4.2 PHYSICAL ENVIRONMENT AND ESSENTIAL FISH HABITAT (EFH)

The description of the affected environment is presented to provide sufficient background information on the various resources and entities likely to be affected by the actions proposed or under consideration in the SEIS. Several recent reports have been published which add to our understanding of the physical and biological environment of this region. This section deals with the *affected* environment and does not present the effects of the proposed management program.

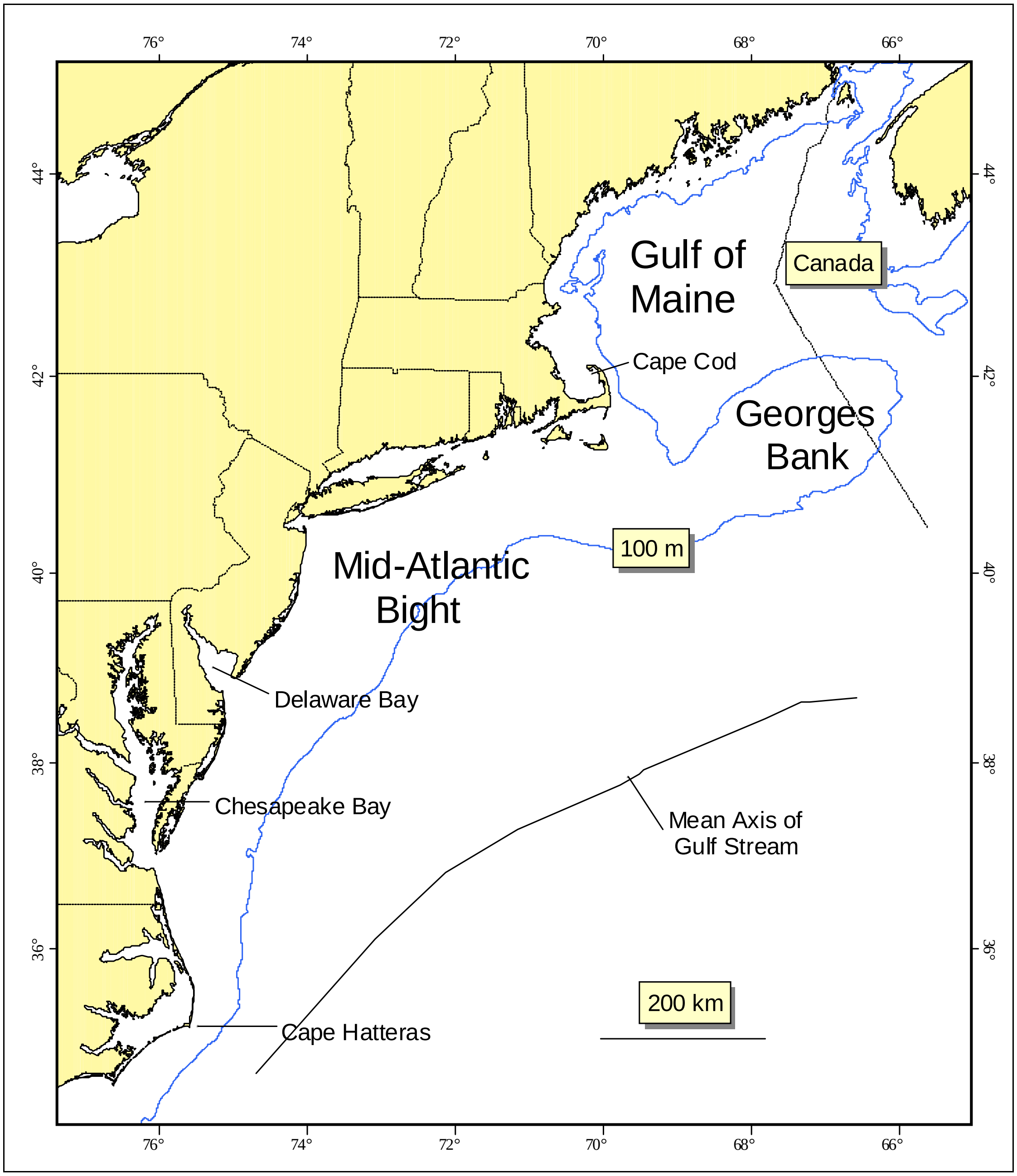
4.2.1 Physical Environment

This section contains a description of the physical environment of the Atlantic sea scallop fishery, including physical habitat conditions in the terrestrial/inshore areas and continental shelf and slope of the Gulf of Maine – Georges Bank and Mid-Atlantic regions.

The Northeast shelf ecosystem (Figure 9) has been described as including the area from the Gulf of Maine south to the state of North Carolina, extending from the coast seaward to the edge of the continental shelf, including the slope sea offshore to the Gulf Stream (Sherman et al. 1996). The continental slope of this region includes the area east of the shelf, out to a depth of 2000m. A number of distinct sub-systems comprise the region, including the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight, the continental slope, and some of the New England Seamounts. Occasionally another subsystem, Southern New England, is described; however, we incorporated the distinctive features of this region into the descriptions of Georges Bank and the Mid-Atlantic Bight.

The Gulf of Maine is an enclosed coastal sea, characterized by relatively cold waters and deep basins, with a patchwork of various sediment types. Georges Bank is a relatively shallow coastal plateau that slopes gently from north to south and has steep submarine canyons on its eastern and southeastern edge. It is characterized by highly productive, well-mixed waters and strong currents. The Mid-Atlantic Bight is comprised of the sandy, relatively flat, gently sloping continental shelf from Southern New England to Cape Hatteras, NC. The continental slope begins at the continental shelf break and continues eastward with increasing depth until it becomes the continental rise. It is fairly homogenous, with exceptions at the shelf break, some of the canyons, the Hudson Shelf Valley, and in areas of glacially rafted hard bottom. Pertinent aspects of the physical characteristics of each of these systems are described in sections that follow. This review is based on several summary reviews (Backus 1987; Schmitz et al. 1987; Tucholke 1987; Wiebe et al. 1987; Cook 1988; Stumpf and Biggs 1988; Abernathy 1989; Dorsey 1998; Townsend 1992; Mountain et al. 1994; Conkling 1995; Beardsley et al. 1996; Brooks 1996; Sherman et al. 1996; Kelley 1998; NEFMC 1998; EPA 2003; Packer 2003; StormCenter Communications, Inc. 2004). Literature citations are not included for generally accepted concepts; however, new research and specific results of research findings are cited.

Figure 9 - U.S. Northeast Shelf Ecosystem



4.2.1.1 Inshore

The Gulf of Maine includes more than 59,570 km^2 (23,000 mi^2) of estuarine drainage areas, and the long State of Maine coast supports the largest number of estuaries; west to east, important ones are Saco Bay, Casco Bay, Merrymeeting Bay, Sheepscot Bay, Muscongus Bay, Penobscot Bay, Blue Hill Bay, Frenchman Bay, Narraguagus Bay, Englishman Bay, Machias Bay, Cobscook Bay, and Passamaquoddy Bay (which straddles the international border). Among the major estuaries in the southwestern part of the Gulf are Massachusetts Bay and Great Bay in the State of New Hampshire. Estuarine features such as salt marshes, mud flats, and submerged aquatic vegetation are critical to inshore and offshore fishery resources of the Gulf. Estuaries are important for nutrient recycling, primary production, and function as important breeding and feeding grounds for many fish and shellfish populations and shorebirds, migratory waterfowl, and mammals. Sheltered areas may support salt marshes at higher tide levels, intertidal mudflats, and seagrass beds and muddy substratum subtidally; salt marshes are not as prominent in the Gulf region as they are farther south. Sandy beaches are also found more extensively farther south than in the Gulf.

The coast of the Gulf of Maine consists of rocky intertidal zones and sand beaches that are important habitats for fishery resources of the Gulf. As with the estuaries, coastal areas are important for nutrient recycling and primary production. Exposed or high wave energy places with bedrock or boulders support seaweed communities both intertidally and subtidally. Fishery resources may depend upon particular habitat features of the rocky intertidal/subtidal that provide important levels of refuge and nutrient sources.

Human activities in the surrounding watersheds influences the chemical loading of nutrients (especially nitrogen and phosphorus) and contaminants (heavy metals and organic) that enter estuarine systems. The biological effects of the loading is influenced by processes occurring within the estuaries, such as hydrology (balance between freshwater input from rivers and tidal/wind forced saltwater transport from ocean), sediment type on the bottom and bioavailability of contaminants to biota, metabolism of imported non-living dissolved organic carbon (DOC) and particulate organic carbon (POC) by biota in the water column and sediments, burial of DOC and POC in the sediments and chemical coagulation processes that transport toxics attached to suspended particles to the bottom, geochemical processes linking the sediments to the water column, biological processes that convert nutrients to phytoplankton and POC to DOC, and export of living and non-living total organic matter (TOC = DOC + POC) to the coastal ocean. These physical, chemical, geological and biological processes provide the context for the water column and benthic sedimentary habitat characteristics and biological/physical structure.

Another important set of estuarine characteristics is the seasonal/interannual changes in temperature and salinity as influenced by changes in the positive and negative stages of the North Atlantic Oscillation (NAO). The NAO is based on atmospheric pressure differences between the North Atlantic Ocean (Greenland or Iceland) and Mid-Atlantic regions (Lisbon or Azores) which influence the strength of the westerly winds. As pointed out by Oviatt (2004) for Narragansett Bay, the positive NAO index is associated with warmer water temperatures, higher salinity values, decline of winter-spring diatom bloom and higher early spring zooplankton abundance (due to increased grazing by benthic filter feeders and macrozooplankton), decrease in demersal fish biomass (including winter flounder, windowpane flounder, red hake) and increase in demersal decapods (crabs and lobsters), and immigration of smaller, southern pelagic fish species (anchovy, butterfish, long finned squid). The negative NAO index is associated with colder, less saline water masses with lower nutrient values and a well developed winter-spring diatom bloom and strong recruitment of benthic fauna (polychaetes).The warmer winters and increased spring zooplankton levels fueled increases in ctenophore grazing on zooplankton and fish/invertebrate larvae. This grazing activity influences recruitment of fish and shellfish and increases the summer phytoplankton biomass. The opposite pattern occurs during cold winters. Thus large scale meteorological events affect the interannual temperature and salinity seasonal patterns in Narragansett Bay and other East coast estuaries.

4.2.1.2 Gulf of Maine/Georges Bank/Mid-Atlantic

Gulf of Maine

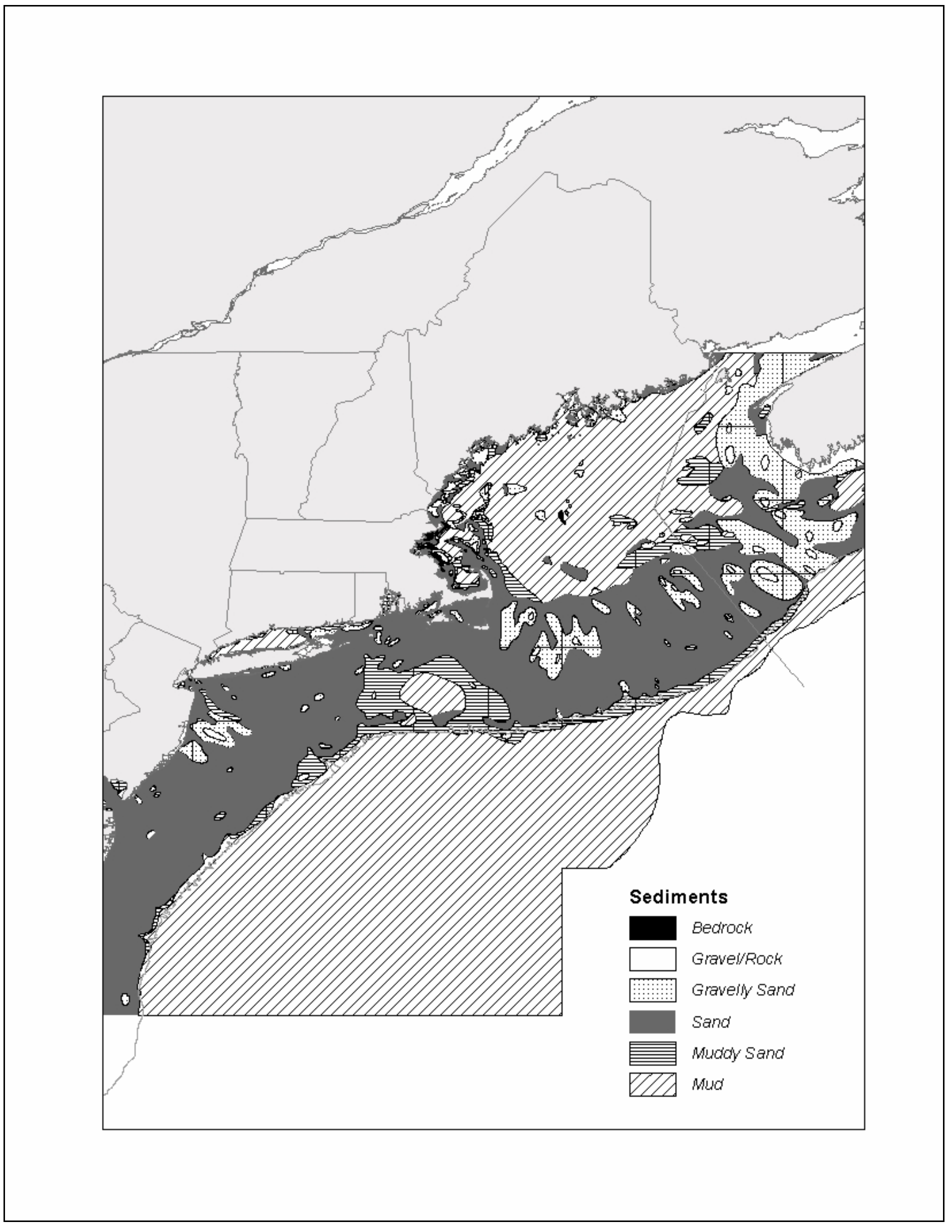
Although not obvious in appearance, the Gulf of Maine is actually an enclosed coastal sea of 90,700 km^2, bounded on the east by Browns Bank, on the north by the Nova Scotian (Scotian) Shelf, on the west by the New England states and on the south by Cape Cod and Georges Bank (GB). The Gulf of Maine (GOM) was glacially derived, and is characterized by a system of deep basins, moraines and rocky protrusions with limited access to the open ocean. This geomorphology influences complex oceanographic processes which result in a rich biological community.

