, there are several islands of importance to avifauna actually within the planning area (*e.g.*, off of Rockport, Beverly, Boston Harbor, Wellfleet, and within Buzzards Bay) that must be acknowledged.

Owing to the fact that a large part of the Massachusetts coastline (*i.e,* Cape Cod) juts into the Atlantic flyway, one of four major north American migration routes, the Massachusetts coastline and its waters provide habitat for thousands of migrating ducks, shore birds, predatory birds, and songbirds (Figure 4.2). Waters and islands within the planning area regularly serve as staging grounds or stopovers for migrating birds, providing shelter from winds and waves, and in some cases also important high-calorie foods needed for migration or to survive New England's harsh winters. Given the importance of the planning area as part of an international flyway, it is critical to consider how any new, large, structural obstacles might possibly affect the safe passage of migratory birds.

Shorebirds

Shorebirds utilizing the planning area in late spring and early summer feast on a variety of invertebrates, such as amphipods, small mollusks, marine worms, and possibly horseshoe crab eggs. The migrant shorebirds most common in coastal Massachusetts during spring migration are Black-bellied and Semipalmated plover, Greater Yellowlegs, Ruddy Turnstone, Red Knot, Sanderling, Least Sandpiper, Dunlin, and Short-billed Dowitcher. Most numerous of the breeding species are Piping Plover, American Oystercatcher, and Willet. During autumn migration, the species above are joined by varying numbers of Lesser Yellowlegs, Whimbrel, Hudsonian Godwit, Semipalmated and White-rumped sandpipers. Less common fall migrants include American Golden-Plover, Marbled Godwit, and Western, Baird's, Pectoral, and Buff-breasted sandpipers (USFWS 2001).

Many of these species fly thousands of miles in each direction during their annual migration—some going as far south as the southern tip of South America (*e.g.*, Hudsonian Godwit, Red Knot, White-rumped Sandpiper) and as far north as the Canadian arctic or western Greenland. In order to support their epic migrations, most shorebirds typically make several stops at key locations to replenish their fat reserves. Within the planning area, there are several key shorebird stopover sites, most notably the Parker River National Wildlife Refuge and the Great Marsh Important Bird Area (IBA) on the north shore, Duxbury and Plymouth Bay IBA on the south shore, Monomoy National Wildlife Refuge/South Beach IBA in Chatham, and several key sites on the Cape Cod National Seashore (*e.g.*, Nauset Marsh and First Encounter Beach in Eastham).

Colonial Waterbirds

Small, off-shore islands provide important nesting areas for colonial nesting waterbirds including Leach's Storm-Petrel, Double-crested Cormorant, egrets, herons, Glossy Ibis, gulls, terns, and Black Skimmers. Because some of these species are ground nesters (*e.g.,* gulls, terns, and skimmers) they are at a great risk from trampling by foot traffic or predation by mammals that may occur on their nesting islands. Long-legged wading bird nests are usually built in trees and shrubs, which gives them increased protection from trampling and predation from exclusively ground predators; however, because they occur in dense aggregations of up to dozens of nesting pairs, entire colonies may be affected if they are disturbed by human activities.

There are several islands within the planning area that support large nesting waterbird colonies (*e.g.*, Ram and Bird Islands in Buzzards Bay. In addition to the importance of Massachusetts coastal areas and surrounding waters for breeding, several sites are essential post-breeding staging habitat for terns. The majority of the entire North American population of Endangered Roseate Terns uses Cape Cod, south shore, and Buzzards Bay sites for resting/foraging before migrating to South America. Thousands of Common Terns, hundreds of Forster's Terns, and Black Terns also use these staging sites. Based on color-band re-sighting information, it is known that individual Roseate Terns (in mixed flocks with Common Terns) often make repeated transits across open ocean throughout the project area, moving from site to site throughout the July-September staging period (B. Harris and J. Spendelow, unpublished data).

Waterfowl

The many coves, coastal ponds, and estuaries in the planning area regularly harbor waterfowl during the spring and fall migration, as well as during the winter, and a few also support foraging and nesting habitat for resident species. From late summer through fall, Gadwall, American Wigeon, American Black Duck, Mallard, Northern Shoveler, Northern Pintail, and Green-winged Teal, migrate through the planning area, while mid to late fall brings huge numbers of coastally migrating eiders, scoters, and Long-tailed Ducks.

Recent data collected by Mass Audubon suggest that the waters around Nantucket probably hold the densest winter aggregations of Long-tailed Ducks in the world (Simon Perkins personal communication). Long-tailed Ducks apparently forage on amphipods and mollusks from the south side of Nantucket out to Nantucket Shoals during the day, only to return to more protected waters north of Nantucket Sound for the night. The largest aggregations of eiders and scoters in New England have also been documented overwintering in the waters near Nantucket and Martha's Vineyard. Analysis of gut contents suggest that eiders are usually foraging on mussels along the western side of Muskeget Channel (S. Perkins, personal communication).

