2.0 INTRODUCTION

2.1 BACKGROUND

2.1.1 History

The Magnuson Fishery Conservation and Management Act of 1976, (renamed the Magnuson-Stevens Fishery Conservation and Management Act when amended on October 11, 1996) established a U. S. exclusive economic zone (EEZ) between 3 and 200 miles offshore, and established eight regional fishery management councils that manage the living marine resources within that area. The twenty-one member New England Fishery Management Council's (Council) authority extends from Maine to southern New England and, in some cases, to the mid-Atlantic because of the range of the species.

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act, known as the Sustainable Fisheries Act (SFA), changed the focus of the Act by emphasizing the importance of habitat protection to healthy fisheries and by strengthening the ability of the National Marine Fisheries Service (NMFS) and the Councils to protect and conserve the habitat of marine, estuarine, and anadromous finfish, mollusks, and crustaceans. This habitat is termed "essential fish habitat" and is broadly defined to include "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

2.1.2 New Requirements for NMFS, Councils, and Federal Agencies

To improve fish habitat protection, the SFA requires or authorizes that the Councils, NMFS, and other federal agencies take new actions. The SFA requires the Council, after receiving recommendations from NMFS, amend its fishery management plans by October 1998 to:

- describe and identify the essential habitat for the species managed by the Council
- minimize to the extent practicable adverse effects on EFH caused by fishing
- identify other actions to encourage the conservation and enhancement of EFH

The Council must describe EFH and identify adverse impacts and conservation measures for Atlantic herring, sea scallops, Atlantic salmon, and fifteen species of groundfish.

2.1.3 Strengthened Habitat Protection

Once fishery management plans are amended with EFH information, NMFS and the Councils will be more proactive in protecting habitat areas by alerting other federal and state agencies about areas of concern, and urging them to avoid planning projects in these areas. When projects are planned that may adversely affect EFH, the Councils and NMFS can recommend conservation measures to mitigate problems. The SFA requires federal agencies (and other entities funded by federal dollars) engaging in activities that may adversely affect EFH to consult with NMFS regarding those activities. NMFS (and the Councils) may make suggestions on how to mitigate any potential habitat damage.

Once these agencies receive NMFS' comments, they must respond in writing within 30 days, outlining the measures they are proposing to mitigate the impact of the activity on EFH. They must also explain any inconsistencies between the mitigation actions they propose with the recommendations made by NMFS.

2.1.4 EFH Roles and Responsibilities

The roles of NMFS, the Councils, and federal agencies in protecting EFH is detailed below, with citations provided to the appropriate section of the SFA (Public Law 104-267). (Source: Guidelines published in the *Federal Register* via an Interim Final Rule on December 19, 1997, Vol. 62, No. 244):

NMFS is required to:

- develop guidelines, by regulation, to assist the Councils in the description and identification of EFH in FMPs (including adverse impacts on EFH) and consideration of actions to ensure conservation and enhancement of EFH by April 11, 1997 (Section 305(b)(1)(A));
- develop schedules for amending FMPs for EFH, and for future periodic review of EFH amendments (Section 305(b)(1)(A));
- provide each Council with recommendations and information regarding EFH for each fishery under that Council's authority (Section 305(b)(1)(B));
- review programs administered by the Department of Commerce and ensure that relevant programs further the conservation and enhancement of EFH (Section 305(b)(1)(C));
- consult with federal agencies regarding any activity, or proposed activity, authorized, funded, or undertaken by the agency that may adversely affect EFH (Section 305(b)(2));
- coordinate with and provide information to other federal agencies to further the conservation and enhancement of EFH (Section 305(b)(1)(D)); and,
- recommend conservation measures for any action undertaken by any state or federal agency that may adversely affect EFH (Section 305(b)(4)(A)).

The Councils are required or authorized to:

- submit FMP amendments to the Secretary to implement the EFH and other new FMP requirements by October 11, 1998;
- describe and identify EFH for the fisheries based on the guidelines established by NMFS, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of EFH (Section 303);
- comment on and make recommendations to NMFS and any federal or state agency concerning any activity, or proposed activity, authorized, funded, or undertaken by any federal or state agency that may adversely affect the habitat, including EFH, of a fishery under its authority (Section 305(b)(3)(A)); and,

- comment on and make recommendations to NMFS and any federal or state agency concerning an activity that is likely to substantially affect the habitat, including EFH, of an anadromous fishery. (Section 305(b)(3)(B))

Other federal agencies are required to:

- consult with NMFS regarding any activity, or proposed activity, authorized, funded, or undertaken by the agency that may adversely affect EFH (Section 305(b)(2)); and,
- provide NMFS and any Council that comments on an activity, or proposed activity, with a written description of the measures proposed by the agency for avoiding, mitigating or offsetting the impact of the activity on EFH within 30 days of receipt of a recommendation. If this response is inconsistent with NMFS recommendations, the agency must explain why it is inconsistent (Section 305(b)(4)(B)).

2.2 PURPOSE AND NEED

2.2.1 Purpose of Amendment

The purpose of the amendment is to identify and describe the EFH for all species of marine, estuarine, and anadromous finfish, and mollusks managed by the Council to better protect, conserve, and enhance this habitat. This amendment also will identify the major threats to essential fish habitat from both fishing and non-fishing related activities and identify conservation and enhancement measures.

2.2.2 Need for Improved Management

Fish in the coastal waters of New England, species of the continental shelf, and anadromous species that spawn in rivers or estuaries, constitute valuable and renewable natural resources. These fishery resources contribute to the food supply, economy, welfare, health, and recreational opportunities of the nation as well as New England. A habitat program is necessary to rebuild overfished stocks, to ensure conservation, to facilitate long-term protection of essential fish habitats, and to realize the full potential of the region's fishery resources. The Council is addressing these needs via this amendment to its fishery management plans.

2.2.3 Definitions

The Magnuson-Stevens Act defines essential fish habitat as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." For the purposes of interpreting this definition, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include historic areas where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

Fish habitat is where a fish species is found during some or all of its life. Fish habitat is used here both in the traditional sense where structure or substrate delineates its geographic boundaries (e.g., coral reefs, marshes, and kelp beds) and in the less conventional sense where boundaries are more fluid (e.g., turbidity zones, thermoclines, and fronts separating water masses). Historical fish habitat is the geographic area where a fish species was found at some point in time; this habitat may not be used now if the species distribution has changed or has been reduced, or access has been altered by man or natural events. Fish use habitat for spawning, breeding, migration, feeding and growth, and for shelter to reduce mortality. Most habitats provide only a subset of these functions. Fish habitat can change with life history stage, abundance, the presence of other species, and with temporal and spatial variability in the environment. The type of habitat available, its attributes, and its functions are important to the productivity of a fish species.

2.3 HABITAT POLICY AND MANAGEMENT OBJECTIVES

Recognizing that all species are dependent on the quantity and quality of their habitat, it is the policy of the New England Fishery Management Council to promote and encourage the conservation, restoration and enhancement of the habitat upon which living marine resources depend.

This policy shall be supported by four policy objectives which are to:

(1) Maintain and enhance the current quantity and quality of habitats supporting harvested species, including their prey base.

(2) Restore and rehabilitate fish habitats which have already been degraded.

(3) Create and develop fish habitats where increased availability of fishery resources will benefit society.

(4) Modify fishing methods and create incentives to reduce the impacts on habitat associated with fishing.

These objectives are based on ensuring the sustainability of harvested species and optimizing the societal benefits of our marine resources.

The Council shall assume an active role in the protection and enhancement of habitats important to marine and anadromous fish. In support of the Council’s habitat policy, the management objectives for the EFH amendment will be:

1. To the maximum extent possible, to identify and describe all essential fish habitat for those species of finfish and mollusks managed by the Council;

2. To identify all major threats (fishing and non-fishing related) to the essential fish habitat of those species managed by the Council; and,
3. To identify existing and potential mechanisms to protect, conserve and enhance the essential fish habitat of those species managed by the Council, to the extent practicable.

