New England Fishery Management Council
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John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

PHASE 1

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

APPENDICES

March 2007

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PHASE 1

APPENDIX A
"EFH DESIGNATION METHODOLOGIES"

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1.0 Introduction

The New England Fishery Management Council (Council) is responsible for managing the fishery resources within the federal 200-mile limit off the coasts of Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut. Currently, the Council manages fisheries which target twenty-seven species (27) (Table A-1):

Table A-1. List of species under management by the New England Fishery Management Council

FMP	Species – Scientific Name	Common Names
Multispecies (Groundfish)	*Gadus morhua*	Atlantic cod (official) rock cod
Multispecies	*Glyptocephalus cynoglossus*	witch flounder (official) gray sole Craig fluke pole flounder
Multispecies	*Hippoglossus hippoglossus*	Atlantic halibut (official)
Multispecies	*Hippoglossoides platessoides*	American plaice (official) American dab Canadian plaice long rough dab
Multispecies	*Pleuronectes ferruginea*	yellowtail flounder (official) rusty flounder
Multispecies	*Macrozoarces americanus*	ocean pout (official) eelpout Congo eel muttonfish
Multispecies	*Melanogrammus aeglefinus*	haddock (official)
Multispecies	*Merluccius bilinearis*	whiting silver hake (official) New England hake
Multispecies	*Pollachius virens*	pollock (official) Boston bluefish coalfish green cod
Multispecies	*Pleuronectes americanus*	winter flounder (official) blackback Georges Bank flounder lemon sole

FMP	Species – Scientific Name	Common Names
		sole flatfish rough flounder mud dab black flounder
Multispecies	*Scophthalmus aquosus*	windowpane flounder (official) sand flounder spotted flounder New York plaice sand dab spotted turbot
Multispecies	*Sebastes* spp.	redfish (official) rosefish ocean perch red sea perch red bream Norway haddock
Multispecies	*Urophycis chuss*	red hake (official) squirrel hake ling blue hake
Multispecies	*Urophycis tenuis*	white hake (official) Boston hake black hake mud hake
Multispecies	*Merluccius albidus*	Offshore hake (official) Blackeye whiting
Monkfish	*Lophius americanus*	monkfish (official) American goosefish angler allmouth molligut fishing frog
Sea Scallop	*Placopecten magellanicus*	Atlantic sea scallop (official) giant scallop smooth scallop deep sea scallop Digby scallop Ocean scallop
Skates	*Amblyraja radiata*	Thorny skate (official) Mud skate Starry skate

FMP	Species – Scientific Name	Common Names
		Spanish skate
Skates	*Dipturus laevis*	Barndoor skate (official)
Skates	*Leucoraja erinacea*	Little skate (official) Common skate Summer skate Hedgehog skate Tobacco Box skate
Skates	*Leucoraja garmani*	Rosette skate (official) Leopard skate
Skates	*Malacoraja senta*	Smooth skate (official) Smooth-tailed skate Prickly skate
Skates	*Leucoraja ocellata*	Winter skate (official) Big skate Spotted skate Eyed skate
Skates	*Raja eglanteria*	Clearnose skate (official) Brier skate
Deep-Sea Red Crab	*Chaceon quinquedens*	Deep-Sea red crab (official)
Atlantic Herring	*Clupea harengus*	Atlantic sea herring (official) Labrador herring sardine sperling brit
Atlantic Salmon	*Salmo salar*	Atlantic salmon (official) sea salmon silver salmon black salmon

The EFH Final Rule (50 CFR Part 600.815(a)(1)(i))) states that "FMPs must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. FMPs should explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the **species/life stage**. FMPs must identify the specific geographic location or extent of habitats described as EFH. FMPs must include maps of the geographic locations of EFH or the geographic boundaries within which EFH for each

species and life stage is found." Life stages are unique developmental periods and for the purposes of this action are defined as follows:

1. Egg stage – The life history stage of an animal that occurs after reproduction and refers to the developing embryo, its food store, and sometimes jelly or albumen, all surrounded by an outer shell or membrane. Occurs before the *larval* or *juvenile stage*.