Songbirds

During fall migration, northwesterly winds following cold fronts periodically drift migrating songbirds over the planning area, most notably in the Cape Cod region. Under normal conditions the presence of these birds in the study area is minimal; however, under adverse migration conditions during fog or light rain, many birds could be affected by a combination of winds, lighted towers, or other obstructing objects in their course of migration (*e.g.*, lighthouses, wind turbines, *etc.*).

Pelagic Seabirds

The near coastal waters of the Stellwagen Bank National Marine Sanctuary and the waters to the east of Cape Cod routinely host an abundance of seabirds in many of the same locations that are important for marine mammals. Seabirds such as shearwaters, storm-petrels, Northern Gannet, and jaegers spend the majority of their lives at sea; however, during extreme weather events such as hurricanes and nor'easters, very large numbers regularly enter the study area, especially the waters bounded by Cape Cod Bay. The unusual coastal configuration of Cape Cod makes the waters of Cape Cod Bay of considerable significance, even if only under episodic conditions.

Predatory Birds

Several species of migratory raptors also regularly follow the coastline within the study area. These primarily include Northern Harrier, Sharp-shinned Hawk, and falcons of three species. The Northern Harrier is listed as a threatened species in Massachusetts due to a loss of appropriate nesting habitat; however the explanation for the precipitous decline in American Kestrel numbers is currently unclear.

Species with Special Protection

Sixteen species of protected birds use coastal habitats in Massachusetts for at least part of their life cycle (Table 4.2). In particular, significant numbers of federally listed species, including Roseate and Least Terns and Piping Plovers, nest on beaches and small islands within Massachusetts coastal areas. The breeding habitats of these species have special protection under state and federal laws. In particular no habitat alterations that result in a "take" (*i.e,* killing, maiming, or harassment) of these species is allowed. In addition to these habitats that are protected by state and federal regulations, there has been an effort to identify and conserve areas that provide habitat of significance to avifauna in Massachusetts. The Important Bird Area (IBA) Program, a national effort coordinated in Massachusetts by Mass Audubon, lists twenty-eight coastal sites in Massachusetts as IBAs for their value as feeding, nesting, and migration locations. Mass Audubon is currently cooperating with other interested parties to develop conservation plans for future habitat management in designated sites (Figure 4.3).

Table 4.2. Bird species with special state or federal protection that use the planning area.

Common name *Genus species*	Planning Area Use N = nesting M = migration F = foraging	State Listing * Federal Listing as well
Common Loon *Gavia immer*	M, F	Special Concern
Pied-billed Grebe *Podilymbus podiceps*	M, F	Endangered
Leach's Storm petrel *Oceanodroma leucorhoa*	M, F, N	Endangered

Piping Plover *Charadrius melodus*	M	Threatened*
Upland Sandpiper *Bartramia longicauda*	M	Endangered
Roseate Tern *Sterna dougallii*	M, F, N	Endangered*
Common Tern *Sterna hirundo*	N, M, F	Special Concern
Arctic Tern *Sterna paradisaea*	M, F	Special Concern
Least Tern *Sterna antillarum*	M, F	Special Concern
Golden winged Warbler *Vermivora chrysoptera*	M	Endangered
Northern Parula *Parula americana*	M	Threatened
Blackpoll Warbler *Dendroica striata*	M	Special Concern
Mourning Warbler *Oporornis philadelphia*	M	Special Concern
Vesper Sparrow *Pooecetes gramineus*	M	Threatened
Grasshopper Sparrow *Ammodramus savannarum*	M	Threatened
Henslow's Sparrow Ammodramus henslowii	M	Endangered

MARINE MAMMALS AND REPTILES

Major contributor: Erin Burke

Massachusetts waters provide excellent feeding and nursery habitat for a variety of marine mammals and reptiles. All of these species are either protected under the Marine Mammal Protection Act (MMPA) or listed as threatened or endangered under the Endangered Species Act (ESA). Many are also listed under the Massachusetts Endangered Species Act (MESA) (Table 4.3).

Table 4.3. Marine mammal and reptile species found in the Massachusetts ocean planning area.