2.4 FISHERY MANAGEMENT UNITS

2.4.1 Atlantic salmon

The management unit for the Atlantic Salmon (*Salmo salar*) FMP is intended to encompass the entire range of the species of U.S. origin while recognizing the jurisdictional authority of signatory nations to North Atlantic Salmon Conservation Organization (NASCO). Accordingly, the management unit for this FMP amendment includes all anadromous salmonids of U.S. origin in the North Atlantic area throughout their migratory ranges except while they are found within any foreign nation's territorial sea or fishery conservation zone (or the equivalent), to the extent that such sea or zone is recognized by the United States.

2.4.2 Atlantic herring

The Council is currently working to develop a fishery management plan for Atlantic herring (*Clupea harengus*), in conjunction with the Atlantic States Marine Fisheries Commission. In order to be as consistent as possible in designating and addressing EFH for all species, including Atlantic herring, this omnibus EFH amendment document includes all of the required EFH components of the proposed Atlantic herring FMP. Once the Atlantic herring FMP is complete, the EFH components related to Atlantic herring will be incorporated by reference.

The management unit for the proposed Atlantic herring FMP is defined as the Atlantic herring resource throughout the range of the species within the U.S. waters of the northwest Atlantic Ocean from the shoreline to the seaward boundary of the EEZ. The management unit does not include the entire range of the Atlantic herring stock complex. The stock complex includes herring which migrate through Canadian waters, beyond the range of management of the proposed Atlantic herring FMP.

2.4.3 Atlantic sea scallop

The management unit for the Sea Scallop (*Placopecten magellanicus*) FMP consists of the sea scallop resource throughout its range in waters under the jurisdiction of the United States. This includes all populations of sea scallops from the shoreline to the outer boundary of the EEZ. The principal resource areas are the Northeast Peak of Georges Bank, westward to the Great South Channel, and southward along the continental shelf of the mid-Atlantic.

The management unit also includes populations found within the Gulf of Maine and Cape

Cod Bay. These areas include the territorial seas throughout the range, primarily in Maine and Massachusetts. Fishing for sea scallops within state territorial waters is not subject to regulation under the Scallop FMP except for vessels that do not hold a federal permit when scalloping in state waters. Nonetheless, populations within state waters are included within the management unit in recognition of market interactions and the need for complementary state management action.

Five resource areas are generally defined within the management unit: Delmarva, New York Bight, South Channel and Southeast Part of Georges Bank, Northeast Peak and Northern Part of Georges Bank, and the Gulf of Maine. The Delmarva area includes scallops as far south as North Carolina.

2.4.4 Monkfish

The management unit for the Monkfish (*Lophius americanus*) FMP consists of the monkfish resource throughout its range in waters under the jurisdiction of the United States. This includes all populations of monkfish from the shoreline to the outer boundary of the EEZ. There are two management areas for monkfish, although management extends throughout the range of monkfish in U.S. waters. It is unclear if the monkfish resource in the Northwest Atlantic is composed of one, two, or several stocks.

2.4.5 Groundfish

The management unit for the Northeast Multispecies FMP is the multispecies (finfish) fishery that occurs from eastern Maine through southern New England, encompassing all commercial and recreational harvesting sectors in New England and all fish species that factor into a fishery within a trip, from trip to trip and from season to season, except those species that are subject to other fishery management plans under the Magnuson-Stevens Fishery Conservation and Management Act.

Multispecies fisheries management is inherently comprehensive in it scope and, consequently, cooperation from all relevant entities (state, regional, federal) is essential for effective achievement of this program's management objectives. It is necessary that each species specifically regulated under this FMP shall be regulated throughout its range. Major species within this fishery that may be subject to specific regulation under this FMP amendment include:

American plaice (*Hippoglossoides platessoides*)
Atlantic cod (*Gadus morhua*)
Atlantic halibut (*Hippoglossus hippoglossus*)
haddock (*Melanogrammus aeglefinus*)
ocean pout (*Macrozoarces americanus*)
pollock (*Pollachius virens*)
red hake (*Urophycis chuss*)

redfish (*Sebastes* spp.)
white hake (*Urophycis tenuis*)
whiting (*Merluccius bilinearis*)
windowpane flounder (*Scopthalmus aquosus*)
winter flounder (*Pleuronectes americanus*)
witch flounder (*Glyptocephalus cynoglossus*)
yellowtail flounder (*Pleuronectes ferruginea*)

2.5 AMENDMENT DEVELOPMENT PROCESS

This amendment package amends all existing Council FMPs, including the Monkfish FMP, the Sea Scallop FMP, the Northeast Multispecies FMP, and the Atlantic Salmon FMP. This amendment package also includes components of the proposed Atlantic Herring FMP to address the required EFH elements. The EFH information related to Atlantic herring and contained herein will be incorporated by reference into the Atlantic Herring FMP. The Council had the option to submit separate EFH amendments to each of its FMPs, or to incorporate the EFH components into the FMP amendments addressing the other SFA requirements. The Council considered these options and determined that a single, omnibus EFH amendment was the most efficient and appropriate mechanism. This option eliminates unnecessary duplication (for instance, including the Non-Fishing Related Threats assessment in multiple FMP amendments), and allowed the Council to take a more "ecosystem-based" approach in the development of the amendment. In the future, any FMP amendments or new FMPs will include EFH provisions directly within the parent documents.

In developing this EFH amendment package, the Council divided the overall process into several distinct phases. The end result of each phase was one or more components of the amendment focused on one of the required elements. These components were integrated as amendment sections at the end of the development process, providing a single "omnibus" EFH amendment for all Council-managed species.

- The first phase of the process was identifying and describing the essential fish habitat for all Council-managed species. This was the most time-consuming phase of the process. NMFS developed species reports that detailed the life history and habitat requirements of each species and the Council considered and evaluated the available data on the distribution and abundance of each species.
- The second phase of the process was identifying and characterizing all known and potential adverse impacts to essential fish habitat, both from fishing-related and non-fishing related activities. This phase involved extensive literature reviews and included a special contracted report on the effects of fishing activities on habitat.
- The third phase was to identify a range of actions to mitigate the adverse impacts.

For the fishing-related impacts, this took the form of a review of current Council management measures that may provide habitat conservation, a consideration of new management measures, and expanding the framework adjustment process to include habitat concerns. Mitigation for the non-fishing impacts took the form of recommendations to state and federal agencies on measures to improve habitat protection.

- The fourth phase was to identify the range of information and research needs that the Council has in order to complete a more comprehensive assessment of essential fish habitat in the future. This phase also included developing a strategic plan for future Council EFH work.

The Council will continue to develop and refine these processes. Unfortunately, there are some limitations associated with this approach and the Council was required to make some assumptions, but it remains a scientific approach based on the best available information. Some limitations and assumptions of the process include:

- The primary sources of information for Council consideration were the NMFS surveys. The NMFS bottom trawl survey does not survey everywhere, and there are biases associated with where it does survey. The NMFS scallop survey does not necessarily survey where it is known that high densities of scallops occur. The results of the MARMAP survey are biased against certain types of eggs and larvae.
- State and inshore surveys are not necessarily compatible to NMFS data or each other, nor are they all complete and in electronic format. In fact, only one state, Massachusetts, had a survey that was used extensively by NMFS and the Council.
- None of the surveys actively collect the habitat information the Council and NMFS are most interested in (habitat type, substrate, biological associations, etc.).
- Additional sources of information (fishermen, historical, etc.) are sparse, difficult to verify, and largely anecdotal.
- There were no data available to the Council on many small estuaries along the coast, in spite of their apparent importance for fish production. The information that was available, from the NOAA Estuarine Living Marine Resource program, provided simply presence/absence (Level 1) information about a subset of the bays and estuaries in the New England and Mid-Atlantic regions.
- Certain habitat features, such as edges or transitions between different bottom types, rapid changes in topography, beds of benthic invertebrates (such as stalked ascidians and mussels), and special bottom structures such as clay pipes and gravel pavement, have been identified by fishermen and scientists as types of habitat features that appear very important to some species of fish (Dorsey and Pederson 1998). Unfortunately, most of these features occur as scales much smaller than the ten minute squares used by the Council.