The Gulf of Maine is topographically unlike any other part of the continental border along the U.S. east coast. It contains 21 distinct basins separated by ridges, banks, and swells. The three (3) largest basins are Wilkinson, Georges, and Jordan. Depths in the basins exceed 250 m, with a maximum depth of 350 m in Georges Basin, just north of Georges Bank. The Northeast Channel between Georges Bank and Browns Bank, leads into Georges Basin, and is one of the primary avenues for exchange of water between the GOM and the North Atlantic Ocean.

High points within the Gulf include irregular ridges, such as Cashes Ledge, which peaks at 9 m below the surface, as well as lower flat-topped banks and gentle swells. Some of these rises are remnants of the sedimentary shelf left after the glaciers removed most of it. Others are glacial moraines and a few, like Cashes Ledge, are out-croppings of bedrock. Very fine sediment particles created and eroded by the glaciers have collected in thick deposits over much of the Gulf of Maine, particularly in its deep basins. These mud deposits blanket and obscure the irregularities of the underlying bedrock, forming topographically smooth terrains. Some shallower basins are covered with mud as well, including some in coastal waters. In the rises between the basins, other materials are usually at the surface. Unsorted glacial till covers some morainal areas, as on Sewell Ridge to the north of Georges Basin and on Truxton Swell to the south of Jordan Basin. Sand predominates on some high areas and gravel, sometimes with boulders, predominates on others.

Coastal sediments exhibit a high degree of small-scale variability. Bedrock is the predominant substrate along the western edge of the Gulf of Maine north of Cape Cod in a narrow band out to a depth of about 60 m. Rocky areas become less common with increasing depth, but some rock outcrops poke through the mud covering the deeper sea floor. Mud is the second most common substrate on the inner continental shelf. Mud predominates in coastal valleys and basins that often border abruptly on rocky substrates. Many of these basins extend without interruption into deeper water. Gravel, often mixed with shell, is common adjacent to bedrock outcrops and in fractures in the rock. Large expanses of gravel are not common, but do occur near reworked glacial moraines and in areas where the seabed has been scoured by bottom currents. Gravel is most abundant at depths of 20-40 m, except in eastern Maine where a gravel-covered plain exists to depths of at least 100 m. Bottom currents are stronger in eastern Maine where the mean tidal range exceeds 5 m. Sandy areas are relatively rare along the inner shelf of the western Gulf of Maine, but are more common south of Casco Bay, especially offshore of sandy beaches.

Figure 10 - Distribution of surficial sediments, Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight (modified from original map by Poppe *et al.* 1989a, b)



An intense seasonal cycle of winter cooling and turnover, springtime freshwater runoff, and summer warming influences oceanographic and biologic processes in the Gulf of Maine. The Gulf has a general counterclockwise nontidal surface current that flows around its coastal margin. It is primarily driven by fresh, cold Scotian Shelf water that enters over the Scotian Shelf and through the Northeast Channel, and freshwater river runoff, which is particularly important in the spring. Dense relatively warm and saline slope water entering through the bottom of the Northeast Channel from the continental slope also influences gyre formation. The gyre moves surface waters at a rate of approximately 7 nm/day, with a single revolution around the entire Gulf taking about three (3) months. These surface gyres are more pronounced in spring and summer; with winter, they weaken and become more influenced by the wind. Counterclockwise gyres generally form in Jordan, Wilkinson, and Georges Basins and the Northeast Channel as well; they circulate more slowly, taking about a year for deep Gulf water to cycle through the basin system. In the summer, the water of these basins becomes layered into warm, nutrient-poor surface water; cold, nutrient-rich intermediate water; and cool, high-salinity bottom water. Water exits the Gulf primarily through the 75 m deep Great South Channel, between western Georges Bank and Nantucket Shoals. Water also flows out of the Gulf over the eastern portion of Georges Bank.

Stratification of surface waters during spring and summer seals off a mid-depth layer of water that preserves winter salinity and temperatures. This cold layer of water is called “Maine intermediate water” (MIW) and is located between more saline Maine bottom water and the warmer, stratified Maine surface water. The stratified surface layer is most pronounced in the deep portions of the western GOM. Tidal mixing of shallow areas prevents thermal stratification and results in thermal fronts between the stratified areas and cooler mixed areas. Typically, mixed areas include Georges Bank, the southwest Scotian Shelf, eastern Maine coastal waters, and the narrow coastal band surrounding the remainder of the Gulf.

The Northeast Channel provides an exit for cold MIW and outgoing surface water while it allows warmer more saline slope water to move in along the bottom and spill into the deeper basins. The influx of water occurs in pulses, and appears to be seasonal, with lower flow in late winter and a maximum in early summer.

Gulf of Maine circulation and water properties can vary significantly from year to year. Notable episodic events include shelf-slope interactions such as the entrainment of shelf water by Gulf Stream rings, and strong winds that can create currents as high as 1.1 meters/second over Georges Bank. Warm core Gulf Stream rings can also influence upwelling and nutrient exchange on the Scotian shelf, and affect the water masses entering the GOM. Annual and seasonal inflow variations also affect water circulation.

Internal waves are episodic and can greatly affect the biological properties of certain habitats. Internal waves can shift water layers vertically, so that habitats normally surrounded by cold MIW are temporarily bathed in warm, organic-rich surface water. On Cashes Ledge, it is thought that deeper nutrient rich water is driven into the photic zone, providing for increased productivity. Localized areas of upwelling interaction occur in numerous places throughout the Gulf.

Georges Bank

Georges Bank is a shallow (3-150 m depth), elongate (161 km wide by 322 km long) extension of the continental shelf which was formed by the Wisconsinian glacial episode and is characterized by a steep slope on its northern edge and a broad, flat, gently sloping southern flank. The Great South Channel lies to the west of the bank and separates it from Nantucket Shoals and the mainland. Natural processes continue to erode and rework the sediments on Georges Bank. It is anticipated that erosion and reworking of sediments will reduce the amount of sand available to the sand sheets, and cause an overall coarsening of the bottom sediments (Valentine et al.,1993).

Glacial retreat during the late Pleistocene deposited the bottom sediments currently observed on the eastern section of Georges Bank, and the sediments have been continuously reworked and redistributed by the action of rising sea level, and by tidal, storm and other currents. The strong, erosive currents affect the character of the biological community. Bottom topography on Georges Bank is characterized by linear ridges in the western shoal areas; a relatively smooth, gently dipping sea floor on the deeper, easternmost part; a highly energetic peak in the north with sand ridges up to 30 m high and extensive gravel pavement, and steeper and smoother topography incised by submarine canyons on the southeastern margin. The nature of the seabed sediments varies widely, ranging from sand to mixtures of sand and gravel, patches of gravel pavement, and very small exposures of clay.

The central region of the bank is shallow; shoals and troughs characterize the bottom, with sand dunes superimposed upon them. The two most prominent elevations on the ridge and trough area are Cultivator and Georges Shoals. This shoal and trough area is a region of strong currents, with average flood and ebb tidal currents greater than 4 km per hour, and as high as 7 km per hour. The dunes migrate at variable rates, and the ridges may move, also. In an area that lies between the central part and Northeast Peak, Almeida et al. (2000) identified high energy areas as between 35-65 m deep, where sand is transported on a daily basis by tidal currents; and a low energy area at depths > 65 m that is affected only by storm currents. The area west of the Great South Channel, known as Nantucket shoals, is similar in nature to the central region of the bank. Currents in these areas are strongest where water depth is shallower than 50 m. This type of traveling dune and swale morphology is also found in the Mid-Atlantic Bight.

The Great South Channel separates the main part of Georges Bank from Nantucket Shoals. Sediments in the Great South Channel include gravel pavement and mounds, some scattered boulders, sand with storm generated ripples, scattered shell and mussel beds. Tidal and storm currents may range from moderate to strong, depending upon location and storm activity (Valentine, pers. comm).

In the Georges Bank region, strong oceanographic frontal systems occur between water masses of the Gulf of Maine, Georges Bank, and the Atlantic Ocean. These water masses differ in temperature, salinity, nutrient concentration, and planktonic communities, which influence productivity and may influence fish abundance and distribution. Tidal currents over the shallow top of Georges Bank can be very strong, and keep the waters over the bank well mixed vertically. This results in a tidal front that separates the cool waters of the well-mixed shallows of the central bank from the warmer, seasonally stratified shelf waters on the shoreward and seaward sides of the bank. There is a persistent clockwise gyre around the Bank; a strong semidiurnal tidal flow predominantly northwest and southeast; and very strong, intermittent, storm-induced currents; all of which can all occur simultaneously. The clockwise gyre is instrumental in distribution of the planktonic community, including larval fish. For example, Lough and Potter (1993) describe passive drift of Atlantic cod and haddock eggs and larvae in a southwest residual pattern around Georges Bank. Larval concentrations are found at varying depths along the southern edge between 60-100 m.

Mid-Atlantic Bight

The Mid-Atlantic Bight includes the shelf and slope waters from Georges Bank south to Cape Hatteras, and east to the Gulf Stream. Like the rest of the continental shelf, the topography of the Mid-Atlantic Bight was shaped largely by sea level fluctuations caused by past ice ages. Unlike Georges Bank, glaciers did not advance onto the Mid-Atlantic Bight shelf, and the sandy sediments are generally finer-grained than those on the bank. The shelf's basic morphology and sediments derive from the retreat of the last ice sheet, and the subsequent rise in sea level. Since that time, currents and waves have modified this basic structure.

Shelf and slope waters of the Mid-Atlantic Bight have a slow southwestward flow that is occasionally interrupted by warm core rings or meanders from the Gulf Stream. On average, shelf water moves parallel to bathymetry isobars at speeds of 5-10 cm/second at the surface and 2 cm/second or less at the bottom. Storm events can cause much more energetic variations in flow. Tidal currents on the inner shelf have a higher flow rate of 20 cm/second that increases to 100 cm/second near inlets.

Slope water tends to be warmer than shelf water because of its proximity to the Gulf Stream, and also tends to be more saline. The abrupt gradient where these two water masses meet is called the shelf-slope front. This front is usually located at the edge of the shelf and touches bottom at about 75-100 m depth of water, and then slopes up to the east (seaward) towards the ocean surface. It reaches surface waters approximately 25-55 km further offshore. The position of the front is highly variable, and can be influenced by many physical factors. Vertical structure of temperature and salinity within the front can develop complex patterns because of the interleaving of shelf and slope waters – for example cold shelf waters can protrude offshore, or warmer slope water can intrude up onto the shelf.