Common name	Species name	Federal Protection	State Protection	Use of Planning Area
Right whale	*Eubalaena glacialis*	MMPA, ESA	MESA	Seasonal feeding
Humpback whale	*Megaptera novaeangliae*	MMPA, ESA	MESA	Seasonal feeding

Fin whale	*Balaenoptera physalus*	MMPA, ESA	MESA	Seasonal feeding
Minke whale	*Balaenoptera acutorostrata*	MMPA	none	Seasonal feeding
Harbor porpoise	*Phocoena phocoena*	MMPA	none	Seasonal feeding
Atlantic white-sided dolphin	*Lagenorhyncus acutus*	MMPA	none	Seasonal feeding
Gray seal	*Halichoerus grypus*	MMPA	none	Year-round feeding, pupping
Harbor seal	*Phoca vitulina*	MMPA	none	Seasonal feeding
Loggerhead sea turtle	*Caretta caretta*	ESA	MESA	Seasonal feeding
Green sea turtle	*Chelonia mydas*	ESA	MESA	Seasonal feeding
Hawksbill sea turtle	*Eretmochelys imbricata*	ESA	MESA	Seasonal feeding
Kemp's Ridley sea turtle	*Lepidochelys kempii*	ESA	MESA	Seasonal feeding
Leatherback sea turtle	*Dermochelys coriacea*	ESA	MESA	Seasonal feeding

The spatial and temporal distribution and abundance of these animals varies according to species. The greater Gulf of Maine and beyond is the actual range of many of these animals, and the individual bays and sounds could be thought of as neighborhoods (or restaurants) within a human city. For example, a right whale may go to Cape Cod Bay for lunch, but check out the Great South Channel for dinner. These "restaurants" are relatively spatially explicit, and genetic clustering of feeding populations of whales is possible, but there is no overall consensus on the geographic structure of whale populations in the North Atlantic Ocean, including the well-studied humpbacks (Raposa *et al.* In review).

From January through May, the endangered North Atlantic right whale returns each year to feed on abundant zooplankton in Cape Cod Bay (Leeney *et al.* 2008). Only around 400 individuals remain in this population and almost half of the population visited Cape Cod Bay in 2008. Because Cape Cod Bay provides such important forage for this highly endangered population, almost the entire bay is federally-designated as Right Whale Critical Habitat under the ESA. Right whales are also the official state mammal of Massachusetts.

Other endangered baleen whales, such as the fin and humpback whales, visit the Gulf of Maine in large numbers from April to October to feed on small schooling fish. While the food resource is mainly aggregated in federal waters around Stellwagen Bank and the Great South Channel, the whales do spend time feeding in Massachusetts waters, including Cape Cod and Massachusetts Bays. The Race Point area off Provincetown is an important large whale feeding area in late April and often throughout the summer months (Figure 4-X if we want a whale picture). In addition, many other seal, dolphin, and whale species depend on habitat in Massachusetts waters for all or part of their life cycles. For instance, gray seals are year-round residents in Massachusetts and have established colonies on Monomoy and Muskeget Islands, where they pup in the winter.

Five marine sea turtles species are found seasonally in Massachusetts waters, including the loggerhead, Kemp's Ridley, leatherback, green, and hawksbill sea turtles. These species have ranges that cover the entire Atlantic Ocean basin. All five species are listed as either endangered or threatened under the ESA. The most abundant reptile is the leatherback sea turtle, which can grow to 1.8 m (6 ft) in length. The leatherback feeds on jellyfish and other gelatinous zooplankton in areas including Nantucket Sound, Cape Cod Bay, and Buzzards Bay. South of Cape Cod, researchers from the University of New Hampshire and Woods Hole Oceanographic Institute have been studying the movements and prey abundance of leatherback sea turtles. The planning area plays a crucial role in the survival and prosperity of a wide range of marine mammal and sea turtle species. However, interactions such as entanglement in fishing gear, vessel strike, and increasing ocean noise pose threats to these species.

"IMPORTANT" MARINE HABITAT

As part of the development of the Massachusetts ocean management plan, a Habitat Work Group was formed and charged with identifying, characterizing, and ranking areas within the ocean planning area that are priorities as "important" habitat, irrespective of other ocean uses or resources.

Massachusetts coastal and marine areas—both inside and outside the ocean planning area—encompass essential and diverse habitats for a wide variety of estuarine and marine species and communities. The process of defining habitats can be approached from many angles and determining the overall and/or relative importance of particular habitats or species is a particularly taller order, especially in the context of inadequate or non-existent information. The Habitat Work Group used the language provided in Section 2 of the Oceans Act, "…identify…special, sensitive, or unique estuarine and marine life and habitats," as general guidance for the determination of important habitat: With that as an operative basis, the Work Group focused on three "tracks", with a short term goal of being able to identify priority areas within each component based on available information. The three "tracks" as defined by the Habitat Workgroup were: 1) mapped areas/resources with special legal protection, 2) habitat critical to or providing specific life stage support for important species (or group of species, such as guilds or assemblages), and 3) unique and/or sensitive habitats as indicated by abiotic parameters. The Work Group also agreed that it was critical to adopt a long term goal of acquiring, developing, and synthesizing data and information to revise the short term priority areas over time, based on a more complete and accurate understanding of habitat attributes, species life histories, and other data.