However, even while faced with these limitations, the Council is reasonably assured of where most of the fish tend to be and where they tend to occur in higher concentrations. This is the first step toward a complete designation of essential fish habitat and meets the objectives of the Interim Final Rule. Thus, for this amendment, the Council has designated EFH based on the limited information available, and set the stage for gathering new and better information. This additional information will help the Council eliminate the limitations of the current process and either verify or discredit the assumptions used.   It is important to remember is that this is but the first step in the process, and the Council will review and modify, as necessary, the EFH designations, as well as the other provisions of the EFH amendment.

2.6 HABITAT CHARACTERISTICS OF THE NEW ENGLAND REGION

2.6.1 Introduction

The EFH amendment focuses on three major, distinct geographic regions – the Gulf of Maine, Georges Bank, and the portions of the continental shelf south of New England (Figure 1). The topographic and oceanographic features of each region are distinct and support diverse biological communities. The diverse habitat conditions, oceanographic processes, and biological composition in New England waters form some of the most productive fishing grounds in the world.

Habitat can be difficult to define because there are different perspectives of what environmental conditions are important or unimportant to living resources. Habitat has been described at different spatial and temporal scales. Generally, habitat is thought of as a place where an organism is found (e.g. estuaries, tidal flats, seagrass meadows, cobble fields, etc.) (Peters and Cross 1992). Habitat has been described by the following definitions:

- the place where an organism lives or the place one would find it (Odum 1971);
- an area that performs a subset of all ecological functions (Edwards *et al*. 1992);
- that part of the environment on which organisms depend directly or indirectly to carry out their life processes (Deegan and Buchsbaum 1997);
- three levels of habitat include (1) the geographic range of the species, (2) its essential habitat, and (3) its critical habitat (i.e. the amount of habitat needed to sustain a viable population) (Cross *et al*. 1996);
- an essential resource for sustaining the production of commercially and recreationally important species (Langton *et al*. 1996); and,
- essential fish habitat is those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (SFA, P.L. 104-297).

The importance of habitat, in general, to the sustainability of fishery resources is a frequently discussed concept. Researchers have looked at particular habitat parameters at varying geographic and seasonal scales that appear to be important for the development of finfish and shellfish species. It is critical to describe essential habitat according to ontogenetic stage due to dramatic differences in species behavior, morphology, and habitat requirements throughout development. For example, organisms may exhibit specific habitat shifts throughout life history stages for a variety of reasons (e.g. changing dietary requirements). Current and future research may further develop the descriptions of environmental variables important to fishery resources. Research may demonstrate and explain the dynamic nature of the marine environment and its relationship to fishery production.

2.6.2 Gulf of Maine

The Gulf of Maine is a deep, large, dynamic, coastal sea bound on the east, north, west, and south by Browns Bank, Nova Scotian Shelf, the New England States, Cape Cod, and Georges Bank, respectively (Figure 1). A suite of complex oceanographic conditions result in the rich biological community, highly variable bottom type and transport processes of the Gulf of Maine (Townsend 1991). Sediments (ranging from boulders to clay) were deposited in the Gulf of Maine during glacial retreat. Bottom sediment type is quite patchy and generally related to topography (Schlee 1973) and characterized by deep basins associated with silty clay or clay and topographic peaks exposed to winnowing and reworking action of the currents with sand and gravel (NEFMC 1993). Coastal regions are complex, such that, sediment type and texture vary from mud to boulders (Valentine and Schmuck 1995) (refer to Figure 2).

Three major basins (Georges, Jordan, and Wilkinson) exceed 250 meters in depth and are surrounded by irregular topographic features (Jeffreys Ledge, Stellwagen Bank, Platts Bank, Cashes Ledge, Browns Bank, and Georges Bank) (Figure 1). The Northeast Channel (located between Browns and Georges Bank) and the Great South Channel (located between Georges Bank and Nantucket Shoals) connect the Gulf of Maine to the north Atlantic.

Currents (tidal, wind, and storm-induced) (Witman 1996) and seasonal variability of water properties appear to be major physical forces related to the productivity of the Gulf of Maine. There is a general counterclockwise current around the Gulf of Maine influenced by water masses from the Scotian Shelf and offshore (Figure 3). Many gyres and minor currents occur within the Gulf (Lynch 1996). Coastal currents also move counterclockwise, except south of the Penobscot Bay region where a portion of the current turns offshore towards Jeffreys Ledge and the shallow topography between Jordan and Wilkinson Basin (Brooks 1985). Freshwater run-off from numerous rivers along the coast of the Gulf of Maine substantially influences coastal circulation, phytoplankton blooms, and overall productivity (Townsend 1992). While there is an increasing amount of information on patterns of distribution and abundance of macrofauna at the scale of local sites (Watling *et al.* 1988; Langton and Watling 1990; Langton *et al.* 1990), there is little quantitative information on the distribution of benthic assemblages on larger Gulf of Maine-wide scales (Witman 1996). Understanding the variable relationship between fisheries and the environment is needed for effective habitat-based management for the marine resources of the Gulf of Maine (Townsend 1992; Langton and Haedrich 1996).