The seasonal effects of warming and cooling increase in shallower, near shore waters. Stratification of the water column occurs over the shelf and the top layer of slope water during the spring-summer and is usually established by early June. Fall mixing results in homogenous shelf and upper slope waters by October in most years. A permanent thermocline exists in slope waters from 200-600 m. Temperatures decrease at the rate of about 0.02°C per meter and remain relatively constant except for occasional incursions of Gulf stream eddies or meanders. Below 600 m, temperature declines, and usually averages about 2.2°C at 4000 m. A warm, mixed layer approximately 40 m thick resides above the permanent thermocline.

The "cold pool" is an annual phenomenon particularly important to the Mid-Atlantic Bight. It stretches from the Gulf of Maine along the outer edge of Georges Bank and then southwest to

Cape Hatteras. It becomes identifiable with the onset of thermal stratification in the spring and lasts into early fall until normal seasonal mixing occurs. It usually exists along the bottom between the 40 m and 100 m isobaths and extends up into the water column for about 35 m, to the bottom of the seasonal thermocline. The cold pool usually represents about 30% of the volume of shelf water. Minimum temperatures for the cold pool occur in early spring and summer, and range from 1.1°C to 4.7°C.

The shelf slopes gently from shore out to between 100 and 200 km offshore where it transforms to the slope (100 – 200 m water depth) at the shelf break. In both the Mid-Atlantic and on Georges Bank, numerous canyons incise the slope, and some cut up onto the shelf itself. The primary morphological features of the shelf include shallow shelf valleys and channels, shoal massifs, scarps, and low sand ridges and swales (Figure 11).

Most of these structures are relic except for some sand ridges and smaller sand-formed features. Shelf valleys and slope canyons were formed by rivers of melted glacier that deposited sediments on the outer shelf edge as they entered the ocean. Most valleys cut about 10 m into the shelf, with the exception of the Hudson Shelf Valley, which is about 35 m deep. The valleys were partially filled as glacial meltwater transported sediments seaward from land. Rising sea level also left behind a lengthy scarp near the shelf break from Chesapeake Bay north to the eastern end of Long Island. Shoal retreat massifs were produced by extensive deposition at a cape or estuary mouth. Massifs were also formed as estuaries retreated across the shelf.

The sediment type covering most of the shelf in the Mid-Atlantic Bight is sand, with some relatively small, localized areas of gravel and gravelly sand (
Figure 10). On the slope, muddy sand and mud predominate. Sediments are fairly uniformly distributed over the shelf in this region. A sheet of sand and gravel varying in thickness from 0 to 10 m covers most of the shelf. The mean bottom flow from the constant southwesterly current is not fast enough to move sand, so sediment transport must be episodic and storm-related. Net sediment movement is in the same southwesterly direction as the current. The sands are mostly medium- to coarse-grained, with finer sand in the Hudson Shelf Valley and on the outer shelf. Mud is rare over most of the shelf, but is common in the Hudson Shelf Valley. Occasionally relic estuarine mud deposits are re-exposed in the swales between sand ridges. Fine sediment content increases rapidly at the shelf break, which is sometimes called the “mud line,” and sediments are 70-100% fine-grained on the slope.

Figure 11 - Mid-Atlantic Bight submarine morphology. Source: Stumpf and Biggs (1988).

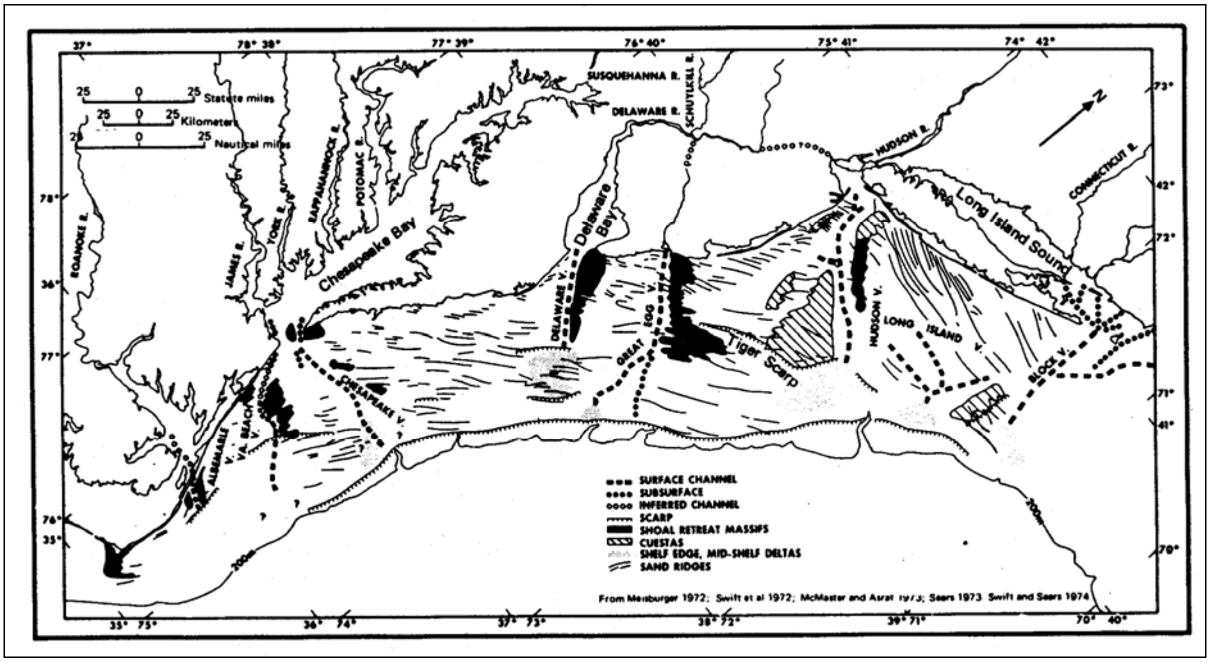
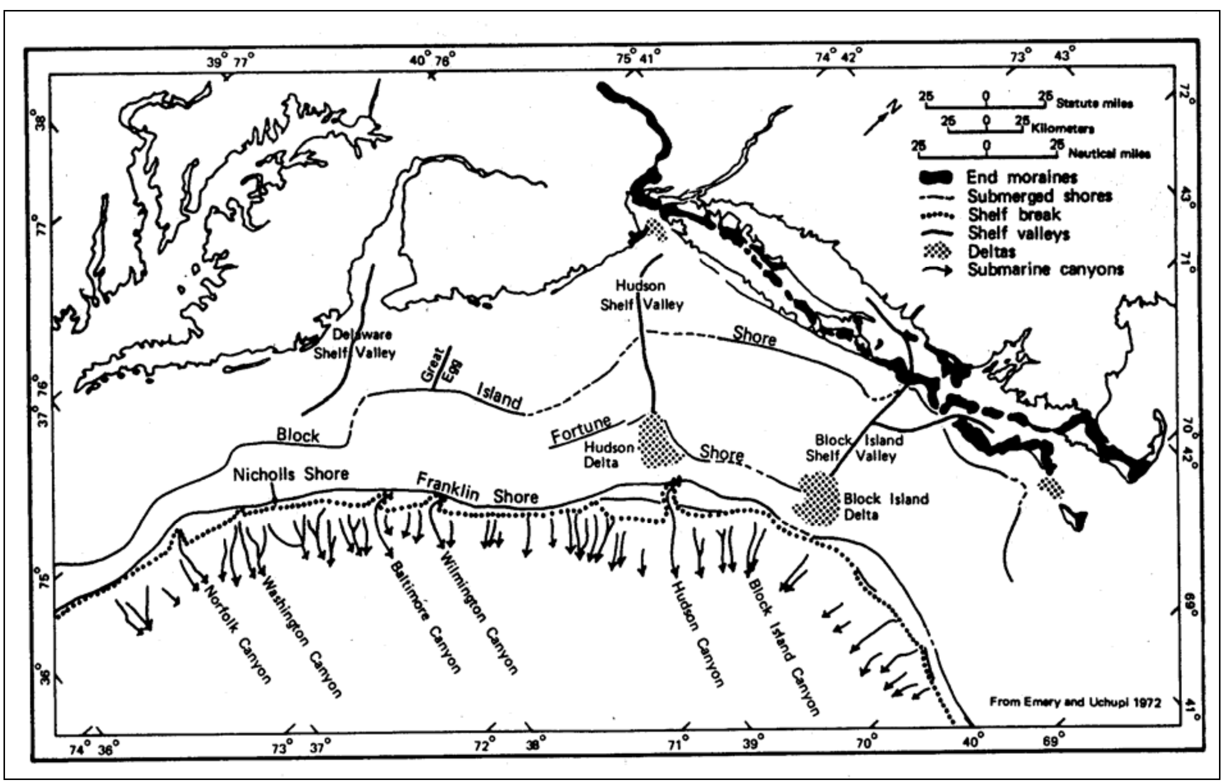


Figure 12 - Major features of the Mid-Atlantic and Southern New England continental shelf. Source: Stumpf and Biggs (1988).



In addition to sand ridges that were formed during rising sea level, some sand ridges have been formed since the end of the last ice age. Their formation is not well understood; however, they appear to develop from the sediments that erode from the shore face. They maintain their shape, so it is assumed that they are in equilibrium with modern current and storm regimes. They are usually grouped, with heights of about 10 m, lengths of 10-50 km and spacing of 2 km. Ridges are usually oriented at a slight angle towards shore, running in length from northeast to southwest. The seaward face usually has the steepest slope. Sand ridges are often covered with smaller similar forms such as sand waves, megaripples, and ripples. Swales occur between sand ridges. Since ridges are higher than the adjacent swales, they are exposed to more energy from water currents, and experience more sediment mobility than swales. Ridges tend to contain less fine sand, silt and clay while relatively sheltered swales contain more of the finer particles. Swales have greater benthic macrofaunal density, species richness and biomass, due in part to the increased abundance of detrital food and the physically less rigorous conditions.

Low sand waves are usually found in patches of 5-10 with heights of about 2 m, lengths of 50-100 m and 1-2 km between patches. Sand waves are primarily found on the inner shelf, and often observed on sides of sand ridges. They may remain intact over several seasons. Megaripples occur on sand waves or separately on the inner or central shelf. During the winter storm season, they may cover as much as 15% of the inner shelf. They tend to form in large patches and usually have lengths of 3-5 m with heights of 0.5-1 m. Megaripples tend to survive for less than a season. They can form during a storm and reshape the upper 50-100 cm of the sediments within a few hours. Ripples are also found everywhere on the shelf, and appear or disappear within hours or days, depending upon storms and currents. Ripples usually have lengths of about 1-150 cm and heights of a few centimeters.

The northern portion of the Mid-Atlantic Bight is sometimes referred to as the southern New England Shelf. Some of the features of this area were described earlier; however, one other formation of this region that deserves note is the “mud patch” which is located on the outer shelf just southwest of Nantucket Shoals and southeast of Long Island (Figure 12). Tidal currents in this area slow significantly, which allows silts and clays to settle out. The mud is mixed with sand, and is occasionally re-suspended by large storms. This habitat is an anomaly of the outer continental shelf.

4.2.2 Essential Fish Habitat / Biological Environment

Essential Fish Habitat
EFH descriptions and maps for Northeast region species can be accessed at http://www.nero.nmfs.gov/ro/doc/hcd/. The following description and map of EFH for Atlantic sea scallops *(Placopecten magellanicus*) is excerpted from the Omnibus EFH Amendment. Essential fish habitat for Atlantic sea scallops is described as those areas of the coastal and offshore waters (out to the offshore U.S. boundary of the exclusive economic zone) that are designated on Map 32 in Amendment 10 to the Atlantic sea scallop FMP and meet the following conditions:

Eggs: *Bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia -North Carolina border as depicted in Map 32. Eggs are heavier than seawater and remain on the seafloor until they develop into the first free-swimming larval stage. Generally, sea scallop eggs are thought to occur where water temperatures are below 17 °_C. Spawning occurs from May through October, with peaks in May and June in the middle Atlantic area and in September and October on Georges Bank and in the Gulf of Maine.*

Larvae: *Pelagic waters and bottom habitats with a substrate of gravelly sand, shell fragments, and pebbles, or on various red algae, hydroids, amphipod tubes and bryozoans in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia -North Carolina border as depicted in Map 32. Generally, the following conditions exist where sea scallop larvae are found: sea surface temperatures below 18 °_C and salinities between 16.9‰ and 30‰.*

Juveniles: *Bottom habitats with a substrate of cobble, shells and silt in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia -North Carolina border that support the highest densities of sea scallops as depicted in Map 32. Generally, the following conditions exist where most sea scallop juveniles are found: water temperatures below 15 °_C, and water depths from 18 - 110 meters.*

Adults: *Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia –North Carolina border that support the highest densities of sea scallops as depicted in Map 32. Generally, the following conditions exist where most sea scallop adults are found: water temperatures below 21 °_C, water depths from 18 - 110 meters, and salinities above 16.5‰.*

Spawning Adults: *Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia -North Carolina border that support the highest densities of sea scallops as depicted in Map 32. Generally, the following conditions exist where spawning sea scallop adults are found: water temperatures below 16 °_C, depths from 18 - 110 meters, and salinities above 16.5‰. Spawning occurs from May through October, with peaks in May and June in the middle Atlantic area and in September and October on Georges Bank and in the Gulf of Maine.*

Section 7.2.5 of the FSEIS to Amendment 10 described benthic habitats that exist within the range of the scallop fishery biological characteristics of regional systems, and assemblages of fish and benthic organisms. It also included a description of canyon habitats on the edge of the continental shelf. No new information is available.