The first track of important habitat is comprised of priority habitats of State-and Federally-listed species mapped by the Commonwealth's Natural Heritage and Endangered Species Program (NHESP). Other mapped resources in this first component were: Ocean Sanctuaries, Massachusetts Department of Environmental Protection's eelgrass maps, Massachusetts Division of Marine Fisheries Shellfish Suitability Areas, Areas of Critical Environmental Concern, Cape Cod National Seashore, and National Wildlife Refuges. The second track identified important habitat areas including: 1) breeding, staging, and foraging for listed terns; 2) foraging for listed whales; 3) breeding and staging for Leach's Storm Petrels; 4) significant haul-out sites for seals; 5) breeding and staging areas for colonial seabirds; 6) seasonal locations of significant concentrations of Long-tailed Ducks; and 7) mapped eelgrass beds. The third track to identify important habitat utilized benthic terrain, rugosity, and sediment type to distinguish regions with high heterogeneity of bottom types.

INVASIVES

Invasive species are defined as non-native or cryptogenic (species with unresolved origins) species that are introduced by humans to a new location and cause harm to the ecosystem or economic resources of the area that they invade. Invasions can lead to negative impacts on native species from competition for food and/or habitat, physical overgrowth or smothering, spread of associated pathogens (or being a pathogen in itself), preying on native species, and habitat degradation (Figure 4.4). All of these factors individually or in combination may lead to a decline in the survival and population numbers of native organisms. The invading species may also foul structures, reduce navigation and recreational access, and appear unsightly. These additional side effects of invasive species can lead to negative impacts from loss of aesthetic, recreation, and resource values.

Most of the information known about invasive species presence in Massachusetts is reported through monitoring surveys of the low intertidal to shallow subtidal zone (A. Pappal, personal communication; Pederson *et al.* 2005). We do not know as much about species composition within the Ocean Management Area specifically, but given the life history characteristics and aggressive nature of marine invasives, we can make a reasonable assumption that the majority of these species could inhabit or impact the planning area. Table 1 lists marine introduced species known to be present in Massachusetts. The table does not include species with only a general habitat range that includes Massachusetts or cryptogenic species. Given a lack of information about species origins and limited monitoring of all marine habitats of Massachusetts, the number of introduced species could number into the hundreds (Carlton 2003).

The majority of marine introduced species listed in Table 1 are native to Europe or Asia (Carlton 2003). The high number of European species present in Massachusetts reflects the well-traveled shipping routes between the east coast of the U.S. and southern England, while Asian species may be the result of secondary introductions from established populations in Europe (Pederson *et al.* 2005). This highlights the importance of shipping as a vector for marine invasive species transport in Massachusetts and elsewhere (Ruiz *et al.* 2000). Other possible introduction mechanisms include escapes and releases from the aquaculture and fisheries industry, the pet trade, intentional introductions for food sources, research, and educational supplies.

Although many of the species listed in Table 4.4 have the potential to negatively impact ecosystems and economic resources of the Ocean Management Area, there are a few of particular concern:

***Didemnum vexillum* (mystery tunicate):** *D. vexillum* is one of seven introduced tunicates present in Massachusetts. First discovered in the Gulf of Maine in 1988, it has since rapidly colonized both nearshore and subtidal habitats, including Stellwagen Bank, Tillies Bank, and significant portions of Georges Bank, potentially smothering critical habitat and competing with native species (Bullard *et al.* 2007). This species is abundant on the north shore on both man-made and natural structures, at marinas in Buzzards Bay, the outer Cape, in tidepools of Cape Cod Bay, and in the South Essex Ocean Sanctuary portion of the Ocean Planning Area (A. Pappal, personal communication). In addition, there have been recent reports of *D. vexillum* colonizing eelgrass in areas around Martha's Vineyard (Carmen, personal communication). This species has no known predators and currently there are no means to control its spread. Like many other species, *D. vexillum*, can reproduce and spread from fragments (Bullard *et. al* 2007). Thus any activity within or outside the planning area that can fragment *D. vexillum* (trawls, dredges, power-washing) will facilitate its spread.

Table 4.4 Marine introduced species in low intertidal to shallow subtidal waters of Massachusetts.