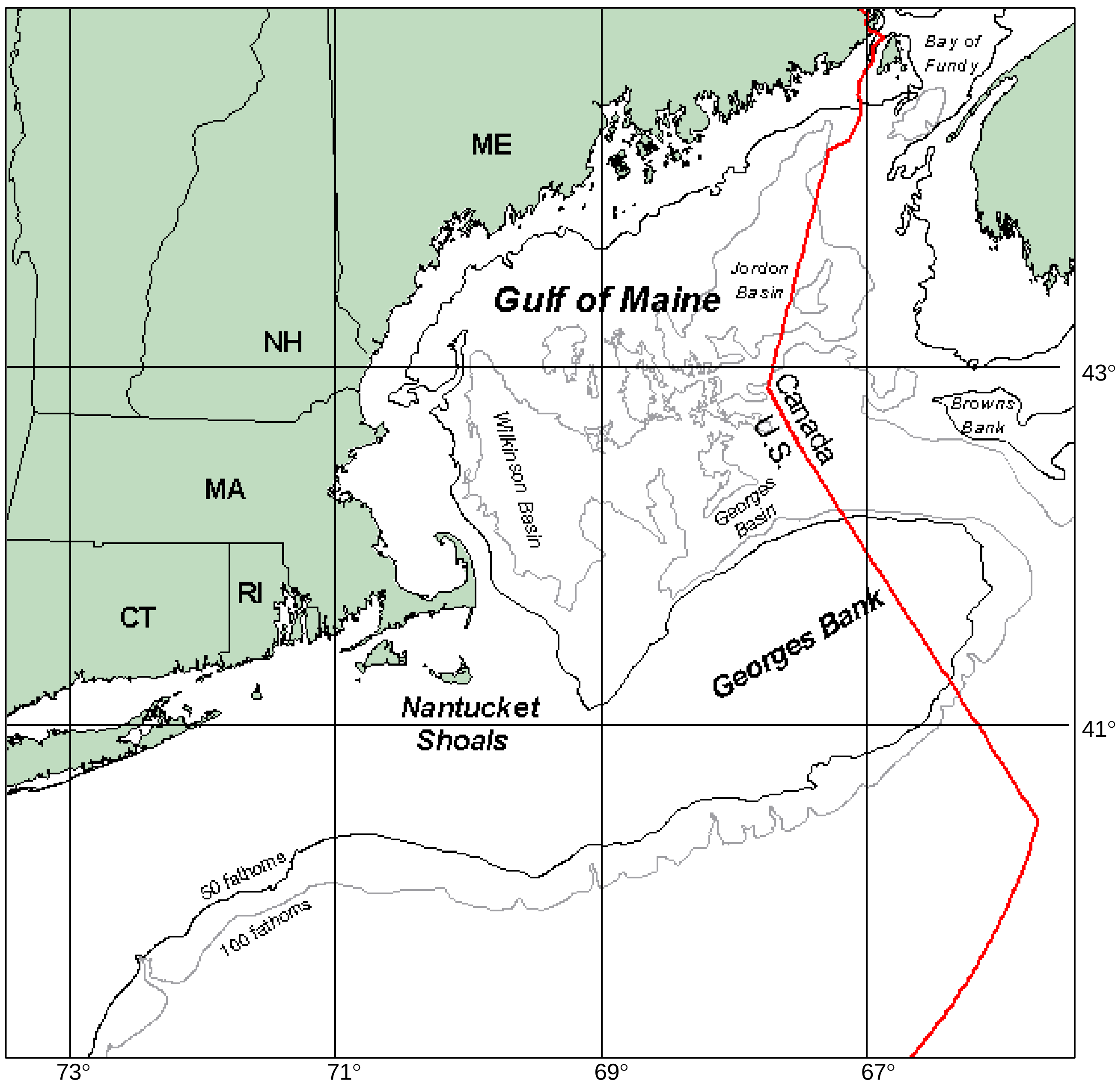

Figure 1: The New England region, including Gulf of Maine, Georges Bank, and Nantucket Shoals.

Surveys have attempted to describe biological associations over a large geographic region in the Gulf of Maine. Demersal fish groups associated with large geographic areas have been discussed for the Georges Bank and Gulf of Maine regions (Table 1) (reviewed by Langton *et al.* 1994). Gordon (1994) illustrates there are three distinct herring stocks in the Gulf of Maine; herring spawning beds are restricted in area to more complex bottom structure with strong currents for preferential egg attachment conditions. Other studies demonstrate small-scale invertebrate distributions in the Gulf of Maine (Theroux and Grosslein 1987; Watling *et al.* 1988; Langton and Uzmann 1990).

2.6.3 Georges Bank

Georges Bank is a shallow (3-150 m water depth), elongate extension of the northeastern U.S. Atlantic continental shelf (Valentine and Lough 1991) formed by the Wisconsinan glacial episode (Valentine *et al.* 1993) (Figure 1). The Bank is a submarine plateau (Fogarty and Murawski 1998) characterized by a steep slope on its northern edge and a broad, flat, gently sloping southern flank. It is separated from the rest of the continental shelf to the west by the Great South Channel. The central region of the Bank is shallow, and the bottom is characterized by large amplitude sand waves (Emery and Uchupi 1972). Valentine *et al.* (1993) researched and summarized the surficial sediment, topography, and currents of eastern Georges Bank to be used in conjunction with faunal distribution maps of the region. Glacial retreat during the late Pleistocene deposited the bottom sediments currently observed on eastern Georges Bank, and the sediments have been continuously reworked and redistributed by the action of rising sea level, tidal, storm, and other currents (Valentine and Lough 1991). The nature of the sea bed sediments varies widely on Georges Bank, ranging from clay to gravel (Figure 2).

Currents on Georges Bank include a weak, persistent clockwise gyre around the bank, strong semidiurnal tidal flow predominantly northwest and southeast, and very strong, intermittent storm-induced currents, occurring simultaneously (Valentine *et al.* 1993). Sherman *et al*. (1996) describes tidal currents over the shallow top of Georges Bank as very strong, accounting for more than 80% of the total current variance near and over the bank. The vigorous tidal currents keep the waters over the bank well mixed vertically resulting in a tidal front that separates the cool waters of the well-mixed shallows from the warmer seasonally stratified shelf waters on the seaward and shoreward sides of the bank (Sherman *et al*. 1996) (Figure 3).

Bottom topography on eastern Georges Bank is characterized by linear ridges in the western shoal areas; relatively smooth, gently dipping sea floor on the deeper, eastern most part of the bank; and steeper and smoother topography incised by submarine canyons on the southeastern margin (Valentine *et al.* 1993). Oceanographic frontal systems separate water masses from the Gulf of Maine and the remainder of the Atlantic on Georges Bank and differ in temperature, salinity, nutrient concentration, and planktonic communities (Valentine and Lough 1991) which influence productivity and may influence fish abundance and distribution. The interaction of environmental factors (i.e. availability and type of sediment, current speed and direction, and bottom topography) have been investigated thoroughly and form seven sedimentary provinces on eastern Georges Bank (Valentine *et al.* 1993). Approximate depth ranges are provided in brackets for each of the seven provinces:

1. *Northern edge*: Dominated by gravel with portions of sand, common boulder areas, and tightly packed pebbles. Epifauna (bryozoa, hydrozoa, and worm tubes) are abundant in areas of boulders where bottom trawling is low. [40 - 200 meters]
2. *Northern slope and Northeast Channel*: Variable sediment type (gravel, gravel-sand, and sand) with ripples and scattered bedforms. This is a transition zone between the northern edge (1) and southern slope (7). [200 - 240 meters]
3. *North-central shelf*: Highly variable sediment type (ranging from gravel to sand) with rippled sand, large bedforms, and patchy gravel lag deposits. [60 - 120 meters]
4. *Shoal ridges, and central and southwestern shelf*: Dominated by sand (fine and medium grained) with large sand ridges, dunes, waves, and ripples. Small bedforms in southern part. [10 - 80 meters]
5. *Shoal troughs*: Gravel (including gravel lag) and gravel-sand between large sand ridges. Patchy large bedforms. Strong currents. Few samples – submersible observation noted presence of gravel lag, rippled gravel-sand, and large bedforms. [40 - 60 meters]
6. *Southeastern shelf*: Rippled gravel-sand (medium and fine-grained sand) with patchy large bedforms and gravel lag. Weaker currents. [80 - 200 meters]
7. *Southeastern slope*: Dominated by silt and clay with portions of sand (medium and fine) with rippled sand on shallow slope and smooth silt-sand sheet deeper. [400 - 2000 meters]

Natural processes continue to erode and rework the sediment type and availability on Georges Bank. Erosion and reworking of sediments will increase the amount of gravel pavement and less sand will be available to the sand sheets causing an overall coarsening of the bottom sediments of Georges Bank (Valentine *et al.* 1993). The physical disturbance of the seabed caused by strong, erosive currents (tidal and storm) potentially dictates the character of the biological community (Valentine and Lough 1991).

Georges Bank is characterized by high levels of primary productivity and, historically, high levels of fish production (Fogarty and Murawski 1998). It has a diverse biological community that is influenced by many environmental conditions. Several studies have attempted to identify demersal fish assemblages over large spatial scales on Georges Bank. Five depth-related groundfish assemblages were persistent temporally and spatially, with depth and salinity identified as major physical influences explaining the assemblage structure. The assemblages appeared to maintain temporal integrity and spatial configuration for the survey period (Table 1) (Overholtz and Tyler 1985).