Section 7.2.6 of the FSEIS to Amendment 10 evaluated the potential adverse effects of gears used in the scallop fishery on EFH for scallop and other federally-managed species and the effects of fishing activities regulated under other federal FMPs on scallop EFH. The evaluation considered the effects of each activity on each type of habitat found within EFH. The two gears used in the directed scallop fishery are bottom trawls and scallop dredges. Scallop EFH has been determined to only be minimally vulnerable to bottom-tending mobile gear (bottom trawls and dredges) and bottom gillnets. Therefore, the effects of the scallop fishery and other fisheries on scallop EFH do not require any management action. However, the scallop dredge and trawl fisheries do have more than a minimal and temporary impact on EFH for a number of other demersal species in the region.

The following conclusions were reached in Amendment 10 to the Atlantic sea scallop FMP:

- Potentially adverse habitat impacts from bottom trawling occur throughout most of the NE region on a variety of substrates;
- High levels of fishing activity with scallop dredges occur primarily in the Mid-Atlantic region and secondarily on Georges Bank, according to the vessel trip report data from 1995 – 2001. Intense dredge activity from the same data show that the highest intensity of scallop fishing is in the Great South Channel and portions of the Mid-Atlantic region from Long Island to VA. The VMS data from 1998 confirms this assessment and also shows high scallop fishing intensity in the southern part of Closed Area II because the period included the area access program during the 1999 and 2000 fishing years which was intended to have high levels of effort to reduce impacts in open areas where smaller scallops existed.
- Potentially adverse habitat impacts from scallop dredging may occur in areas where scallop effort overlaps with areas where EFH has been designated for species with vulnerable EFH. According to the analysis within this document, scallop fishing effort is distributed in the same proportion as juvenile and adult EFH designations, but areas with more intense scallop fishing effort tend to be over areas with less EFH designations for species with vulnerable EFH.

Adverse impacts that were more than minimal and less than temporary in nature were identified for the following species and life stages, based on an evaluation of species life history and habitat requirements and the spatial distributions and impacts of bottom otter trawls in the region (Stevenson *et al*., in press):

<u>Otter Trawls</u>

The use of Otter Trawls may have an adverse effect on the following species (and life stages) EFH as designated in Amendment 11 to the Northeast Multispecies FMP (1998):

American plaice (Juvenile (J), Adult (A)), Atlantic cod (J, A), Atlantic halibut (J, A), haddock (J, A), ocean pout (E, L, J, A), red hake (J, A), redfish (J, A), white hake (J), silver hake (J), winter *flounder (A), witch flounder (J, A), yellowtail flounder (J, A), red crab (J, A), black sea bass (J, A), scup (J), tilefish (J, A), barndoor skate (J, A), clearnose skate (J, A), little skate (J, A), rosette skate (J, A), smooth skate (J, A), thorny skate (J, A), and winter skate (J, A).*

Scallop Dredge (New Bedford style)

The use of New Bedford style Scallop Dredges may have an adverse effect on the following species (and life stages) EFH as designated in Amendment 11 to the Northeast Multispecies FMP (1998):

American plaice (J, A), Atlantic cod (J, A), Atlantic halibut (J, A), haddock (J, A), ocean pout (E, L, J, A), red hake (J, A), redfish (J, A), white hake (J), silver hake (J), winter flounder (J, A), yellowtail flounder (J, A), black sea bass, (J, A), scup (J), barndoor skate (J, A), clearnose skate (J, A), little skate (J, A), rosette skate (J, A), smooth skate (J, A), thorny skate (J, A), and winter skate (J, A).*

Gear types other than otter trawls and scallop dredges, in the context of the Atlantic Sea Scallop fishery, were not found to have adverse effects the Essential Fish Habitat as currently designated in this region. See Table 9 for a description of the species and life staged that were determined to be adversely impacted in a manner that is more than minimal and less than temporary in nature in Amendment 10.

Table 9 - Summary species and life stage's EFH adversely impacted by otter trawling and scallop dredging (gears that adversely impact EFH used in the Scallop fishery).

Species	Life Stage	Vulnerability to Otter Trawling	Vulnerability to Scallop Dredging	Depth in meters (EFH Designation)	Substrate (EFH Designation)
American Plaice	A	High	High	45-150	sand or gravel
American Plaice	J	Mod	Mod	45-175	sand or gravel
Atlantic Cod	A	Mod	Mod	25-75	cobble or gravel
Atlantic Cod	J	High	High	10-150	rocks, pebble, gravel
Atlantic Halibut	A	Mod	Mod	20-60	sand, gravel, clay
Atlantic Halibut	J	Mod	Mod	100-700	sand, gravel, clay
Barndoor Skate	A	Mod	Mod	0-750, mostly <150	mud, gravel, and sand
Barndoor Skate	J	Mod	Mod	0-750, mostly <150	mud, gravel, and sand
Black Sea Bass	A	High	High	20-50	structures, sand and shell
Black Sea Bass	J	High	High	1-38	rough bottom, shell and eelgrass beds, structures and offshore clam beds in winter
Clearnose	A	Mod	Mod	0-500, mostly	soft bottom along

Species	Life Stage	Vulnerability to Otter Trawling	Vulnerability to Scallop Dredging	Depth in meters (EFH Designation)	Substrate (EFH Designation)
Skate				<111	shelf and rocky or gravelly bottom
Clearnose Skate	J	Mod	Mod	0-500, mostly <111	soft bottom along shelf and rocky or gravelly bottom
Haddock	A	High	High	35-100	pebble gravel
Haddock	J	High	High	40-150	broken ground, pebbles, smooth hard sand, smooth areas between rocky patches
Little Skate	A	Mod	Mod	0-137, mostly 73-91	sand or gravel or mud
Little Skate	J	Mod	Mod	0-137, mostly 73-91	sand or gravel or mud
Ocean Pout	A	High	High	<110	soft sediments
Ocean Pout	J	High	High	<80	smooth bottom near rocks or algae
Ocean Pout	L	High	High	<50	close to hard bottom nesting areas
Ocean Pout	E	High	High	<50	hard bottom, sheltered holes
Pollock	A	Mod	Mod	15-365	hard bottom, artificial reefs
Red Hake	A	Mod	Mod	10-130	sand and mud
Red Hake	J	High	High	<100	shell and live scallops
Redfish	A	Mod	Mod	50-350	silt, mud, or hard bottom
Redfish	J	High	High	25-400	silt, mud, or hard bottom
Rosette Skate	A	Mod	Mod	33-530, mostly 74-274	soft substrates including sand/mud and mud
Rosette Skate	J	Mod	Mod	33-530, mostly 74-274	soft substrates including sand/mud and mud
Scup	J	Mod	Mod	0-38	inshore sand, mud, mussel and

Species	Life Stage	Vulnerability to Otter Trawling	Vulnerability to Scallop Dredging	Depth in meters (EFH Designation)	Substrate (EFH Designation)
					eelgrass beds
Silver Hake	J	Mod	Mod	20-270	all substrate types
Smooth Skate	A	High	High	31-874, mostly 110-457	soft mud, sand, broken shells, gravel and pebbles
Smooth Skate	J	Mod	Mod	31-874, mostly 110-457	soft mud, sand, broken shells, gravel and pebbles
Thorny Skate	A	Mod	Mod	18-2000, mostly 111-366	sand gravel, broken shell, pebble, and soft mud
Thorny Skate	J	Mod	Mod	18-2000, mostly 111-366	sand gravel, broken shell, pebble, and soft mud
Tilefish	A	High	Low	76-365	rough, sheltered bottom
Tilefish	J	High	Low	76-365	rough, sheltered bottom
White Hake	J	Mod	Mod	5-225	pelagic during pelagic stage and mud or fine sand during demersal stage
Winter Flounder	A	Mod	Mod	1-100	estuaries with mud, gravel, or sand
Winter Skate	A	Mod	Mod	0-371, mostly <111	sand, gravel, or mud
Winter Skate	J	Mod	Mod	0-371, mostly <111	sand, gravel, or mud
Witch Flounder	A	Mod	Low	25-300	fine-grained sediment
Witch Flounder	J	Mod	Low	50-450	fine-grained sediment
Yellowtail Flounder	A	Mod	Mod	20-50	sand and mud
Yellowtail Flounder	J	Mod	Mod	20-50	sand and mud

Biological Environment

From a biological perspective, habitats provide living things with the basic life requirements of nourishment and shelter. Habitats may also provide a broader range of benefits to the ecosystem. An illustration of the broader context is the way seagrasses physically stabilize the substrate and help recirculate oxygen and nutrients. In this general discussion, we will focus on the primary, direct value of habitats to federally managed species—feeding and shelter from predation.

The spatial and temporal variation of prey abundance influences the survivorship, recruitment, development, and spatial distribution of organisms at every trophic level. For example, phytoplankton abundance and distribution are a great influence on ichthyoplankton community structure and distribution. In addition, the migratory behavior of juvenile and adult fish is directly related to seasonal patterns of prey abundance and changes in environmental conditions, especially water temperature. Prey supply is particularly critical for the starvation-prone early life history stages of fish.

The availability of food for planktivores is highly influenced by oceanographic properties. The seasonal warming of surface waters in temperate latitudes produces vertical stratification of the water column, which isolates sunlit surface waters from deeper, nutrient-rich water, leading to reduced primary productivity. In certain areas, upwelling, induced by wind, storms, and tidal mixing, inject nutrients back into the photic zone, stimulating primary production. Changes in primary production from upwelling and other oceanographic processes affect the amount of organic matter available for other organisms higher up in the food chain, and thus influence their abundance and distribution. Some of the organic matter produced in the photic zone sinks to the bottom and provides food for benthic organisms. In this way, oceanographic properties can also influence the food availability for sessile benthic organisms. In shallower water, benthic macro and microalgae also contribute to primary production. Recent research on benthic primary productivity indicates that benthic microalgae may contribute more to primary production than has been originally estimated (Cahoon 1999).

Benthic organisms provide an important food source for many managed species. Populations of bottom-dwelling sand lance are important food sources for many piscivorous species, and benthic invertebrates are the main source of nutrition for many demersal fishes. Temporal and spatial variations in benthic community structure affect the distribution and abundance of bottom-feeding fish. Likewise, the abundance and species composition of benthic communities are affected by a number of environmental factors including temperature, sediment type, and the amount of organic matter.

In addition to providing food sources, another important functional value of benthic habitat is the shelter and refuge from predators provided by structure. Three -dimensional structure is provided by physical features such as boulders, cobbles and pebbles, sand waves and ripples, and mounds, burrows and depressions created by organisms. Structure is also provided by attached and emergent epifauna. The importance of benthic habitat complexity was discussed by Auster (1998) and Auster and Langton (1999) in the context of providing a conceptual model to visualize patterns in fishing gear impacts across a gradient of habitat types. Based on this model, habitat value increases with increased structural complexity, from the lowest value in flat sand

and mud to the highest value in piled boulders. The importance of habitat complexity to federally managed species is a key issue in the Northeast Region.