2. Larval stage – The first stage of development after hatching from the *egg* for many fishes and invertebrates. This life stage looks fundamentally different than the *juvenile* and *adult stages*, and is incapable of reproduction; it must undergo metamorphosis into the juvenile or adult shape or form.

3. Juvenile stage – The life history stage of an animal that comes between the *egg* or *larval stage* and the *adult stage*; juveniles are considered immature in the sense that they are not yet capable of reproducing, yet they differ from the larval stage because they look like smaller versions of the adults. Young-of-the-year juveniles are juveniles less than one year old.

4. Adult stage – In vertebrates, the life history stage where the animal is capable of reproducing. Spawning adults are adults that are currently producing eggs.

<u>Deep-Sea Red Crab and Atlantic Salmon Methods</u>

This appendix describes the methods and data used to develop each major EFH designation alternative for all species. Deep-sea red crab and Atlantic salmon have decidedly different methods for designating EFH due to the very different life history characteristics and data sources. As such, the methods for these species are found at the end of the document in a separate section.

2.0 Alternative 1 – No Action

The 1998 Omnibus EFH Amendment 1 (NEFMC 1998) established EFH designations for 18 of the 26 species managed by the New England Fishery Management Council. Designations for offshore hake, deep sea red crab, and seven species of skate were completed in subsequent management plans (NEFMC Multispecies Amendment 12, NEFMC Red Crab FMP 2002, NEFMC Skate FMP).

Several sources of distribution and abundance data were used to develop the original EFH maps.[1] The NMFS bottom trawl survey (1963 - 1997) and the NMFS Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton survey (1977 - 1987) provide the best available information on the distribution and relative abundance of Council-managed species in offshore waters. The bottom trawl survey was used for juveniles and adults, and the MARMAP survey was used for eggs and larvae. The Council used other sources of information to map EFH in inshore areas, including the Massachusetts inshore trawl survey (1978 - 1997), information from Long Island Sound (1990 - 1996), and NOAA's Estuarine Living Marine Resources (ELMR) program. Data on the distribution and relative abundance of fish in other inshore areas, especially estuaries and embayments, were not available in a timely manner in some cases. The Council also considered information provided by the fishing industry, as well as several sources of historical information. Information on the distribution and abundance of sea scallops was obtained primarily from the NMFS sea scallop survey (1982 - 1997) and from representatives of the scallop fishing industry. Information on the range and distribution of Atlantic salmon was obtained primarily from the available literature.

The original EFH text descriptions were based on information contained in a series of NOAA Technical Memos (also known as the EFH Source Documents) that included information on the geographic distribution and habitat requirements for each managed species. These descriptions included, the area covered in the map, the type of habitat (pelagic or benthic), and general information regarding substrates, and ranges of depth, temperature, and salinity where EFH for each life stage of each species is found. In addition to eggs, larvae, juveniles, and adults, the original EFH descriptions included spawning adults as a fifth separate life stage.

Detailed descriptions of the surveys and databases used by the Council in the EFH designation process, including the sampling protocols and methods, are provided in

[1] The designation methodology used originally to define the extent of EFH was the same for most of the species managed by the NEFMC. The exceptions were Atlantic salmon and deep sea red crab. Atlantic salmon EFH was defined to include the watersheds of rivers and estuaries currently or historically accessible to salmon for spawning and rearing. EFH for red crabs was based on their presence in different depth ranges on the continental slope.

Appendix C of the 1998 EFH Omnibus Amendment. A detailed discussion of the limitations associated with using these data and information sources as the basis for designating EFH is provided in Appendix D of the 1998 EFH Omnibus Amendment.

ELMR Program Information

Used by the Council as the primary source of information on species distribution and abundance in the bays and estuaries of New England and the Mid-Atlantic, NOAA's Estuarine Living Marine Resources (ELMR) program has been conducted jointly by the Strategic Environmental Assessments (SEA) Division of NOAA's Office of Ocean Resources Conservation and Assessment (ORCA), NMFS, and other agencies and institutions. The goal of this program is to develop a comprehensive information base on the life history, relative abundance and distribution of fishes and invertebrates in estuaries throughout the nation. The nationwide ELMR database was completed in 1994, and includes information for 135 species found in 122 estuaries and coastal embayments. The Jury *et al.* (1994) report summarizes information on the distribution and abundance of 58 fish and invertebrate species in 17 North Atlantic estuaries. The Stone *et al.* (1994) report summarizes information on the distribution and abundance of 61 fish and invertebrate species in 14 Mid-Atlantic estuaries.