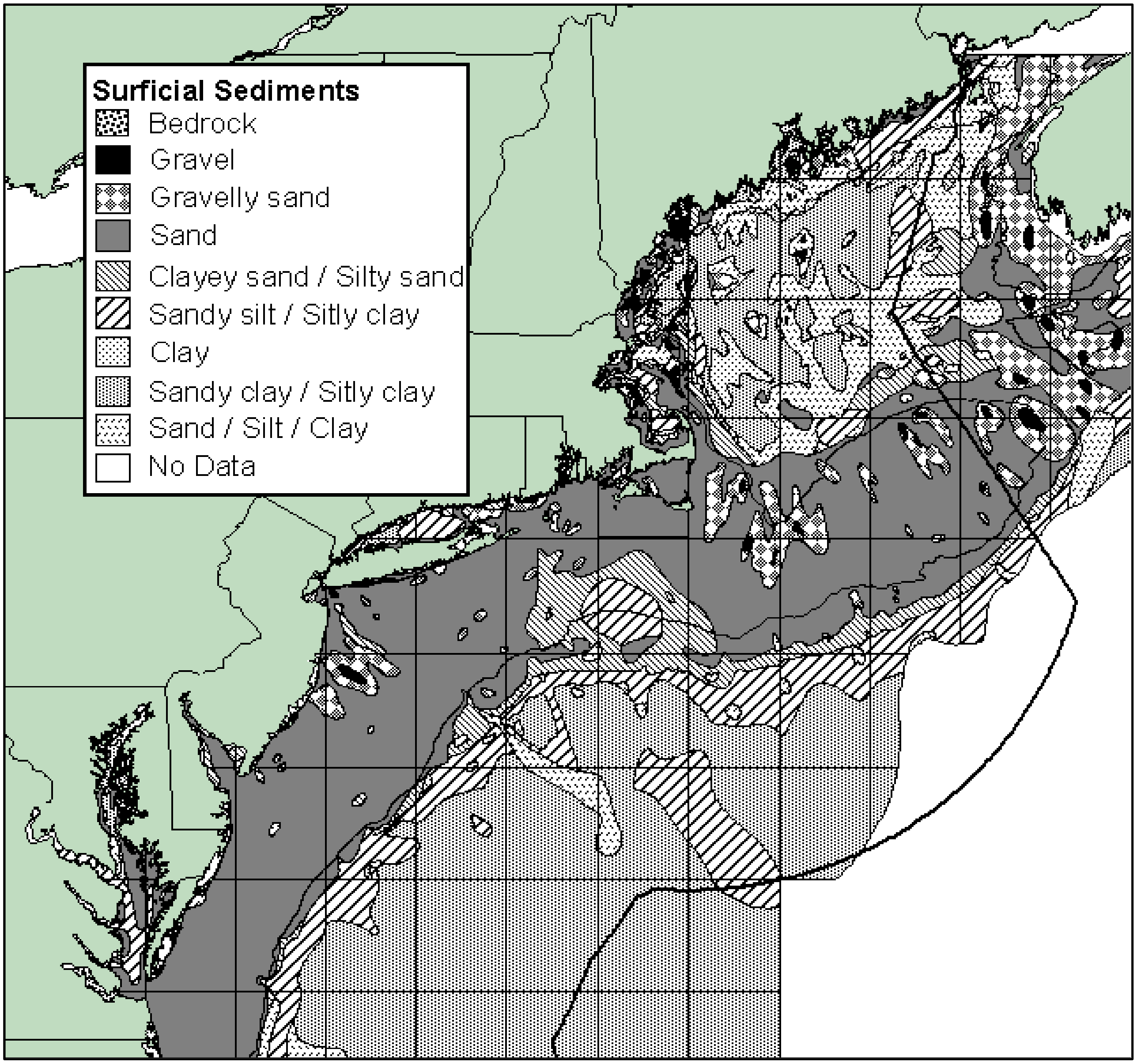

Figure 2: Map showing distribution of surficial sediments, Gulf of Maine, Georges Bank, and southern New England. Southern New England surficial sediment distribution similar to the Mid-Atlantic Bight region (Figure reproduced from Poppe *et al.* 1989).

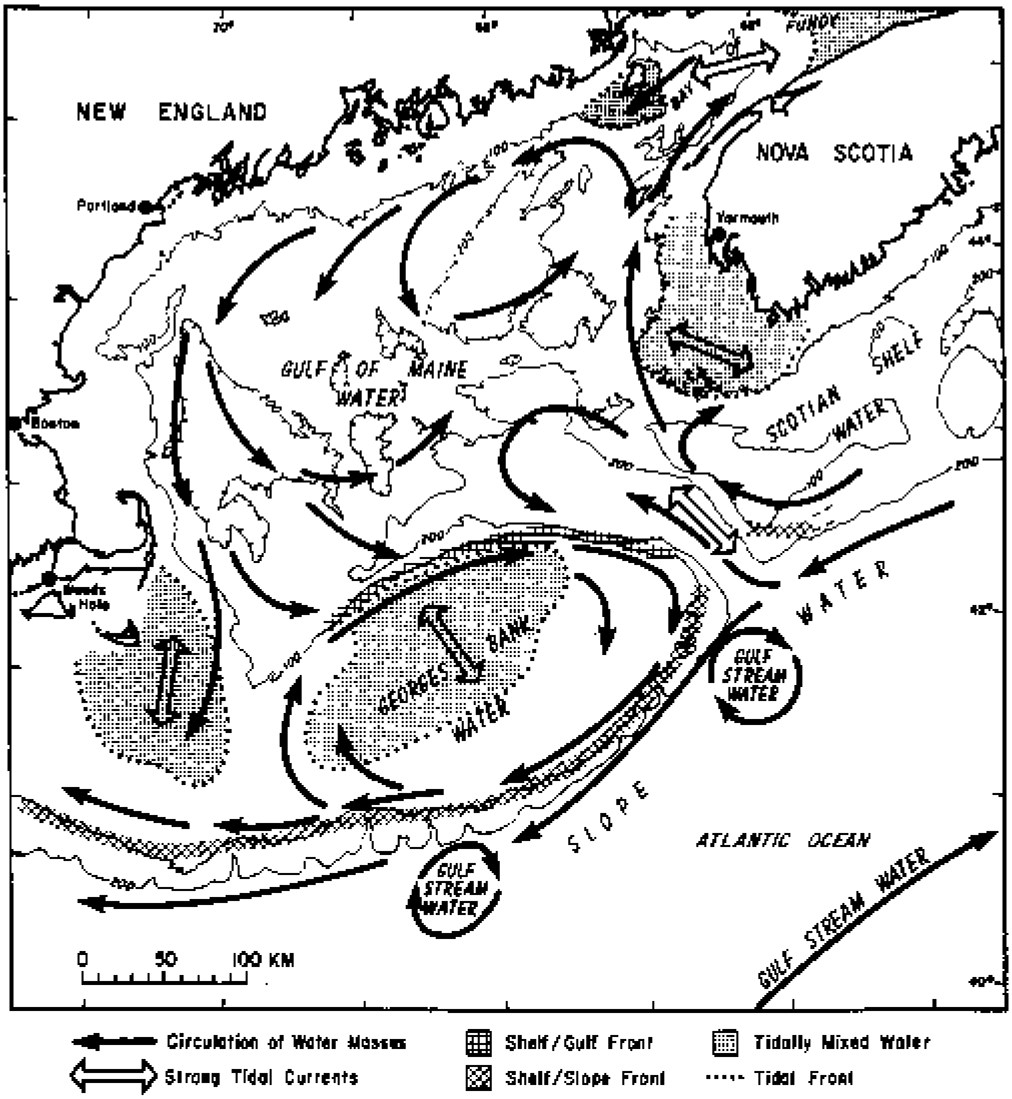

Figure 3: Map showing water mass circulation patterns in the Georges Bank – Gulf of Maine region. Water masses exhibit distinctive physical patterns (temperature, salinity, stratification, mixing, nutrient concentration). Mixing of bottom and surface waters in shallow areas by strong tidal currents recycles nutrients which leads to high biological productivity. Depths in meters. (after: Brooks 1985; Loder and Greenberg 1986; Butman *et al*. 1987) (figure reproduced from Valentine and Lough 1991).

Table 1: Demersal fish assemblages of Georges Bank and the Gulf of Maine based on a large geographic scale, for the period of 1963 - 1978 (Overholtz and Tyler 1985).