4.2.2.1 Inshore

Gulf of Maine to Long Island Sound

As described by Tyrrell (2005), the Gulf of Maine rocky intertidal zone is often inhabited by an abundance of brown seaweeds. At high tide, the algae form an underwater canopy similar to a kelp forest. When the tide is low, the algae lie on the rocks and protect snails, mussels, barnacles, and crabs from exposure to sun, wind, rain, and bird predators. Typical canopy-forming fucoid brown algal species are collectively known as rockweed and include knotted wrack (*Ascophyllum nodosum*), bladder wrack (*Fucus vesiculosus*), and spiral wrack (*Fucus spiralis*). *Ascophyllum nodosum* and *Fucus vesiculosus* are found in the mid-intertidal zone, and *F. spiralis* is found in the upper intertidal zone. Their abundance and primary productivity contributes to the high productivity of the rocky intertidal shores, which is nearly ten times greater than that of the adjacent open ocean (Harvey et al. 1995). On rocky shores, invertebrates and algae live in horizontal zones between the high and low tide marks. The zones reflect the varying abilities of species to tolerate the environmental conditions, predation, and competitive pressures at different heights. The highest zone is the splash zone, which is colored darkly by lichens that tolerate salt spray. Just below the splash zone, acorn barnacles inhabit the high intertidal zone. On wave-exposed shores, blue mussels often populate the middle and low intertidal zone with many small invertebrates living in crevices among them. At less wave exposed sites, rockweeds may dominate the mid-intertidal zone, and red algae (*Chondrus crispus* and *Mastocarpus stellatus*) may cover the low intertidal zone. Tide pools form in depressions in intertidal rock outcrops and provide habitat for some animals and algae that otherwise might not survive exposure to air.

Boulders in the Gulf of Maine intertidal zone support similar species as rocky outcrops because they are not frequently overturned by waves due to their large size (Tyrrell 2005). They serve as substrate for algae, mollusks, barnacles, hydroids, and other sessile organisms. In addition, boulders provide shelter from wind, sun, rain, and predators for small organisms that can take shelter underneath and beside them. Fish forage less efficiently in boulder fields than on flat, rocky outcrops because the boulders offer hiding places for prey (Tyrrell 2005).

Southern New England

For Southern New England, a distinct pattern of vegetation is observed, with a narrow band of tall *Spartina alterniflora* occupying the low marsh, areas flooded twice daily by tides, and with high marsh areas flooded less frequently and forming a mosaic of vegetation types that may include *Spartina patens*, *Distichlis spicata*, the short form of *S. alterniflora*, and *Juncus gerardii*. Salt marsh panes, shallow depressions on the marsh surface often vegetated with forbs, and salt marsh pools can be present throughout the high marsh mosaic (Roman et al. 2000).

Habitats dominated by seagrass and other submerged aquatic vegetation occur along the estuarine gradient from marine to freshwater tidal portions of estuaries from the State of Maine to Long Island (Roman et al. 2000). Seagrass species include eelgrass (*Zosteria marina*) and widgeon grass (*Ruppia maritima*); both of which have broad salinity tolerances, although *Ruppia* commonly occurs in brackish to freshwater estuarine areas or in salt marsh pools (Richardson

1980; Thayer et al. 1984). Within freshwater or brackish water tidal portions of the relatively shallow Hudson and Connecticut River estuaries, submerged aquatic vegetation can be extensive (e.g., *Ruppia, Vallisneria americana*, *Potamogeton perfoliatus*) (Roman et al. 2000). In the Hudson River, beds of submerged vegetation, primarily *Vallisneria*, can occupy as much as 20% of the river bottom in areas shallow enough for establishment and growth of these light-limited plants (Harley and Findlay 1994).

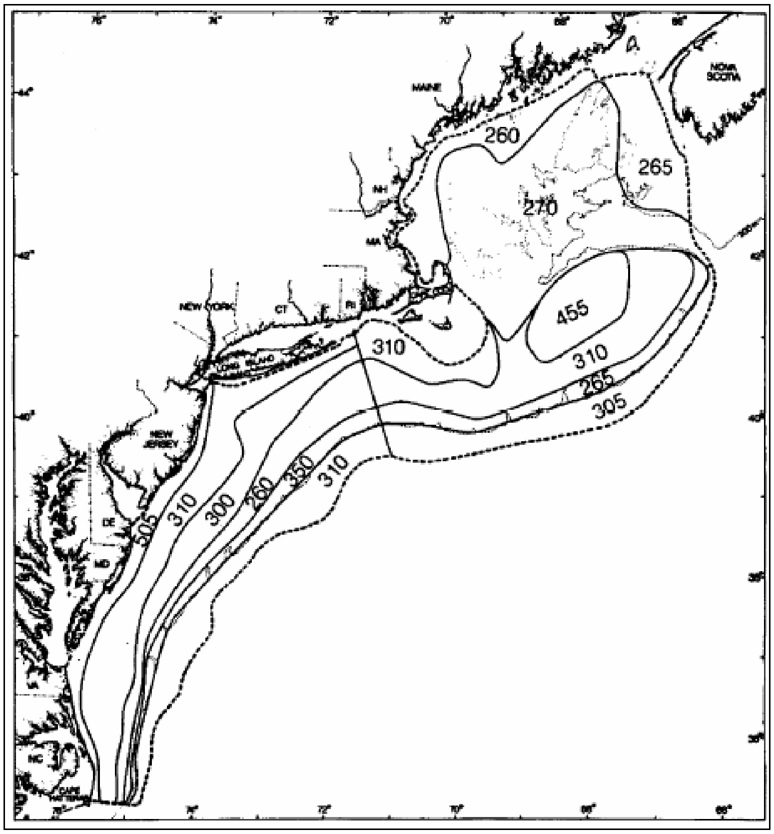
Salt marshes and submerged aquatic vegetation (sea grasses and macroalgae) provide an important food supplement in the form of detritus (POC) to the estuarine food web. This supplements the phytoplankton production in the water column and the riverine input of DOC/POC from the larger watershed that support the grazing food chain. The geomorphology (size, shape, volume, etc.) and hydrology of the estuary determine how important this detritus food web is in supplementing the grazing food chain. In general the detritus food web is an important supplement in shallow coastal embayments surrounded by wetlands or adjacent to urban areas which have high loading rates for DOC and POC.

Much of the POC in estuaries is converted to DOC by microbes, which is then exported to the coastal ocean. In the coastal ocean the ratio of DOC/POC/phytoplankton carbon is roughly 75:5:1. Much of the non-living DOC and POC is processed by the microbial loop (which is why $P<R$), while the phytoplankton carbon and some of the POC (detritus) supports the grazing food chain that leads to fish/shellfish. It is not known whether the microbial food loop is linked to the grazing food chain through the activity of micro-, meso- and macrozooplankton and filter feeding macrobenthic organisms, or whether most of the carbon in the microbial loop is respired (sink). Biogeochemical cycling is dominated by the lower trophic levels in the water column (microbial loop) with the majority of the primary production supported by recycled nutrients (ammonium). In the coastal ocean the spring or fall phytoplankton bloom is supported by new nutrients (nitrate) introduced from the bottom waters into the surface waters. This bloom transports carbon from diatoms to zooplankton which lies at the base of the grazing food chain supporting pelagic (directly) and demersal fish (indirectly).

4.2.2.2 Gulf of Maine/Georges Bank/Mid-Atlantic

The following summary of phytoplankton primary productivity and chlorophyll *a* of the Northeast shelf ecosystem and the sources for this summary can be found in Sherman et al. (2003). Estimates of annual total phytoplankton primary production from Nova Scotia to Cape Hatteras are shown in Figure 13 by region. Annual production on the shelf ranges from 10,834 to 21,043 kJ m^{-2} yr^{-1} (260-505 gCm^{-2} yr^{-1}) with the annual average of 350 gCm^{-2} yr^{-1}. The areas of highest estimated production on the shelf occur on the central, shallow portion of Georges Bank [18,960 kJ m^{-2} yr^{-1} (445 gCm^{-2} yr^{-1})] and along the coast between the States of New Jersey and North Carolina [21,043 kJ m^{-2} yr^{-1} (505 gCm^{-2} yr^{-1})] which correspond to the areas with consistently high chlorophyll *a* concentrations (O'Reilly and Zetlin 1998). The areas of the shelf with the lowest estimated annual production include the outer shelf area between Cape Hatteras, the southern edge of Georges Bank and nearshore Gulf of Maine, and the mid-shelf area between Delaware Bay and Chesapeake Bay.

Figure 13 - Estimated annual primary production in the Northeast shelf ecosystem

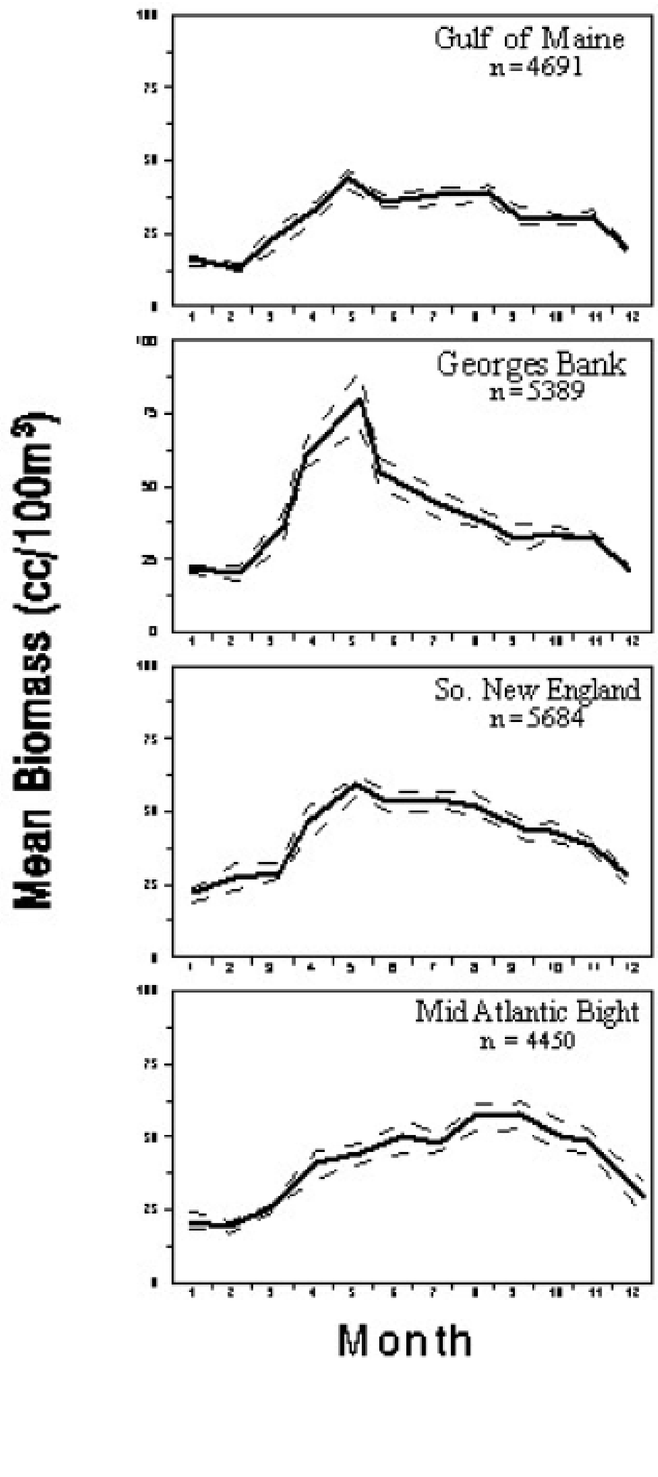


The regions selected are based on the recurring seasonal patterns of chlorophyll distribution along the continental shelf. Source: Sherman et al. (2003).

Sherman et al. (2003) also discussed the zooplankton of the Northeast shelf ecosystem. The zooplankton biodiversity during the NEFSC Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton surveys of the shelf during the 1970s and 1980s included 394 taxa, with 50 dominant in at least one location in one (1) or more seasons. Taxa included copepods, chaetognaths, barnacle larvae, cladocerans, appendicularia, doliolids, brachyuran larvae, echinoderm larvae, and thaliaceans (Sherman et al. 1988). The annual cycle of zooplankton biomass on the Northeast shelf ecosystem is shown in Figure 14.

In the Gulf of Maine, biomass peaks during spring (44 cc/100 m^3) and remains high through the summer (36-39 cc/100 m^3). The biomass declines in autumn (September) to a winter low (January-February). On Georges Bank, the spring increase in biomass peaks in May at a level that is nearly twice the spring peak in the Gulf of Maine, followed by a decline that continues through autumn to a winter minimum (< 20.2 cc/100 m^3). The waters of Southern New England maintain a relatively high biomass from May through August (55-60 cc/100 m^3). The annual decline in biomass extends from late August through autumn to a winter minimum. Further south in the Mid-Atlantic Bight, the annual peak is not reached until late August and September (60 cc/100 m^3) followed by a decline from November until the annual minimum in February (19 cc/100 m^3) (Sherman et al. 2003).

Figure 14 - The annual cycle of zooplankton biomass on the Northeast shelf ecosystem.
The solid line is the time series monthly mean sample displacement volume and the dashed lines represent the 95% confidence interval. Source: Sherman et al. (2003).