Most existing estuarine fisheries data cannot be compared among estuaries because of the variable sampling strategies. In addition, existing research programs do not focus on how groups of estuaries may be important for regional fishery management. The ELMR program was developed to integrate fragments of information on many species and their associated habitats into a useful, comprehensive and consistent format. The framework employed for the ELMR program enables a consistent compilation and organization of all available data on the distribution and abundance of fishes and invertebrates in estuaries. For the New England region, thirteen north Atlantic estuaries were selected from the National Estuarine Inventory (NEI) Data Atlas Volume I, and after discussions with several regional researchers, four additional estuaries were included. Although not every New England or mid-Atlantic estuary is addressed, thirty-one estuaries are included in the Jury *et al.* (1994) and Stone *et al.* (1994) reports:

Passamaquoddy Bay
Englishman/Machias Bays
Narraguagus Bay
Blue Hill Bay
Penobscot Bay
Muscongus Bay
Damariscotta River
Sheepscot River
Kennebec/Androscoggin Rivers
Casco Bay

Saco River
Wells Harbor
Great Bay
Merrimack River
Massachusetts Bay
Boston Harbor
Cape Cod Bay
Waquoit Bay
Buzzards Bay
Narragansett Bay

Connecticut River
Gardiners Bay
Long Island Sound
Great South Bay
Hudson River/Raritan Bay
Barnegat Bay
New Jersey Inland Bays
Delaware Bay
Delaware Inland Bays
Chincoteague Bay
Chesapeake Bay

Project staff compiled species distribution and abundance information for these estuaries by conducting exhaustive literature searches and examining published and unpublished data sets. To complement the information from these quantitative studies, regional, state, and local biologists were interviewed for their knowledge of estuary/species-specific spatial and temporal distribution patterns and relative abundance levels based upon their experience and research. The final level of relative abundance assigned to a particular species was determined from the available data and expert review. To rank relative abundance, ELMR staff used the following categories:

Not present -- species or life history stage not found, questionable data as to identification of species, and/or recent loss of habitat or environmental degradation suggests absence.

No information available -- no existing data available, and after expert review it was determined that not even an educated guess would be appropriate. This category was also used if the limited data available were extremely conflicting and/or contradictory; in these cases, *no information available* actually describes a situation where the available information was indecipherable.

Rare -- species is definitely present but not frequently encountered.

Common -- species is frequently encountered but not in large numbers; does not imply a uniform distribution over a specific salinity zone.

Abundant -- species is often encountered in substantial numbers relative to other species with similar life modes.

Highly abundant -- species is numerically dominant relative to other species with similar life modes. The Council considers the *abundant* and *highly abundant* categories to be the same for the purposes of designating EFH.

For many well-studies species, quantitative data were used to estimate spatial and temporal distributions. For other species, however, reliable quantitative data were limited. Therefore, nearly all information used in the reports was submitted to panels of local researchers, managers, and technicians for peer review based upon their knowledge of individual species within an estuary. More than 72 scientists and managers at 33 institutions were consulted (the ELMR reports list the individuals and their affiliations). An important aspect of the ELMR program, because it is based primarily on literature and consultations, was to determine the reliability of the available information. The reliability of available information varied between species, life stage, and estuary, due to differences in gear selectivity, difficulty in identifying larvae, difficulty in sampling various habitats, and the extent of sampling and analysis in particular studies. Data reliability was classified using the following categories:

Highly certain -- considerable sampling data available. Distribution, behavior, and preferred habitats well documented within the estuary.

Moderately certain -- some sampling data available for the estuary. Distribution, preferred habitat, and behavior well documented in similar estuaries.

Reasonable inference -- little or no sampling data available. Information on distributions, ecology, and preferred habitats documented in similar estuaries.