Slope and Canyon	Intermediate	Shallow	GOM Deep	Northeast Peak
whiting	red hake	whiting	American plaice	Atlantic cod
white hake	whiting	Atlantic cod	witch flounder	haddock*
red hake	Atlantic cod	haddock	white hake	pollock
offshore hake	haddock	pollock	whiting	white hake
monkfish	monkfish	white hake	Atlantic cod	winter flounder
	ocean pout	red hake	haddock	ocean pout
	yellowtail flounder	yellowtail flounder		
		windowpane		
		ocean pout		
		monkfish		

** majority of haddock was collected in the Northeast Peak group*

2.6.4 Southern New England

The continental shelf south of New England is broad and flat. The sedimentary composition is dominated by fine grained sediments. Sand dominates surficial bottom sediment composition with regions of clayey sand/silty sand, sandy silt/clayey silt, and gravel-sand. Gravel pavement and other coarse sediments are found sporadically on relatively small geographic scales throughout the region. Southeast of Nantucket, the Nantucket Shoals is characterized by sand waves and patches of gravel on the western flank of the Great South Channel. Finer sediments (sandy clay/silt clay) dominate the bottom further offshore (Poppe *et al.* 1989) (Figure 2).

Faunal associations were described at a broad geographic scale for the middle Atlantic bight continental shelf demersal fishes, based on the NMFS Bottom Trawl Survey, 1967-1976 (Table 2) (Colvocoresses and Musick 1983). There were clear variations in species abundances, yet they demonstrate consistent patterns of community composition and distribution among demersal fishes of the middle Atlantic continental shelf, especially for five strongly recurring species associations. The boundaries between fish assemblages generally followed isotherms and isobaths. The species 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. Although substrate preferences were not generated during this study, comparison of species group distribution with bottom sediment maps do not demonstrate any strong species group – substrate relationship. The major recurrent, dominant species groups were associated with the continental shelf region and distinguished for the spring and fall (Colvocoresses and Musick 1983).

Table 2: Major recurrent demersal species groups of the middle-Atlantic bight area during the spring and fall (boreal ≡ northern regions; warm temperate ≡ southern region). (Colvocoresses and Musick 1983).

Spring

Boreal	Warm Temperate	Inner Shelf	Slope Resident
Atlantic cod	black sea bass	windowpane	shortnose greeneye
little skate	summer flounder		offshore hake
sea raven	butterfish	Outer Shelf	blackbelly rosefish
monkfish	scup	fourspot flounder	white hake
winter flounder	spotted hake		
longhorn sculpin	northern searobin		
ocean pout			
whiting			
red hake			
white hake			
spiny dogfish			

Fall

Boreal	Warm Temperate	Inner Shelf	Slope Resident
white hake	black sea bass	windowpane	witch flounder
whiting	summer flounder		offshore hake
red hake	scup	Outer Shelf	white hake
monkfish	spotted hake	fourspot flounder	shortnose greeneye
longhorn sculpin	butterfish	fawn cusk-eel	blackbelly rosefish
winter flounder	northern searobin	gulf stream flounder	
yellowtail flounder	smooth dogfish		
witch flounder			
little skate			
spiny dogfish			

2.6.5 General Habitat Features

Biological Characteristics

Fish distribution and abundance data are used as a proxy for identifying locations of EFH. It is important to understand and consider species assemblages when discussing habitat features. Several faunal associations among northwest Atlantic groundfish have been identified (Colvocoresses and Musick 1983; Overholtz and Tyler 1985; Mahon and Smith 1989). For example, surveys on the Scotian Shelf demonstrate close associations among groundfish stocks (Mahon and Smith 1989). White hake and witch flounder appear closely associated throughout the year with whiting joining the assemblage in the summer. Haddock and halibut populations appear to be closely related with Atlantic cod joining the complex in the spring. Mahon and Smith (1989) provided a large-scale view of the associations between demersal finfish species of the northwest Atlantic.

The spatial and temporal boundaries of prey abundance can influence survivorship, recruitment, and development of any organism (e.g. Fortier and Gagne 1990). For example, populations of sand lance (*Ammodytes* spp.) are important sources of nutrition for many piscivorous fishes. Benthic invertebrates are the main source of nutrition for many adult demersal fishes (EFH Species Source Documents, Appendix A). The diversity of prey composition found in the dietary analysis of the food habits survey (NMFS 1973 to present) demonstrates the importance of prey supply and distribution to adult and juvenile finfish species. Plankton abundance and distribution may also be a great influence on ichthyoplankton community structure and distribution (Lough and Potter 1993). Early life history fishes are very susceptible to starvation. Therefore, suitable prey supply is an important factor in the survivorship and development of larval and early juvenile fishes. Oceanographic properties often dictate the structure and concentration of plankton communities. Differences in prey availability may influence the abundance and distribution of organisms on every trophic level. Trophic linkages are an important biological characteristic that can potentially dictate the state of fish populations.

Emergent epifauna often contribute to the survivorship of marine organisms because of the increased cover and habitat complexity they provide. A number of studies document the ecological importance of invertebrate growth, cover, and density (e.g. Auster *et al.* 1991; Auster *et al.* 1995; Auster *et al.* 1997). Along with other environmental conditions, submerged aquatic vegetation is also cited as an ecologically important habitat component providing numerous functions in shallow coastal waters (e.g. Short and Burdick 1994).

Marine Sediments

Sedimentary composition of the ocean floor is highly variable in the Gulf of Maine, Georges Bank, and southern New England (Figure 2). Sediments differ in origin, texture, size, transport mechanism, and distribution. Bottom habitats in New England waters are heterogeneous, characterized by patchy surficial sediment composition and irregular topographic peaks. Research demonstrates that fish distributions are often closely associated to specific sediment types (e.g. Scott 1982; Lough *et al.* 1989; Langton and Uzmann 1990; Valentine and Lough 1991; Langton *et al.* 1995; Auster *et al.* 1997; Auster *et al.* In Press) The Gulf of Maine, Georges Bank, and southern New England (which is very characteristic of the middle Atlantic bight sedimentary composition) have similar types of sediments but they occur in distinctly different composition and pattern (Table 3).

Several studies document the importance of seafloor habitats predominantly composed of gravel for the survivorship of certain early life history fishes (Lough *et al.* 1989; Valentine and Lough 1991; Auster and Malatesta 1995; Lindholm *et al.* In Press). Valentine and Lough (1991) demonstrate the importance of gravel for the settlement of haddock and Atlantic cod. Gravel appears to provide predation refuge and an abundant prey supply, increasing the survivorship of cod (Lough *et al.* 1989; Valentine and Lough 1991; Gotceitas and Brown 1993; Tupper and Boutilier 1995; Valentine and Schmuck 1995; Lindholm *et al.* In Press). Gravel has also been noted as an important habitat feature for other demersal species such as winter flounder, yellowtail flounder, longhorn sculpin, and little skate. Atlantic herring spawning grounds have also been closely related to gravel substrate and strong tidal currents (Sinclair and Iles 1985; Valentine and Lough 1991). Gravel provides a firm substrate for egg attachment. For example, suitable environmental conditions for herring spawning grounds appear to be limited to the shallow, western part of the gravel pavement on Georges Bank's northern edge which lies between sand ridges (Sinclair and Iles 1985; Valentine and Lough 1991). Gravel has also been noted as important to the recruitment and settlement of Atlantic sea scallops (Valentine and Lough 1991), and increasing the survivorship of lobsters (Wahle and Steneck 1992). Gravelly substrates are often associated with biologically diverse communities that are dominated by emergent epifauna and other biogenic structures, such as calcareous worm tubes, bryozoans, and cerianthid anemones (Valentine and Lough 1991; Collie *et al*. 1997), which provide some level of cover and refuge.

Table 3: Type of surficial sediment* observed on the seafloor of the New England region.