Gulf of Maine

The Gulf of Maine's geologic features, when coupled with the vertical variation in water properties, result in a great diversity of habitat types. The greatest numbers of invertebrates in this region are classified as mollusks, followed by annelids, crustaceans, and echinoderms (Theroux and Wigley 1998). By weight, the order of taxa changes to echinoderms, mollusks, annelids and cnidarians. Watling (1998) used numerical classification techniques to separate benthic invertebrate samples into seven types of bottom assemblages. These assemblages are identified in Table 10 and their distribution is depicted in Figure 15. This classification system considers benthic assemblage, substrate type and water properties.

An in-depth review of GOM habitat types has been prepared by Brown (1993). Although still preliminary, this classification system is a promising approach. It builds on a number of other schemes, including Cowardin et al. (1979), and tailors them to the State of Maine's marine and estuarine environments. A significant factor that is included in this review (but has been neglected in others) is a measure of "energy" in a habitat. Energy could be a reflection of wind, waves, or currents present. This is a particularly important consideration in a review of fishing gear impacts since it indicates the natural disturbance regime of a habitat. The amount and type of natural disturbance is in turn an indication of the habitat's resistance to and recoverability from disturbance by fishing gear. Although this work appears to be complete in its description of habitat types; unfortunately, the distributions of many of the habitats are unknown.

Demersal fish assemblages for the Gulf of Maine and Georges Bank were part of broad scale geographic investigations conducted by Mahon et al. (1998) and Gabriel (1992). Both these studies and a more limited study by Overholtz and Tyler (1985) on Georges Bank found assemblages that were consistent over space and time in this region. In her analysis, Gabriel (1992) found that the most persistent feature over time in assemblage structure from Nova Scotia to Cape Hatteras was the boundary separating assemblages between the Gulf of Maine and Georges Bank, which occurred at approximately the 100 m isobath on northern Georges Bank.

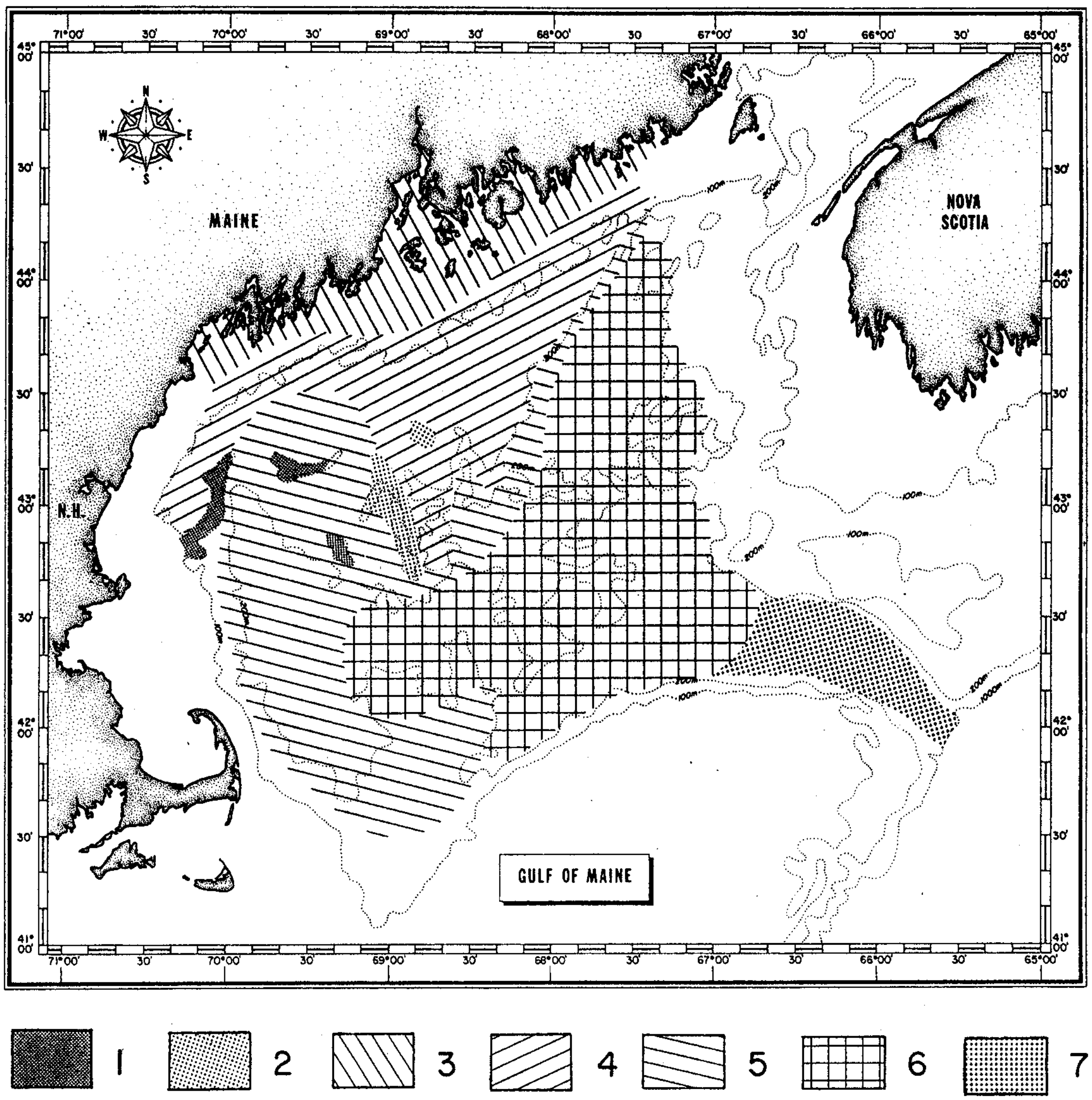
Overholtz and Tyler (1985) identified five (5) assemblages for Georges Bank (Table 11). The Gulf of Maine-deep assemblage included a number of species found in other assemblages, with the exception of American plaice and witch flounder, which were unique to this assemblage. Gabriel's (1992) approach did not allow species to co-occur in assemblages, and also classified these two species as unique to the deepwater Gulf of Maine-Georges Bank assemblage. Results of these two studies are compared in Table 11. Auster et al. (2001) went a step further, and related species clusters on Stellwagen Bank to reflectance values of different substrate types in an attempt to use fish distribution as a proxy for seafloor habitat distribution. They found significant reflectance associations for 12 of 20 species, including American plaice (fine substrate), and haddock (coarse substrate). Species clusters and associated substrate types are given in Table 12.

Auster (2002) did a multivariate analysis of annual trawl survey data at six year intervals (i.e.; 1970, 1975, 1981, 1987, and 1993) from the Georges Bank-GOM region. Results demonstrated consistent patterns of a singular deep and shallow assemblage of fishes across the region. The shallow water assemblage occurred on Georges Bank and around the rim of the Gulf of Maine, while the deep water assemblage occurred within the deeper basins of the GOM proper. While patterns of species dominance shifted over time, the actual distribution of assemblages remained relatively constant (i.e.; there were shifts in assemblage boundaries that were attributed in part due to shifting station locations within survey strata). The differences between this study and the Overholtz and Tyler (1985) and Gabriel (1992) studies can in part be attributed to differences in spatial boundaries of the data. That is, multivariate approaches produce clusters and the variation in the data sets, based on variations in assemblage composition over space and time, produce variable boundaries. Overholtz and Tyler (1985) found a consistent pattern over Georges Bank alone while Auster (2002) showed a singular assemblage at the spatial scale that produced relevant patterns. Gabriel (1992) also found a deep assemblage within the GOM region and is consistent with the Auster (2002) study.

Table 10 - Gulf of Maine benthic assemblages as identified by Watling (1998).

Benthic Assemblage	Benthic Community Description
1	Comprises all sandy offshore banks, most prominently Jeffreys Ledge, Fippennies Ledge, and Platts Bank; depth on top of banks about 70 m; substrate usually coarse sand with some gravel; fauna characteristically sand dwellers with an abundant interstitial component.
2	Comprises the rocky offshore ledges, such as Cashes Ledge, Sigsbee Ridge and Three Dory Ridge; substrate either rock ridge outcrop or very large boulders, often with a covering of very fine sediment; fauna predominantly sponges, tunicates, bryozoans, hydroids, and other hard bottom dwellers; overlying water usually cold Gulf of Maine Intermediate Water.
3	Probably extends all along the coast of the Gulf of Maine in water depths less than 60 m; bottom waters warm in summer and cold in winter; fauna rich and diverse, primarily polychaetes and crustaceans; probably consists of several (sub-) assemblages due to heterogeneity of substrate and water conditions near shore and at mouths of bays.
4	Extends over the soft bottom at depths of 60 to 140 m, well within the cold Gulf of Maine Intermediate Water; bottom sediments primarily fine muds; fauna dominated by polychaetes, shrimp, and cerianthid anemones.
5	A mixed assemblage comprising elements from the cold water fauna as well as a few deeper water species with broader temperature tolerances; overlying water often a mixture of Intermediate Water and Bottom Water, but generally colder than 7° C most of the year; fauna sparse, diversity low, dominated by a few polychaetes, with brittle stars, sea pens, shrimp, and cerianthid also present.
6	Comprises the fauna of the deep basins; bottom sediments generally very fine muds, but may have a gravel component in the offshore morainal regions; overlying water usually 7 to 8° C, with little variation; fauna shows some bathyal affinities but densities are not high, dominated by brittle stars and sea pens, and sporadically by a tube-making amphipod.
7	The true upper slope fauna that extends into the Northeast Channel; water temperatures are always above 8° and salinities are at least 35 ppt; sediments may be either fine muds or a mixture of mud and gravel.

Figure 15 - Distribution of the seven (7) major benthic assemblages in the Gulf of Maine as determined from both soft bottom quantitative sampling and qualitative hard bottom sampling.



The assemblages are characterized as follows: 1. sandy offshore banks; 2. rocky offshore ledges; 3. shallow (< 50 m) temperate bottoms with mixed substrate; 4. boreal muddy bottom, overlain by Maine Intermediate Water, 50 – 160 m (approx.); 5. cold deep water, species with broad tolerances, muddy bottom; 6. deep basin warm water, muddy bottom; 7. upper slope water, mixed sediment. Source: Watling 1998.

Table 11 - Comparison of demersal fish assemblages of Georges Bank and Gulf of Maine identified by Overholtz and Tyler (1985) (Georges Bank only) and Gabriel (1992).

Overholtz and Tyler (1984) – Georges Bank		**Gabriel (1992) – Georges Bank and Gulf of Maine**	
Assemblage	**Species**	**Species**	**Assemblage**
Slope & Canyon	offshore hake blackbelly rosefish Gulf stream flounder fourspot flounder monkfish, whiting white hake, red hake	offshore hake blackbelly rosefish Gulf stream flounder fawn cusk-eel, longfin hake, armored sea robin	Deepwater
Intermediate	whiting red hake monkfish Atlantic cod, haddock, ocean pout, yellowtail flounder, winter skate, little skate, sea raven, longhorn sculpin	whiting red hake monkfish short-finned squid, spiny dogfish, cusk	Combination of Deepwater Gulf of Maine/Georges Bank & Gulf of Maine-Georges Bank Transition
Shallow	Atlantic cod haddock pollock whiting white hake red hake monkfish ocean pout	Atlantic cod haddock pollock	Gulf of Maine-Georges Bank Transition Zone
	yellowtail flounder windowpane winter flounder winter skate little skate longhorn sculpin summer flounder sea raven, sand lance	yellowtail flounder windowpane winter flounder winter skate little skate longhorn sculpin	Shallow Water Georges Bank-Southern New England
Gulf of Maine-Deep	white hake American plaice witch flounder thorny skate whiting, Atlantic cod, haddock, cusk Atlantic wolfish	white hake American plaice witch flounder thorny skate, redfish	Deepwater Gulf of Maine-Georges Bank
Northeast Peak	Atlantic cod haddock pollock ocean pout, winter flounder, white hake, thorny skate, longhorn sculpin	Atlantic cod haddock pollock	Gulf of Maine-Georges Bank Transition Zone

Gabriel analyzed a greater number of species and did not overlap assemblages.

Table 12 - Ten dominant species and mean abundance/tow^{-1} from each cluster species group and its associated substrate type as determined by reflectance value, from Stellwagen Bank, Gulf of Maine (Auster et al. 2001).