The ELMR information, as presented, should be considered "Level 1" data, as defined in the then Interim Final Rule, which was in effect during the development of the 1998 Omnibus Amendment. Guidance in the Interim Final Rule suggests that when working only with Level 1 data, "presence / absence data should be evaluated . . . to identify those habitat areas most commonly used by the species." As it relates to the information presented in the ELMR reports, estuaries where a particular species is *abundant* are assumed to be more commonly used than estuaries where a particular species is *rare*. More commonly used estuaries should be considered in the designation of essential fish habitat.

Several members of the Council's EFH Technical Team (precursor group to the current Habitat Plan Development Team) had direct involvement with the process for developing the ELMR information, either as interviewees or as reviewers. In their experience, all levels of data reliability provide sound information for use in determining the presence or absence of a species within an estuary. Information classified on the basis of *reasonable inference* may not be based on directed research to assess the abundance of a particular species within an estuary, but it does reflect the professional experience and personal knowledge of scientists and managers intimately involved with the species and estuaries in question. Information of a dubious nature, or information that is not verifiable would be categorized as *no information available* and the species would therefore not appear as *rare*, *common*, *abundant*, or *highly abundant* in an estuary.

The Council determined that the information presented in the ELMR reports met the qualifications of the Interim Final Rule, which was in effect in 1998, for "Level 1" data, and as such, should be considered and incorporated into the EFH designation process. Although the NMFS ichthyoplankton and bottom trawl survey remained the primary source of information for designating EFH, the ELMR reports serve as "additional information." Although the Council reserved the right to evaluate individually the appropriate EFH designations based on the ELMR information, the following provides a general guide for how the Council applied the information. For those species' life history stages for which the Council designated EFH based on the 100% alternative (i.e., EFH is designated as 100% of the range observed for the species' life history stage), all estuaries in which the species' life history stage is categorized as *rare*, *common*, *abundant*, or *highly* *abundant* were included in the EFH designation. For those species' life history stages for which the Council designated EFH based on the 90% alternative, all estuaries in which the species' life history stage is categorized as *common*, *abundant*, or *highly abundant* were included in the EFH designation. Species for which the 50% or 75% alternative was used, all estuaries in which the species' life history stage is categorized as *abundant* or *highly abundant* were included in the EFH designation.

Table A-2 displays the level of information available for each species' No Action EFH designation. For most species, the best information consists of relative abundance and distribution data (Level 2) and presence / absence data (Level 1). In a few cases, some Level 3 information is available, but there is a definite lack of detailed and scientific information relating fish productivity to habitat type, quantity, quality and location. Guidance provided by NMFS in the Interim Final Rule, which was in effect in 1998 during the submission period, suggests that when working only with Level 1 and Level 2 data, "the degree that a habitat is utilized is assumed to be indicative of habitat value." In other words, if all that is known is where the fish tend to be in relatively high concentrations, these areas are assumed to be the essential fish habitat. This is the approach the Council adopted, using relative densities and areal extent to determine the EFH designations.

Table A-2. Alternative 1: Sources and Levels of EFH Information for EFH Designations *

Species	eggs	larvae	juvenile	adult	spawners
American plaice	2	2	2	2	1
Atlantic cod	2	2	3	2	1
Atlantic halibut	0	0	1	1	1
Atlantic herring	1	2	2	2	1
Atlantic salmon	1	1	1	1	1
Atlantic sea scallop	0	0	0	2	1
Barndoor skate	0	N/A	2	2	0
Clearnose skate	0	N/A	2	2	0
Deep-sea red crab	1	1	1	1	1
Haddock	2	2	2	2	1
Little skate	0	N/A	2	2	0

Species	eggs	larvae	juvenile	adult	spawners
Monkfish	0	1	2	2	1
Ocean pout	0	0	2	2	1
Offshore hake					
Pollock	2	2	2	2	1
Red hake	2	2	2	2	1
Redfish	N/A	2	2	2	1
Rosette skate	0	N/A	2	2	0
Silver hake	2	2	2	2	1
Smooth skate	0	N/A	2	2	0
Thorny skate	0	N/A	2	2	0
White hake	0	0	2	2	1
Windowpane flounder	2	2	2	2	1
Winter flounder	1	2	2	2	1
Witch flounder	2	2	2	2	1
Winter skate	0	N/A	2	2	0
Yellowtail flounder	2	2	2	2	1