SEDIMENT TYPE	REGION
bedrock	GOM
gravel[1]	GOM, GB[2], SNE[3]
gravel-sand	GOM, GB, SNE
sand	GOM, GB, SNE
clayey sand/silty sand	GOM, GB, SNE
sandy silt/clayey silt	GOM, SNE
clay	GOM, GB
sandy clay/silty clay	GOM, SNE
sand/silt/clay	GOM, SNE

* sediment classifications from Poppe *et al.* (1989)
[1] gravel includes cobble and boulders
[2] boulders common on the northern edge and northeast Peak of GB (Valentine and Lough 1991)
[3] SNE (southern New England) is geologically similar to the middle Atlantic bight

Surficial sediments composed of a gravel-sand mix have also been noted as important postlarval fish habitat for Atlantic cod, haddock, winter flounder, yellowtail flounder, and others (Valentine and Lough 1991). American plaice adults have been demonstrated to associate with gravel-sand sediments (Scott 1982) for a variety of potential reasons (e.g. appropriate coloration for predation refuge and abundant prey availability). Gravel-sand sediments have been noted as recruitment and settlement habitat for sea scallops where the movement of sand is relatively minor (Langton and Uzmann 1990; Valentine and Lough 1991). In the New England region, the gravel-sand mixture is usually a transition zone between coarse gravel and finer sediments (Valentine and Lough 1991).

Sand provides suitable environmental properties for a variety of fishes, invertebrates, and microorganisms and forms large dunes and ridges that may be used by a number of organisms. Invertebrates, such as surf clams, razor clams, and quahogs, burrow between the grains to support their characteristic sessile behavior. Dunes and ridges provide refuge from currents and predators and habitat for ambush predators (Valentine and Lough 1991). Several important prey species inhabit sand habitats (e.g. amphipods, polychaetes, etc.) that flounders prefer. Yellowtail and winter flounder distribution has been correlated to sand (Langton and Uzmann 1990). In general, flatfishes are more closely associated with sand and finer sediments than other demersal fishes.

Fine sediments which include sand, silt, clay, and various combinations of the three are generally found in deeper basins and on smooth topography in the New England region (Valentine and Lough 1991). Fine sediments form bedforms on the seafloor and provide some level of predation refuge, protection against currents, and burrowing habitat for an array of invertebrates. Whiting, winter flounder, American plaice, ocean pout, and snake blennies have been primarily associated with fine sediments (Scott 1982; Langton and Uzmann 1990).

Sediment type alone does not necessarily constitute an important habitat condition. Sediment texture and biogenic structures, along with sediment type, have been demonstrated to be important features with which northwest Atlantic continental shelf fishes associate (reviewed by Auster *et al.* In Press). Auster *et al.* (In Press) developed a hierarchical classification of microhabitat types based on sediment characteristics, vertical relief, and spatial complexity. In general, increases in habitat complexity refer to greater vertical relief and increased variability in the size of interstices between structures and may result in higher survivability of demersal fishes (Auster and Malatesta 1995; Lindholm *et al.* In Press). The following classification may be an important component to overall habitat conditions in New England waters, based on habitat complexity (categories based on Auster *et al.* 1995; Langton *et al.* 1995; Auster *et al.* 1996; and reviewed and Auster and Langton MS1998):

- *smooth sand* or *mud*: areas with no vertical structure
- *sand waves*: troughs and peaks provide shelter from current; previous observations indicate species such as whiting position themselves on the downcurrent sides of sand waves where they ambush drifting demersal zooplankton and shrimp
- *biogenic structures*: burrows, depressions, cerianthid anemones, hydroid patches; features that are created and / or used by mobile fauna for shelter
- *shell aggregates*: provide complex small interstitial spaces for shelter; shell aggregates also provide a complex high contrast background which may confuse visual predators
- *pebbles and cobbles*: provide small interstitial spaces and may be equivalent in shelter value to shell aggregates
- *pebbles and cobbles* with *attached megafauna*: attached fauna such as sponges provide additional spatial complexity for a wider range of size classes of mobile organisms
- *partially buried boulders*: while not providing small interstitial spaces or deeper crevices, partly buried boulders exhibit high vertical relief; the shelter value of this type of habitat may be less or greater than previous types based on the size class and behavior species
- *piled boulders*: this habitat provides deep interstitial spaces of variable sizes.

Bottom topography, along with sediment type, may also influence the distribution and abundance of benthic, demersal, and pelagic organisms. Geologic features such as submarine canyons, rock ledges, and topographic peaks are potential habitat components that are potentially important to a variety of marine organisms. Bottom topography is often associated with particular sediment types (e.g. deep-water canyons and fine sediments), and may contribute to suitable environmental conditions for the survivorship, growth, and reproduction of fishery resources.

Ocean Circulation and Tides

Pelagic habitats are difficult to describe because the pelagic region is poorly understood at scales that allow for observations of change in conditions. Pelagic conditions can, however, be defined based on temperature, light intensity, turbidity, oxygen concentration, currents, frontal boundaries, and a host of oceanographic parameters and patterns. There are relatively few published data that relate the variability of these environmental factors to fishery resources and habitat conditions on large geographic and seasonal scales. Thus, oceanographic features are dynamic, interactive, and highly variable temporally and spatially (Robinson 1998). The New England region is characterized by semidiurnal tides, major and minor currents, variable fronts and eddies, and several convergence and divergence zones (based on average circulation rates) (Figure 3). The tidal flux in New England provides rapid exchange of nutrients, dissolved organic matter, and detrital material from coastal waters to offshore regions. The nutrient levels are greatly influenced by riverine discharge into the coastal environment, especially along the coast of Maine. The nutrient rich waters are the base of the trophic web in the Gulf of Maine, Georges Bank, and southern New England ecosystems, providing a portion of the nutritional requirements for phytoplankton. The tidal range and flux in New England influences many of the physical features (e.g. depth) and oceanographic processes (e.g. currents) that may be associated with the distribution and abundance of biological communities (Klein 1987).

The currents in New England are primarily influenced by the tidal cycle, but short-term, storm-induced currents also occur, especially in winter. Currents play an important role in supplying areas with oxygenated waters, nutrients, and organic matter. The abundance and distribution of ichthyoplankton and other planktonic organisms may be influenced by currents which may affect the population dynamics of finfish and shellfish of New England. Currents and gyres vary on a wide range of geographic and time scales (Beardsley *et al.* 1996). Tidal currents generate strong turbulent mixing in water layers, and storm-induced currents also generate mixing of the water column (Beardsley *et al.* 1996). Mixing the water column to supply critical nutrients to the sea surface waters is an important component of the overall nutrient cycle. Currents are also major transport mechanisms for plankton communities. Organisms are transported throughout the Gulf of Maine, Georges Bank, and southern New England regions. Gyres may restrict the transport of some organisms (e.g. ichthyoplankton) by trapping them in a relatively small geographic area. For example, Lough and Potter (1993) describe and summarize the transport and development of Atlantic cod and haddock eggs and larvae in the Georges Bank region; egg patches passively drift southwest in a clockwise residual pattern around

Georges Bank, larval concentrations are found at varying depths along the southern edge of Georges Bank between the 60 m and 100 m isobath, the concentration moves southwest toward the shoals of western Georges Bank, and larvae metamorph to juveniles and settle to demersal habitat with a consistent high density of juvenile gadids collected on eastern Georges Bank. Currents and gyres contribute to the diverse biological community of the New England region.