SUBSTRATE TYPE					
Coarse		**Coarse**		**Wide Range**	
Species	**Mean**	**Species**	**Mean**	**Species**	**Mean**
Northern Sand Lance	1172.0	Haddock	13.1	American plaice	63.3
Atlantic herring	72.2	Atlantic cod	7.3	Northern sand lance	53.0
Spiny dogfish	38.4	American plaice	5.3	Atlantic herring	28.5
Atlantic cod	37.4	Whiting	3.3	Whiting	22.4
Longhorn sculpin	29.7	Longhorn sculpin	2.0	Acadian redfish	16.0
American plaice	28.0	Yellowtail flounder	1.9	Atlantic cod	14.0
Haddock	25.7	Spiny dogfish	1.6	Longhorn sculpin	9.5
Yellowtail flounder	20.2	Acadian redfish	1.6	Haddock	9.1
Whiting	7.5	Ocean pout	1.3	Pollock	7.9
Ocean pout	9.0	Alewife	1.1	Red hake	6.2
No. tows = 83		No. tows = 60		No. tows = 159	
SUBSTRATE TYPE					
Fine		**Fine**			
Species	**Mean**	**Species**	**Mean**		
American plaice	152.0	Whiting	275.0		
Acadian redfish	31.3	American plaice	97.1		
Whiting	29.5	Atlantic mackerel	42.0		
Atlantic herring	28.0	Pollock	41.1		
Red hake	26.1	Alewife	37.2		
Witch flounder	23.8	Atlantic herring	32.0		
Atlantic cod	13.1	Atlantic cod	18.1		
Haddock	12.7	Longhorn sculpin	16.8		
Longhorn sculpin	12.5	Red hake	15.2		
Daubed shanney	11.4	Haddock	13.2		
No. tows = 66		No. tows = 20			

Georges Bank

The interaction of several environmental factors including availability and type of sediment, current speed and direction, and bottom topography have been found to combine to form seven sedimentary provinces on eastern Georges Bank (Valentine et al. 1993), which are outlined in Table 13 and depicted in Figure 16.

Theroux and Grosslein (1987) identified four (4) macrobenthic invertebrate assemblages that corresponded with previous work in the geographic area. They noted that it is impossible to define distinct boundaries between assemblages because of the considerable intergrading that occurs between adjacent assemblages; however, the assemblages are distinguishable. Their assemblages are associated with those identified by Valentine et al. (1993) in Table 13.

The Western Basin assemblage (Theroux and Grosslein 1987) is found in the upper Great South Channel region at the northwestern corner of Georges Bank, in comparatively deep water (150-200 m) with relatively slow currents and fine bottom sediments of silt, clay and muddy sand. Fauna are comprised mainly of small burrowing detritivores and deposit feeders, and carnivorous scavengers. Representative organisms include bivalves (Thyasira flexuosa, Nucula tenuis, Musculus discors), annelids (Nephtys incisa, Paramphinome pulchella, Onuphis opalina, Sternaspis scutata), the brittle star Ophiura sarsi, the amphipod Haploops tubicola, and red crab (Geryon quedens). Valentine et al. 1993 did not identify a comparable assemblage; however, this assemblage is geographically located adjacent to Assemblage 5 as described by Watling (1998) (Table 10 and Figure 15).

The Northeast Peak assemblage is found along the Northern Edge and Northeast Peak, which varies in depth and current strength and includes coarse sediments, mainly gravel and coarse sand with interspersed boulders, cobbles, and pebbles. Fauna tend to be sessile (cnidarians, brachiopods, barnacles, and tubiferous annelids) or free-living (brittle stars, crustaceans, and polychaetes), with a characteristic absence of burrowing forms. Representative organisms include amphipods (*Acanthonotozoma serratum, Tiron spiniferum*), the isopod *Rocinela americana*, the barnacle *Balanus hameri*, annelids (*Harmothoe imbricata, Eunice pennata, Nothria conchylega*, and *Glycera capitata*), sea scallops (*Placopecten magellanicus*), brittle stars (*Ophiacantha bidentata, Ophiopholis aculeata*), and soft corals (*Primnoa resedaeformis, Paragorgia arborea*).

The Central Georges Bank assemblage occupies the greatest area, including the central and northern portions of Georges Bank in depths less than 100 m. Medium grained shifting sands predominate this dynamic area of strong currents. Organisms tend to be small to moderately large in size with burrowing or motile habits. Sand dollars (*Echinarachnius parma*) are most characteristic of this assemblage. Other representative species include mysids (*Neomysis americana*, *Mysidopsis bigelowi*), the isopod *Chiridotea tuftsi*, the cumacean *Leptocuma minor*, the amphipod *Protohaustorius wigleyi*, annelids (*Sthenelais limicola*, *Goniadella gracilis, Scalibregma inflatum*), gastropods (*Lunatia heros, Nassarius trivittatus*), the starfish *Asterias vulgaris*, the shrimp *Crangon septemspinosa*, and the crab *Cancer irroratus*.

The Southern Georges assemblage is found on the southern and southwestern flanks at depths from 80-200 m, where fine grained sands and moderate currents predominate. Many southern species exist here at the northern limits of their range. Dominant fauna include amphipods, copepods, euphausiids, and the starfish genus *Astropecten*. Representative organisms include amphipods (*Ampelisca compressa, Erichthonius rubricornis, Synchelidium americanum*), the cumacean *Diastylis quadrispinosa,* annelids (*Aglaophamus circinata, Nephtys squamosa, Apistobranchus tullbergi*), crabs (*Euprognatha rastellifera, Catapagurus sharreri*), and the shrimp *Munida iris*.

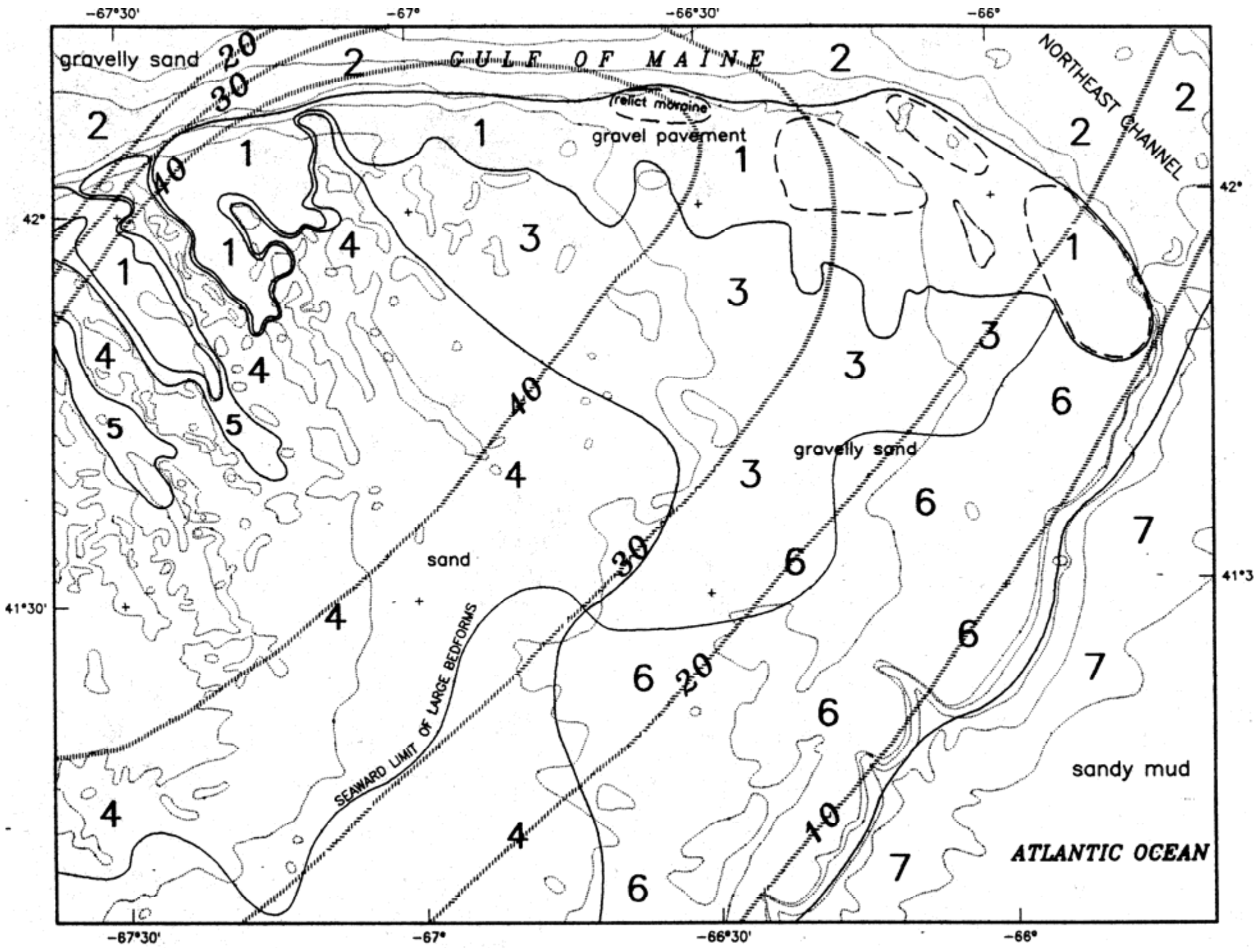
Table 13 - Sedimentary provinces of eastern Georges Bank.

Sedimentary Province	**Depth (m)**	**Description**	**Benthic Assemblage**
Northern Edge / Northeast Peak (1)	40-200	Dominated by gravel with few deposits of coarse sand; boulders common in some areas; predominantly a tightly packed pebble pavement. Representative epifauna bryozoa, hydrozoa, *anemones,* and *calcareous* worm tubes. *Strong tidal and storm currents.*	Northeast Peak
Northern Slope	200-240	Variable sediment type (gravel, gravelly sand, and	Northeast Peak

Sedimentary Province	**Depth (m)**	**Description**	**Benthic Assemblage**
and Northeast Channel (2)		sand) and scattered bedforms. This is a transition zone between the northern edge gravel and the sandy and silty sediment of the Gulf of Maine and the southern bank slope. *Strong tidal and storm currents.*	
North / Central Shelf (3)	60-120	Highly variable sediment type (ranging from gravel to sand) with common rippled sand and large bedforms; patchy gravel lag deposits. *Minimal epifauna on gravel due to sand movement.*	Central Georges
Central and Southwestern Shelf - *shoal ridges* (4)	10-80	Dominated by sand (commonly fine- and medium-grained) with large sand ridges, dunes, waves, and ripples. Small bedforms in southern part. *Minimal epifauna on gravel due to sand movement.*	Central Georges
Central and Southwestern Shelf - *shoal troughs* (5)	40-60	Gravel (including gravel lag) and gravelly sand between large sand ridges. Patchy large bedforms. Strong currents. (Few samples; submersible observations noted presence of gravel lag, rippled gravelly sand, and large bedforms.) *Minimal epifauna on gravel due to sand movement.*	Central Georges
Southeastern Shelf (6)	80-200	Rippled gravelly sand (commonly medium- and fine-grained) with patchy large bedforms and gravel lag. Weaker currents; ripples are formed by intermittent storm currents. Representative epifauna include sponges attached to shell fragments.	Southern Georges
Southeastern Slope (7)	400-2000	Silt and clay greater than 10% of sediment associated with sand (commonly medium- and fine-grained); with rippled sand on shallow slope and smooth silty sand deeper.	none

As defined by Valentine et al. (1993) and Valentine and Lough (1991) with additional comments by Valentine (personal communication) and benthic assemblages assigned from Theroux and Grosslein (1987).

Figure 16 - Sedimentary provinces of eastern Georges Bank based on criteria of sea floor morphology, texture, sediment movement and bedforms, and mean tidal bottom current speed (cm/sec).



Relict moraines (bouldery sea floor) are enclosed by dashed lines. Source: Valentine and Lough (1991).

Along with high levels of primary productivity, Georges Bank has been historically characterized by high levels of fish production. Several studies have attempted to identify demersal fish assemblages over large spatial scales. Overholtz and Tyler (1985) found five depth-related groundfish assemblages for Georges Bank and the Gulf of Maine that were persistent temporally and spatially. Depth and salinity were identified as major physical influences explaining assemblage structure. Gabriel (1992) identified six assemblages, which are compared with the results of Overholtz and Tyler (1985) in Table 11. Mahon et al. (1998) found similar results.

A few recent studies (Garrison 2000, 2001; Garrison and Link 2000) demonstrate the persistence of spatio-temporal overlap among numerically dominant, commercially valuable and /or ecologically important species. The studies by Garrison and associates utilized an index of spatial overlap based on the NOAA spring and fall bottom trawl surveys. He found that among the community of fish species on Georges Bank, only a very few species have high spatial overlaps with other species. The most notable example is silver hake (whiting), which had a very high overlap with most other species, suggestive of a broad distribution. Trends in spatial overlap over time generally reflect changes in species abundance. During the 1960s, haddock and yellowtail flounder were both widely distributed and had high spatial overlaps with other species. As abundance of these species declined through the 1970s into the 1990s, their spatial range contracted and their overlaps with other species subsequently declined. In contrast to this, species whose abundance has increased through time show an expansion of ranges and increased spatial overlap with other species. Interestingly and to confirm other studies of fish assemblages, the major species assemblages have been generally consistent across time given the changes in relative abundance.