* *The numbers represent the highest available level of information available for each life history stage. Level "0" indicates that there is very little information available for this life history stage. "N/A" indicates that this does not exist as a distinct life history stage for this species.*

The alternatives considered by the Council were based on the relative densities of fish (numbers per tow) observed in the fall and spring NMFS surveys on the continental shelf. For all species, a set of alternatives was developed for each of the major life history stages, with the exception of sea scallops, Atlantic salmon, and Atlantic halibut. Those stages include eggs, larvae, juveniles, and adults. The maps presenting the alternatives display the distribution and abundance data by ten minute squares of latitude and longitude. This is the most efficient and understandable spatial scale for use in this process because the NMFS distribution and abundance data were easily represented by ten minute squares and the data can be compared to other data sets, information from the fishing industry, and existing management measures.

Juveniles and adults were distinguished based on lengths-at-maturity for each species, which was defined according to the length at which 50% of the fish in a population mature sexually. For most species, these sizes vary by sex and stock units. They also vary over time, according to changes in growth rate, sometimes considerably. Lengths used to distinguish juveniles and adults for most species were based on data reported by O'Brien et al. (1993). Lengths at maturity for the skate species were based on information included in EFH source documents. These lengths are listed in Table A-3. In most cases, O'Brien et al. based 50% lengths at maturity on females; if there was more than one size available – because of analyses that were performed at different time periods or for different stocks – they were averaged.

Table A-3. Lengths-at-maturity used to distinguish juveniles and adults in EFH designations

Species	***Length at Maturity (cm)***
American Plaice	27
Atlantic Cod	35
Atlantic Halibut	
Atlantic Herring	25
Barndoor Skate	102
Clearnose Skate	61
Deep-sea Red Crab	8
Goosefish	43
Haddock	32
Little Skate	50
Ocean Pout	29
Offshore Hake	30
Pollock	39
Red Hake	26
Redfish	22
Rosette Skate	46
Sea Scallop	10
Silver Hake	23
Smooth Skate	56
Thorny Skate	84
White Hake	35
Windowpane	22
Winter Flounder	27
Winter Skate	85
Witch Flounder	30
Yellowtail Flounder	27

Source: O'Brien et al. (1993) and EFH Source Documents for skates.

The Council used two methods for developing the EFH designation maps: one based on average catch rates per ten minute square (TMS), and the other based on percentages of observed range. The catch rate method was used for all demersal life history stages (juveniles and adults of all species with the exception of Atlantic herring and Atlantic salmon). The percentage of observed range method was used for all planktonic life history stages (eggs and larvae of most species) and the juvenile and adult stages of the pelagic schooling Atlantic herring. The "observed range" for each species includes all TMS where the species was observed during either the NMFS bottom trawl or MARMAP surveys.

Selection factors were applied to the bottom-trawl and ichthyoplankton survey databases to construct the data sets for the Council alternatives and EFH designation maps. The selection factors were recommended by NMFS Northeast Fisheries Science Center (NEFSC) scientists who collected and work with the data. Correction factors were used to standardize the bottom-trawl catch of various species due to variation in doors, trawls, and/or vessels among the surveys. Correction factors were applied to specific species (see Appendix C, Methods Report, Table A-4). After the bottom-trawl and ichthyoplankton data were selected, the summarization process was the same. Data were assigned to a TMS based on the location of the starting point of the bottom-trawl or ichthyoplankton sample tow. Only those squares that had greater than three samples and one positive catch were selected. In order to minimize the effects of occasional large catches on the averages, catch data were transformed by taking the natural logarithm of the catch [ln(catch + 1)] and the mean of the transformed data was calculated for each ten minute square. The resulting values (indices) could be compared on a relative scale, but could not be expressed in units of numbers of fish per tow.

In analyzing the data for each species' life stage using the catch rate method, each TMS throughout the survey area and included in the analysis was ranked from highest to lowest according to an index of the mean catch per tow (i.e., the number of fish caught in each tow of the survey trawl). The second step was to calculate the cumulative percentage that each TMS made up of the total of the average catch rates for all TMS. For each life history stage, the alternatives considered included: (1) the area corresponding to the TMS that account for the top 50% of the cumulative abundance index, (2) the top 75% of the cumulative abundance index, (3) the top 90% of cumulative abundance index, and (4) 100% of the observed range of the species, i.e., the area covered by all TMS where at least one fish was caught in at least three tows.