Currents and tides may also generate fronts, eddies, and divergence and convergence zones that may provide suitable habitat conditions to a suite of organisms. Fronts, eddies, and other convergence zones may function as a congregation area for complexes of organisms and influence the population dynamics of a region. Planktonic organisms may be especially influenced by the circulation of water masses (e.g. transport mechanism). Congregation zones may include areas of high primary productivity, high plankton concentrations, and efficient foraging habitats for larval fishes and other planktonic organisms. Larger organisms may also target fronts and eddies to prey upon the high density of planktonic organisms. Convergence zones (e.g. two currents coming together) may also act as transport mechanisms, supplying food-rich surface waters to the seafloor. Divergence zones (e.g. currents moving away from each other), including upwelling events, have been associated with phytoplankton blooms. Divergence zones transport nutrient-rich bottom waters to the sea surface and promote primary production. These oceanographic features may provide necessary habitat conditions for the survivability, development, and growth of a variety of organisms at particular ontogenetic stages.

Other physical oceanographic properties may contribute to pelagic habitat conditions, such as stratified water layers (e.g. thermoclines, haloclines, and pycnoclines), internal waves, plumes (e.g. riverine discharge), and others (e.g. Langmuir cells). Ekman and Stokes transport (drift) (Leis 1991) are oceanographic features that may contribute to planktonic transport and suitable environmental conditions. Physical oceanography constitutes several roles that influences several aspects of fishery resources and habitat conditions, including the transporting planktonic organisms and water masses throughout New England waters. Population dynamics and habitat conditions in New England are greatly influenced by oceanographic processes.

Submerged Aquatic Vegetation

The primary types of submerged aquatic vegetation (SAV) in New England are eelgrass (Zostera marina) and widgeon grass (Ruppia maritima). Kelp and rockweeds are abundant benthic seaweeds within New England waters. Seagrass and rockweed are found along the coast of the Gulf of Maine and southern New England, and kelp is usually limited to the coast of the Gulf of Maine. SAV plays an integral role in the development and sustainability of important living resources. Research has documented the importance of the ecological functions of SAV (ASMFC 1997).

Eelgrass and widgeon grass, along with all other seagrasses, function as a filter for the maintenance of water quality and fisheries habitat (Short and Burdick 1994). Seagrass serves as nursery grounds for a number of commercially and recreationally important species, specialized refuge, a rich food source for herbivores, and a life cycle transition zone (Short and Burdick 1994; ASMFC 1997). For example, Atlantic cod have been associated with SAV, possibly using it for predation refuge (Gotceitas *et al.* 1997). Eelgrass has also been noted to serve as an attachment site for primary settlement of blue mussels (Univ. of ME and Univ. of NH Sea Grant College Program 1994). Seagrass plays several important ecological functions, including a role in the chemical cycling of water, filtering and accumulating toxics and nutrients from the water, supporting epiphytic growth, and physical stabilization of the sediments (Short and Burdick 1994; ASMFC 1997).

Kelp also functions as a complex habitat, providing refuge from predators and foraging habitat for a variety of marine and estuarine organisms. For example, sea scallops, winter flounder, and lobsters have been documented to inhabit kelp forests. Kelp is also a harvestable plant with an expanding market. Rockweed is also an important habitat feature providing cover for a variety of finfish and shellfish species. Kelp, rockweed, and seagrass function as a source of detritus and primary productivity that is important in the numerous chemical and biological cycles in New England waters.

Coastal Features

The New England coast is probably best known for its magnificent scenery and vacation locations, but the coast of the Gulf of Maine and southern New England have a variety of aquatic, estuarine, and marine ecosystems that serve important ecological functions for many fishery resources. Salt marshes, mud flats, rocky intertidal zones, and sandy beaches are critical to inshore and offshore habitat conditions.

Salt marshes are found throughout the Gulf of Maine where suitable environmental conditions exist, with major marshes located on Cape Cod, the north shore of Massachusetts, and the coast of Maine (Gordon 1994). Tidal and subtidal mud and sand flats are general salt marsh features. Extensive mud and sand flats are found throughout the Gulf of Maine wherever proper sedimentary conditions exist, particularly in Cape Cod Bay (Gordon 1994). Salt marshes are important components of estuarine and coastal habitat, and provide nursery and spawning habitat for many finfish and shellfish species. Salt marsh vegetation is also a large source of organic material (detritus) that is important to the biological and chemical processes of the estuarine and marine environment. Salt marshes provide a large amount of prey for recreational and commercial organisms. Waterfowl and shorebirds also require salt marsh habitats for nesting, feeding, and cover. Salt marshes play an important role in the marine environment and support a number of fishery resources.

Rocky intertidal zones are periodically submerged, high energy environments. Rocky shores are most common around Cape Ann, Massachusetts and along the coast of Maine. Sessile invertebrates and some fish inhabit rocky intertidal zones. A variety of algae, kelp, and rockweed are also important habitat features of rocky shores. Fishery resources may depend on particular habitat features of the rocky intertidal zones, which provide important levels of refuge and nutrient sources. Rocky shores are also known for their importance to colonial seabirds.

Sandy beaches are most extensive along the coasts of Rhode Island, Massachusetts, New Hampshire, and Maine (Gordon 1994). Different zones of the beach present suitable habitat conditions for a variety of marine and terrestrial organisms. For example, the upper beach is necessary for dune grasses, sand fleas, invertebrates, and nesting birds. The intertidal zone presents suitable habitat conditions for many invertebrates and foraging habitat for birds. Several invertebrates and fish are adapted for living in the subtidal zone adjacent to sandy beaches, and transient fish find suitable conditions for foraging, among other activities, in the subtidal region. Beaches exhibit necessary habitat conditions and function as foraging and spawning habitats for marine resources.

Inland Wetlands

New England has a variety of palustrine wetlands that may directly and indirectly influence adjacent estuarine and marine habitats. Palustrine habitats include forested swamps, scrub-shrub, and emergent marshes (reviewed by Pedevillano 1995). Forested swamps provide habitat for a variety of birds, mammals, reptiles, amphibians, and invertebrates. They provide feeding, breeding, nesting, overwintering, and migration habitat. Scrub-shrub habitat is also used by diverse wildlife for feeding, nesting, breeding, and cover. Emergent marshes are a major source of surface water, and provide important habitat for a variety of aquatic and terrestrial organisms. Palustrine habitats are also important in cycling nutrients. Inland wetlands are necessary for a variety of organisms that may be critical to estuarine and marine resources and conditions.

Lacustrine habitats include reservoirs and flooded lakes that provide important breeding and foraging habitat for many natural resources. Rivers provide habitat for a variety of fishery resources and other wildlife (e.g. Atlantic salmon). Riverine conditions are important in providing hydrologic connections between coastal and inland habitats. Vegetation associated with riverine habitats provide suitable environmental conditions for birds, mammals, reptiles, amphibians, and insects that may be important trophic components to freshwater wetlands and estuaries. Riverine habitat conditions are important for the maintenance of healthy aquatic, estuarine, and marine environments and fishery resources.

2.6.6 Discussion

The New England region is characterized by heterogeneous environmental conditions which provides suitable habitat conditions for a diverse collection of living marine resources that are important to the overall health and productivity of New England waters. The interaction of biologic, geologic, and oceanographic features of the Gulf of Maine, Georges Bank, and southern New England sustains, historically, one of the most productive fishing grounds in the world. Fishery resources are influenced by a variety of habitat properties from terrestrial wetlands to seafloor sediment types. Taking into account the multitude of geographic and temporal scales and environmental parameters that potentially interact to influence the distribution and abundance of finfish and shellfish stocks, identifying isolated habitat components may demonstrate particular conditions suitable for fishery resources. The ecological importance of habitat features such as seafloor sediments and submerged aquatic vegetation have been thoroughly demonstrated (e.g. Valentine and Lough 1991; Short and Burdick 1994). Extensive research on the ecological importance of structurally complex seafloor (e.g. gravel pavement with emergent epifauna) for several managed fish (e.g. Atlantic cod) demonstrates the relationship between fishery production and habitat conditions. Further development of multivariate relationships between biological, chemical, and physical features will increase the understanding of the marine environment and advance the evidence of direct links between habitat conditions and fish productivity.