Taxonomic Species	NSOS	SEOS	MB	CCBOS	CCOS	CIOS	Data Source(s)
Protista							
Haplosporidium nelsoni (MSX oyster disease)				○		○	Hickey per. com. 2001
Cholorophyceae							
Codium fragile ssp. tomentosoides (green fleece)	●	●	●	●	●	●	Pappal per. com. 2008 Pederson *et al.* 2005
Rhodophyceae							
Grateloupia turuturu (red algae)			○	○			Mathieson *et al.* 2008b
Neosiphonia harveyi (red algae)			●			●	Pederson *et al.* 2005
Porphyra yezoensis f. yezoensis (nori, red algae)	○		○	○			Mathieson *et al.* 2008a
Porphyra katadae (nori, red algae)				●		●	Mathieson *et al.* 2008a
Porifera							
Halichondria bowerbanki (sponge)			○			○	*Pederson et al.* 2005
Nematoda							
Anguillicola crassus (eel nematode)	●	●	●	●		●	Aeita per. com. 2008
Cnidaria							
Diadumene lineata (orange striped anemone)	●	●	●	●		●	Pappal per. com. 2008, Pederson et. al. 2005
Sagartia elegans (purple anemone)		○					Pederson *et al.* 2005
Polychaeta							
Janua pagenstecheri (spirorbid worm)			○			○	Pederson *et al.* 2005
Mollusca							
Littorina littorea (common periwinkle)	●	●	●	●	●	●	Pappal per. com. 2008, Pederson et al. 2005
Ostrea edulis (flat oyster)		○	○				Pappal per. com. 2008, Pederson et al. 2005
Tritonia plebeia (sea slug)			●				Allmon and Sebens 1998
Arthropoda							
Ianiropsis sp. (isopod)						●	Pederson *et al.* 2005
Caprella mutica (skeleton shrimp)			○			○	Pederson *et al.* 2005
Microdeutopus gryllotalpa (amphipod)						●	Pederson *et al.* 2005
Carcinus maenus (green crab)	○	○	○	○	○	○	Pappal per. com. 2008, Pederson et al. 2005
Hemigrapsus sanguineus (Asian shore crab)	●	●	●	●	●	●	Delaney *et al.* 2008, Pappal per. com. 2008, Pederson *et al.* 2005
Bryozoa							
Alcyonidium sp. (bryozoan)			○	○			Pappal per. com. 2008
Bugula neritina (purple bryozoan)		●	●				Pappal per. com. 2008, Pederson et al. 2005
Membranipora membranacea (lacy crust)	○	○	○				Pappal per. com. 2008, Pederson et al. 2005
Tunicata							
Ascidiella aspersa (European sea squirt)	●	●	●	●		●	Pappal per. com. 2008, Pederson et al. 2005
Botrylloides violaceus (sheath tunicate)	○	○	○	○	○	○	Pappal per. com. 2008, Pederson et al. 2005
Botryllus schlosseri (star tunicate)	●	●	●	●	●	●	Pappal per. com. 2008, Pederson et al. 2005
Didemnum vexillum (mystery tunicate)	○	○	○	○	○	○	Pappal per. com. 2008, Pederson et al. 2005
Diplosoma listerianum (compound tunicate)	●	●	●	●		●	Pappal per. com. 2008, Pederson et al. 2005
Styela canopus (rough tunicate)						○	Pederson *et al.* 2005
Styela clava (club tunicate)	●	●	●	●		●	Pappal per. com. 2008, Pederson et al. 2005

Locations: NSOS = North Shore Ocean Sanctuary, SEOS = South Essex Ocean Sanctuary, MB = Massachusetts Bay, CCBOS = Cape Cod Bay Ocean Sanctuary, CCOS = Cape Cod Ocean Sanctuary, CIOS = Cape Cod and Islands Ocean Sanctuary.

***Codium fragile* ssp. *tomentosoides* (green fleece):** The green algae *Codium fragile* ssp. *tomentosoides* was first documented in the Gulf of Maine in 1964 (Harris and Mathieson 1999). A native of Asia, *C. fragile* can be found at marinas, rocky intertidal, and subtidal habitats across Massachusetts. This species can colonize disturbed areas and displace native seaweeds, leading to a decrease in habitat function and impacts on economically important species of fish, sea urchins, and lobsters (Harris and Mathieson 1999, Scheibling 2001, Scheibling and Gagnon 2006). Once established, *C. fragile* becomes the dominant canopy species and prevents re-colonization by native species (Scheibling and Gagnon 2006). Similarly to *D. vexillum*, *C. fragile* can reproduce by fragmentation (Bégin and Scheibling 2003).

***Membranipora membranacea* (lacy crust bryozoan):** A native of Europe, *M. membranacea* was first discovered in the Gulf of Maine in the late 1980s, most likely the result of a ballast water introduction due to a long-lived planktonic larvae (Berman *et al.* 1992, Yoshioka 1982). *M. membranacea* colonizes and overgrows native kelp species, weakens the blades, and eventually leads to a decrease in density and size of kelp beds due to blade breakage (Lambert *et al.* 1992). Kelp beds are a critical habitat for native species such as juvenile cod (*Gadus morhua*), green sea urchin (*Strongylocentrotus droebochiensis*), and other invertebrates (Scheibling 2001). The reduction of kelp beds by *M. membranacea* not only reduces the amount of habitat available to native species, but also may facilitate colonization of the area by another invader, the green algae *Codium fragile* ssp. *tomentosoides* (Scheibling and Gagnon 2006), further decreasing habitat value.