In analyzing the data using the area percentage method, each TMS throughout the survey area and included in the analysis was also ranked from highest to lowest according to its catch rate index. In this case, however, the alternatives represent the percentage of the total area covered by all the squares (the observed range) rather than a percentage of the total catch rate indices. For each life history stage, the alternatives considered included: (1) the area made up by the TMS that account for the top 50% of the observed range, (2) the area corresponding to the top 75% of the observed range, (3) the top 90% of the observed range, and (4) 100% of the observed range of the species. The percent catch rate method was used because it accurately reflected that, for most benthic life history stages, the population is more concentrated in portions of its range where habitat conditions such as prey resources and substrate are most favorable, and less concentrated in other portions of its range where habitat conditions are not as favorable. Clearly, EFH should be designated where environmental conditions, especially habitat, are most favorable, thus the highest percentages of the catch rate index were a suiTable A-proxy for identifying these areas.

In the case of the planktonic life history stages and the pelagic species (Atlantic herring), the catch rate method was not used to define areas most favorable to the species. Planktonic eggs tend to be concentrated immediately after a spawning event, and then are dispersed over a much larger area by the prevailing currents. Thus, chance plays a large role in the eggs and larvae ending up in areas where environmental conditions are most favorable. Other factors related to the sampling methods for these life stages also affected the decision to use the percent range method for the planktonic life stages and pelagic species (see 1998 Omnibus Amendment Appendices C and D).

For each life history stage of each species, the Council considered the remaining alternatives, selecting the EFH designation for each individually. The Council employed the most consistent approach possible, given the variety of species and unique characteristics of many of the life history stages and the limitations of the available data and information considered. The Council's approach was focused on designating the smallest area possible that accounted for the majority of the observed catch, taking into account the habitat requirements of the species and any areas known to be important for sustaining the fishery. The Council considered the status of the resource, and was more conservative with those species considered at the time to be overfished. The Council also considered the historic range of the species, including areas of historic importance, where appropriate. In some cases, the Council used a proxy to determine the most appropriate EFH designation for certain life history stages. This was done by applying the range of one life history stage as the EFH designation for another stage. The Council most often used a proxy designation when information was not available for a particular life history stage, but also used a proxy on occasion when the observed range of a particular life history stage did not accurately represent the true range.

The habitat description and identification for a managed species is based on the biological requirements and the distribution of the species. For all species, this includes a combination of state, federal, and international waters. According to the regulations, EFH can only be designated within U.S. federal or state waters. Although there may be areas outside of U.S. waters which are very important to Council-managed species, EFH can not be designated in Canadian waters or on the high seas. In cases where the range of a species extends into waters managed by the Mid-Atlantic Fishery Management Council (MAFMC), the NEFMC designated EFH for species that are managed under a New England Fishery Management Council FMP. Accordingly, the maps representing the Council's original EFH designations were based on survey data that included tows made in Canadian waters , but the EFH maps stop at the U.S - Canada boundary. The Council recognized that, in many cases, habitat areas located in Canadian waters may be just as important, if not more important, than habitat areas located in U.S. waters, even though it is identified as EFH.

Quite often, the EFH designations appear quite patchy in spatial distribution. While this is normal in natural systems, to some extent this patchy distribution was based not on the natural distribution of the species, but on the limitations of the sampling methods. Once the proposed designations were completed, including whatever additional information was available (ELMR, inshore surveys, fishing industry, landings, historical, etc.), the Council chose to also include any empty TMS surrounded by either seven or eight "filled in" TMS. This approach "smoothed" the designations, and, thereby reduced to some degree the patchy nature of the EFH designations.