Seasonal trends in spatial overlap are also apparent. Spiny dogfish, for example, has a far stronger association and a far broader range of species' associations in the winter than it does in the summer. Similarly, winter skate is a more prevalent co-correspondent in winter than other times of the year. This metric, like the spatial overlap trend over time, is sensitive to abundance as evidenced by the lack of spatial overlap between Atlantic halibut and any other species.

Mid-Atlantic Bight

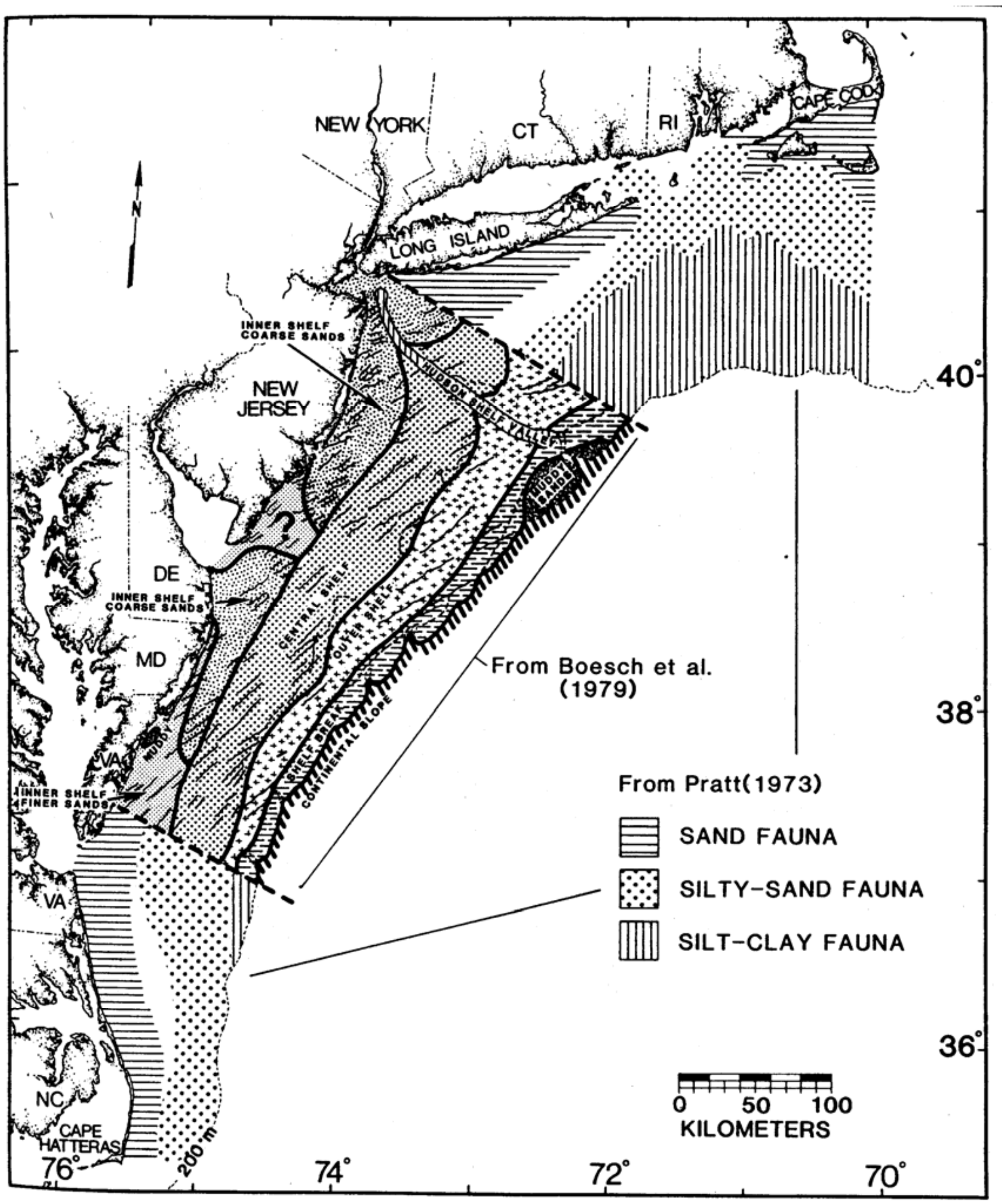
Three broad faunal zones related to water depth and sediment type were identified for the Mid-Atlantic by Pratt (1973). The "sand fauna" zone was defined for sandy sediments (1% or less silt) which are at least occasionally disturbed by waves, from shore out to 50 m. The "silty sand fauna" zone occurred immediately offshore from the sand fauna zone, in stable sands containing at least a few percent silt and slightly more (2%) organic material. Silts and clays become predominant at the shelf break and line the Hudson Shelf Valley, and support the "silt-clay fauna."

Building on Pratt's (1973) work, the Mid-Atlantic shelf was further divided by Boesch (1979) into seven bathymetric/morphologic subdivisions based on faunal assemblages (Table 14, Figure 17). Sediments in the region studied (Hudson Shelf Valley south to Chesapeake Bay) were dominated by sand with little finer material. Ridges and swales are important morphological features in this area. Sediments are coarser on the ridges, and the swales have greater benthic macrofaunal density, species richness and biomass. Faunal species composition differed between these features, and Boesch (1979) incorporated this variation in his subdivisions; much overlap of species distributions was found between depth zones, so the faunal assemblages represented more of a continuum than distinct zones.

Table 14 - Mid-Atlantic habitat types as described by Pratt (1973) and Boesch (1979) with characteristic macrofauna as identified in Boesch (1979).

Habitat Type (after Boesch 1979)	**Description**		
	Depth (m)	**Characterization (Pratt faunal zone)**	**Characteristic Benthic Macrofauna**
Inner shelf	0-30	characterized by coarse sands with finer sands off MD and VA (sand zone)	Polychaetes: Polygordius, Goniadella, Spiophanes
Central shelf	30-50	(sand zone)	Polychaetes: Spiophanes, Goniadella Amphipod: Pseudunciola
Central and inner shelf swales	0-50	occurs in swales between sand ridges (sand zone)	*Polychaetes:* Spiophanes, Lumbrineris, Polygordius
Outer shelf	50-100	(silty sand zone)	Amphipods: Ampelisca vadorum, Erichthonius Polychaetes: Spiophanes
Outer shelf swales	50-100	occurs in swales between sand ridges (silty sand zone)	Amphipods: Ampelisca agassizi, Unciola, Erichthonius
Shelf break	100-200	(silt-clay zone)	not given
Continental slope	>200	(none)	not given

Figure 17 - Schematic representation of major macrofaunal zones on the Mid-Atlantic shelf.



Wigley and Theroux (1981) found a general trend in declining macrobenthic invertebrate density from coastal areas offshore to the slope, and on the shelf from Southern New England south to the Commonwealth of Virginia and State of North Carolina. There were no detectable trends in density from north to south on the slope. Number of individuals was greatest in gravel sediments, and declined in sand-gravel, sand-shell, sand, shell, silty sand, silt, and finally, clay. However, biomass of benthic macrofauna was greatest in shell habitat, followed by silty sand, gravel, sand-gravel, sand, sand-shell, silt, and clay.

Demersal fish assemblages were described at a broad geographic scale for the continental shelf and slope from Cape Chidley, Labrador to Cape Hatteras, North Carolina (Mahon et al.1998) and from Nova Scotia to Cape Hatteras (Gabriel 1992). Factors influencing species distribution included latitude and depth.

Results of these studies were similar to an earlier study confined to the Mid-Atlantic Bight continental shelf (Colvocoresses and Musick 1984). In this study, there were clear variations in species abundances, yet they demonstrated consistent patterns of community composition and distribution among demersal fishes of the Mid-Atlantic shelf. This is especially true for five (5) strongly recurring species associations that varied slightly by season (Table 15). The boundaries between fish assemblages generally followed isotherms and isobaths. The assemblages were largely similar between the spring and fall collections, with the most notable change being a northward and shoreward shift in the temperate group in the spring.

Table 15 - Major recurrent demersal finfish assemblages of the Mid-Atlantic Bight during spring and fall as determined by Colvocoresses and Musick (1984).

Season	Species Assemblage				
	Boreal	**Warm temperate**	**Inner shelf**	**Outer shelf**	**Slope**
Spring	Atlantic cod little skate sea raven monkfish winter flounder longhorn sculpin ocean pout whiting red hake white hake spiny dogfish	black sea bass summer flounder butterfish scup spotted hake northern searobin	windowpane	fourspot flounder	shortnose greeneye offshore hake blackbelly rosefish white hake
Fall	white hake whiting red hake monkfish longhorn sculpin winter flounder yellowtail flounder witch flounder little skate spiny dogfish	black sea bass summer flounder butterfish scup spotted hake northern searobin smooth dogfish	windowpane	fourspot flounder fawn cusk eel gulf stream flounder	shortnose greeneye offshore hake blackbelly rosefish white hake witch flounder

Steimle and Zetlin (2000) described representative finfish species and epibenthic/epibiotic and motile epibenthic invertebrates associated with Mid-Atlantic reef habitats (Table 16). Most of these reefs are human-made structures.

Table 16 - Mid-Atlantic reef types, location, and representative flora and fauna, as described in Steimle and Zetlin (2000).

Location (Type)	Representative Flora and Fauna		
	Epibenthic/Epibiotic	**Motile Epibenthic Invertebrates**	**Fish**
Estuarine (Oyster reefs, blue mussel beds,other hard surfaces, semi-hard clay and Spartina peat reefs)	Oyster, barnacles, ribbed mussel, blue mussel, algae, sponges, tube worms, anemones, hydroids, bryozoans, slipper shell, jingle shell, northern stone coral, sea whips, tunicates, caprellid amphipods, wood borers	Xanthid crabs, blue crab, rock crabs, spider crab, juvenile American lobsters, sea stars	Gobies, spot, striped bass, black sea bass, white perch, toadfish, scup, drum, croaker, spot, sheepshead porgy, pinfish, juvenile and adult tautog, pinfish, northern puffer, cunner, sculpins, juvenile and adult Atlantic cod, rock gunnel, conger eel, American eel, red hake, ocean pout, white hake, juvenile pollock
Coastal (exposed rock/soft marl, harder rock, wrecks & artificial reefs, kelp, other materials)	Boring mollusks (piddocks), red algae, sponges, anemones, hydroids, northern stone coral, soft coral, sea whips, barnacles, blue mussel, horse mussel, bryozoans, skeleton and tubiculous amphipods, polychaetes, jingle shell, sea stars	American lobster, Jonah crab, rock crabs, spider crab, sea stars, urchins, squid egg clusters	Black sea bass, pinfish, scup, cunner, red hake, gray triggerfish, black brouper, smooth dogfish, sumemr flounder, scad, bluefish amberjack, Atlantic cod, tautog, ocean pout, conger eel, sea raven, rock gunnel, radiated shanny
Shelf (rocks & boulders, wrecks & artificial reefs, other solid substrates)	Boring mollusks (piddocks) red algae, sponges, anemones, hydroids, stone coral, soft coral, sea whips, barnacles, blue mussels, horse mussels, bryozoans, amphipods, polychaetes	American lobster, Jonah crabs, rock crabs, spider crabs, sea stars, urchins, squid egg clusters (with addition of some deepwater taxa at shelf edge)	Black sea bass, scup, tautog, cunner, gag, sheepshead porgy, round herring, sardines, amberjack, spadefish, gray triggerfish, mackerels, small tunas, spottail pinfish, tautog, Atlantic cod, ocean pout, red hake, conger eel, cunner, sea raven, rock gunnel, pollock, white hake
Outer shelf (reefs and clay burrows including “pueblo village community”)			Tilefish, white hake, conger eel

4.3 PROTECTED RESOURCES

The following protected species are found in the environment in which the sea scallop fishery is prosecuted. A number of them are listed under the Endangered Species Act of 1973 (ESA) as endangered or threatened, while others are identified as protected under the Marine Mammal Protection Act of 1972 (MMPA). Two right whale critical habitat designations also are located within the action area. An update and summary is provided here to facilitate consideration of the species most likely to interact with the scallop fishery relative to the proposed action.