The Massachusetts Aquatic Invasive Species Working Group (the AIS Working Group) is a collaborative of state agencies, federal agencies, and non-profits tasked with "implementing a coordinated approach to minimize the ecological and socio-economic impacts of Aquatic Invasive Species in the marine and freshwater environments of Massachusetts" (MCZM 2002). To meet these goals, the Massachusetts Aquatic Invasive Species Management Plan (the Management Plan) was developed to coordinate AIS management, prevention, monitoring, and control efforts across the Commonwealth. The Management Plan has become the primary guidance document for aquatic invasive species activities across Massachusetts and was approved by the Federal Aquatic Nuisance Species Task Force in 2002.

Recognizing that early detection is a critical tool in the battle against marine invasive species, the AIS Working Group included a task in the Management Plan to develop a regional Early Detection Network for marine invasive species, and in 2006 the Marine Invader Monitoring and Information Collaborative (MIMIC) was established. The collaborative is a partnership between agency staff, scientific experts, volunteers, and non-profits which monitor marine invasive species at over 50 sites across New England. MIMIC and other monitoring programs such as the Rapid Assessment Survey (Pederson *et al.* 2005) provide critical information about the distribution of marine invasive species. However, additional monitoring within the Ocean Planning Area will be critical to further understand the presence and impacts of marine invasive species to the ecosystem and economic resources of Massachusetts.

MAN-MADE HABITAT, MITIGATION, RESTORATION

Major contributors: Tom Shields, Mark Rousseau, Tay Evans

Shellfish

There are several programs in state waters that involve shellfish seeding or movement for impact avoidance or depuration (Figure 4.5). The *MarineFisheries* Shellfish Stock Enhancement program is the only program that is set up to specifically restore impacted populations of shellfish. This program was created in 2003 under the HubLine gas pipeline mitigation efforts. The program goal is to restore and enhance existing populations of soft shell clams in Boston Harbor communities. Seeding projects are currently underway in five communities (Winthrop, Quincy, Weymouth, Hingham, and Hull). Other restoration projects with shellfish components include the construction of terraced concrete structures deployed as an artificial reef near Sculpin Ledge in Boston Harbor. The terrace design was intended to give hard bottom substrate for blue mussels (*Mytilus edulis*) as partial mitigation for impacts to blue mussel habitat filled during the capping of the Spectacle Island landfill. Another program designed to restore a shellfish resource is an oyster reef that the Town of Wellfleet, The Nature Conservancy and the Audubon Society will be constructing in Wellfleet Harbor. All of these projects are outside of the planning area.

Artificial Reefs

Massachusetts defines an artificial reef as an area within the marine waters of the Commonwealth in which approved structures have intentionally been placed or constructed for the purpose of enhancing benthic relief. Structures may be designed to provide and/or improve opportunities for recreational and commercial fishing, aid in the management or enrichment of fishery resources and ecosystem services, or to achieve a combination of these objectives. Because of the presence of existing hard bottom and patch habitats or because of existing uses, site selection has been identified as the critical issue for artificial reef development in Massachusetts (Barber *et al.* In press). However, with appropriate siting, several benefits of artificial reef development have been identified (*e.g.*, a tool for mitigating habitat loss, increasing biodiversity through the use of more complex structure, and increased commercial and recreational fishing opportunities) (Rousseau 2008).

Two artificial reefs have been used in Massachusetts since 1999 for mitigating cumulative environmental impacts resulting in the loss of fisheries habitat. The Sculpin Ledge reef was constructed in 1999 in Boston Harbor by the Massachusetts Bay Transit Authority (MBTA) to provide blue mussel (*Mytilus edulis*) and American lobster (*Homarus americanus*) habitat. In 2006, *MarineFisheries* constructed an artificial reef east of Lovell Island designed to target the habitat requirements of different life history stages of invertebrate and finfish species. At this reef, efforts to monitor the length of time it takes for an artificial reef to mimic the species abundance and diversity seen on nearby natural reefs is a primary research goal. Currently there is an artificial reef project proposed to mitigate for potential habitat loss resulting from a beach nourishment project on Nantucket.

Prior to 1999, artificial reef development consisted of efforts to increase recreational angling opportunities by deploying materials that provided vertical relief in featureless areas. The Yarmouth tire reef was deployed in 1978 and was designed to provide desirable habitat for finfish and lobsters in a relatively featureless area of Nantucket Sound. The Dartmouth artificial reef was deployed in 1998, and was designed to enhance recreational angling opportunities in Buzzards Bay. This reef, constructed of prefabricated concrete reef balls, was supported by state funds and implemented at the urging of local and state officials. Three of the four artificial reef sites are inside of the planning area.

Eelgrass

Eelgrass (*Zostera marina*) beds were once a dominant subtidal feature in the coastal embayments of Massachusetts. A combination of habitat degradation and disease has hastened their decline over the past century (Orth *et al.* 2006). Because this important habitat continues to be threatened by anthropogenic impacts, efforts are made in the environmental permitting process to avoid, minimize and mitigate for any proposed development-related impacts to eelgrass habitat. Eelgrass mitigation attempts to off-set acreage lost due to dredge and fill projects by transplanting donor plants into a selected restoration site. In the northeastern United States, efforts began to restore eelgrass in the late 1970s but it wasn't until the 1990s and 2000s that transplant success increased as transplant methods, site selection models, and success criteria were developed and refined (Short *et al.* 2002). In Massachusetts, several "test-plot" size restoration efforts of less than 0.03 acres have been attempted with varying degrees of success over the past decade, including sites on Martha's Vineyard, in Boston Harbor, and in the Annisquam River. Successful, full-scale restoration and/or mitigation projects include sites in Boston Harbor, New Bedford, and Gloucester. *Marine Fisheries'* Boston Harbor eelgrass restoration project, is the largest successful restoration to date in Massachusetts, totaling greater than two hectares (five acres) of expanding eelgrass beds at four sites along Long Island and Peddocks Island in Boston Outer Harbor (Leschen *et al.* In review). The *MarineFisheries* effort was completed in 2007 as partial mitigation for impacts from the Hubline pipeline construction. In New Bedford, the NOAA eelgrass habitat restoration project included sites in outer New Bedford Harbor and Clark's Cove; totaling 1.6 hectares (four acres) at five sites. All eelgrass restoration sites are outside of the planning area.

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FIGURES

Figure 4.1 Seafloor habitat classes.

Figure 4.2 The Atlantic flyway.

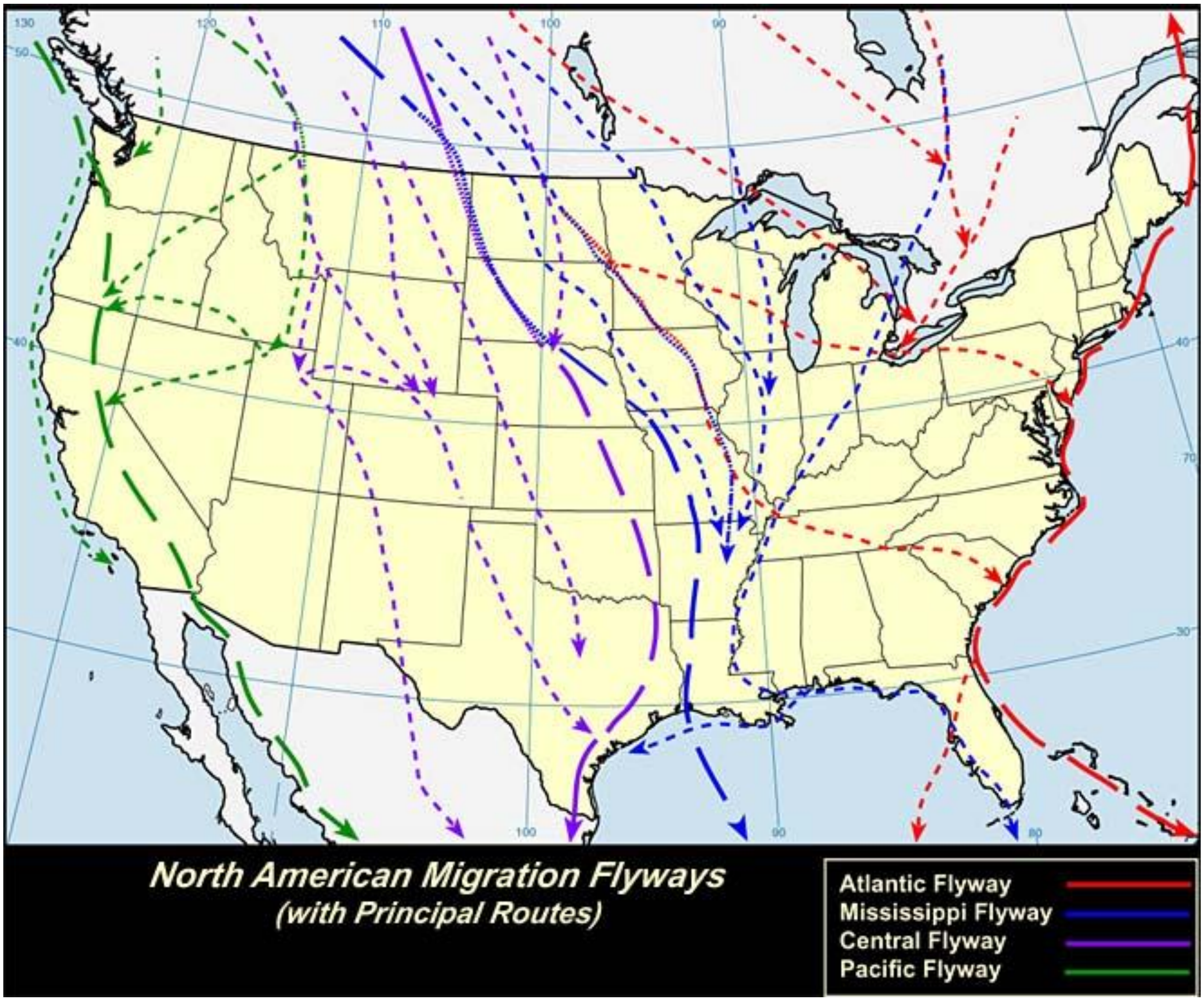

Figure 4.3 Important Birds Areas (IBAs) in Massachusetts. (Image courtesy of Mass Audubon).

Figure 4.4 Invasive species encrusting a piece of kelp (*Laminaria*). Species shown are: *Botrylloides violaceus*, *Botryllus schlosseri*, *Bugula neritina*, *Membranipora membranacea* (photo: Adrienne Pappal).

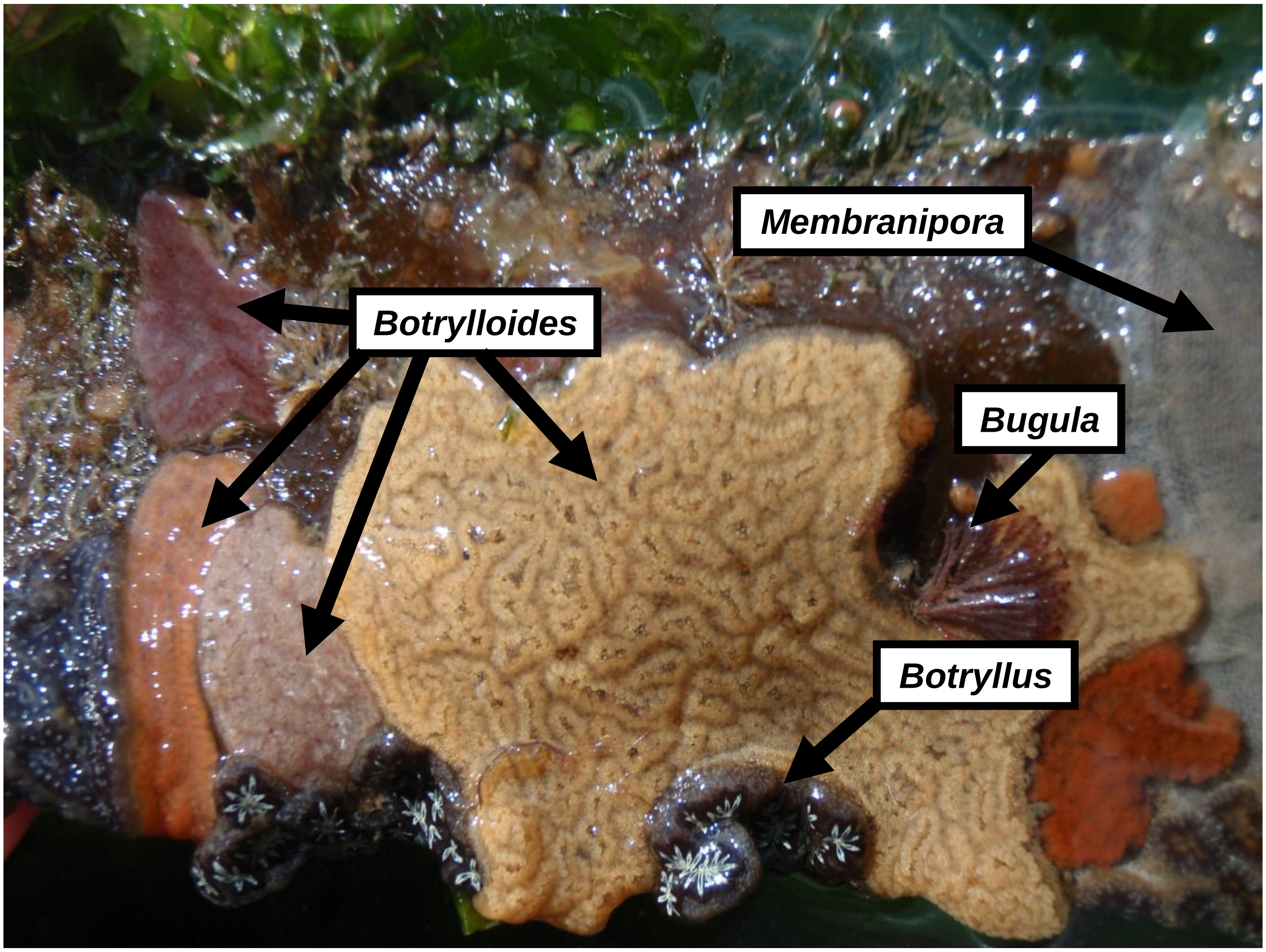

Figure 4.5 Shellfish seeding and relay sites.