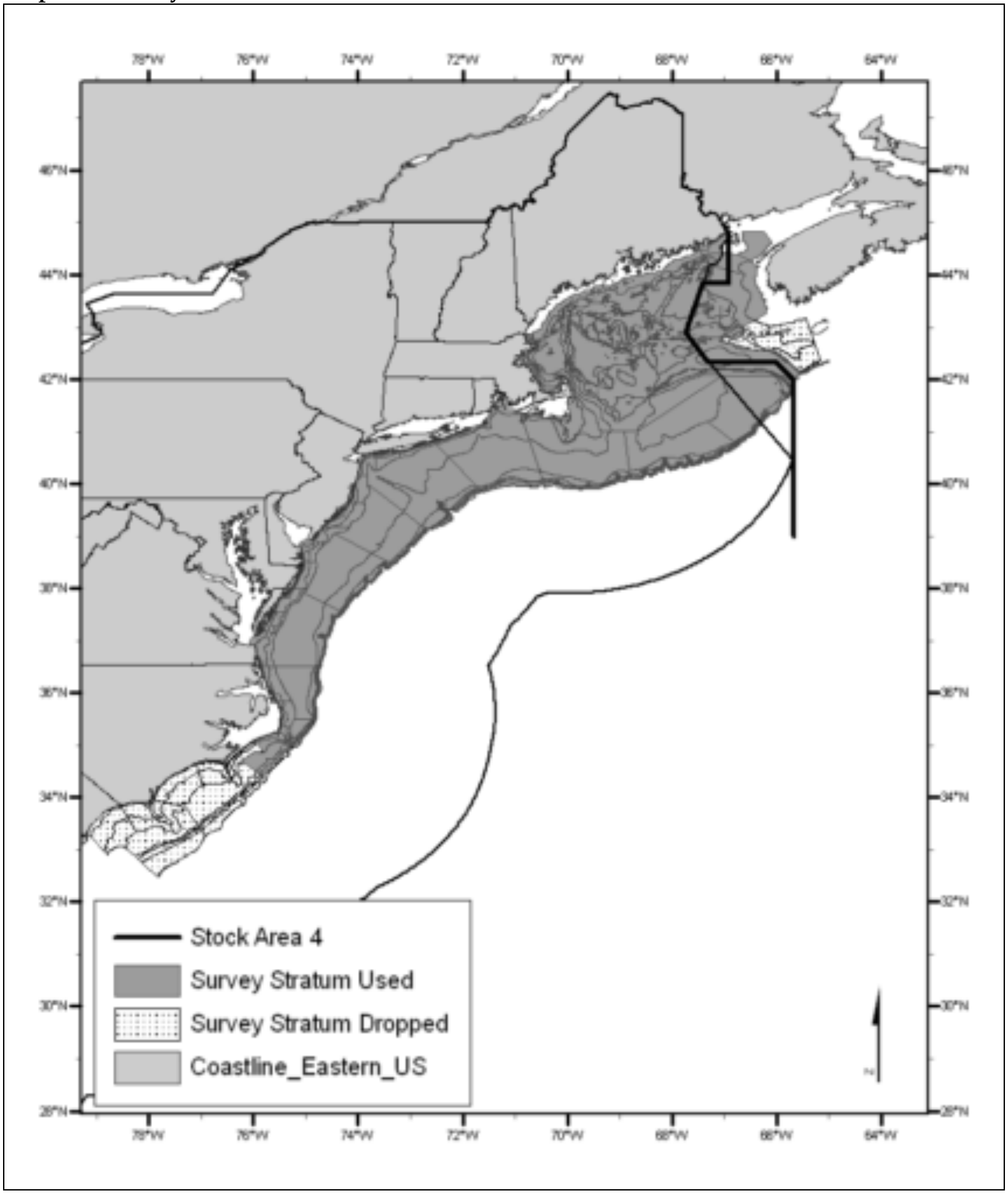
Certain geographic regions were not represented in the data originally considered by the Council, such as near shore waters of Maine, Rhode Island, eastern Long Island, and Nantucket Sound where either no survey has been conducted, or where the data were not available, and smaller bays and estuaries not included in the ELMR database. These areas, therefore, were not considered in the EFH designation process. This does not mean that they are not potentially important, only that they represent data and information gaps. Similarly, the original EFH designations (text and maps) did not extend beyond the edge of the continental shelf (approximately 500 meters), which is the deepest extent of the NMFS trawl survey.[2]

[2] The exception is deep sea red crab, which was designated to a depth of 1800 meters on the continental slope, based on limited red crab survey data.

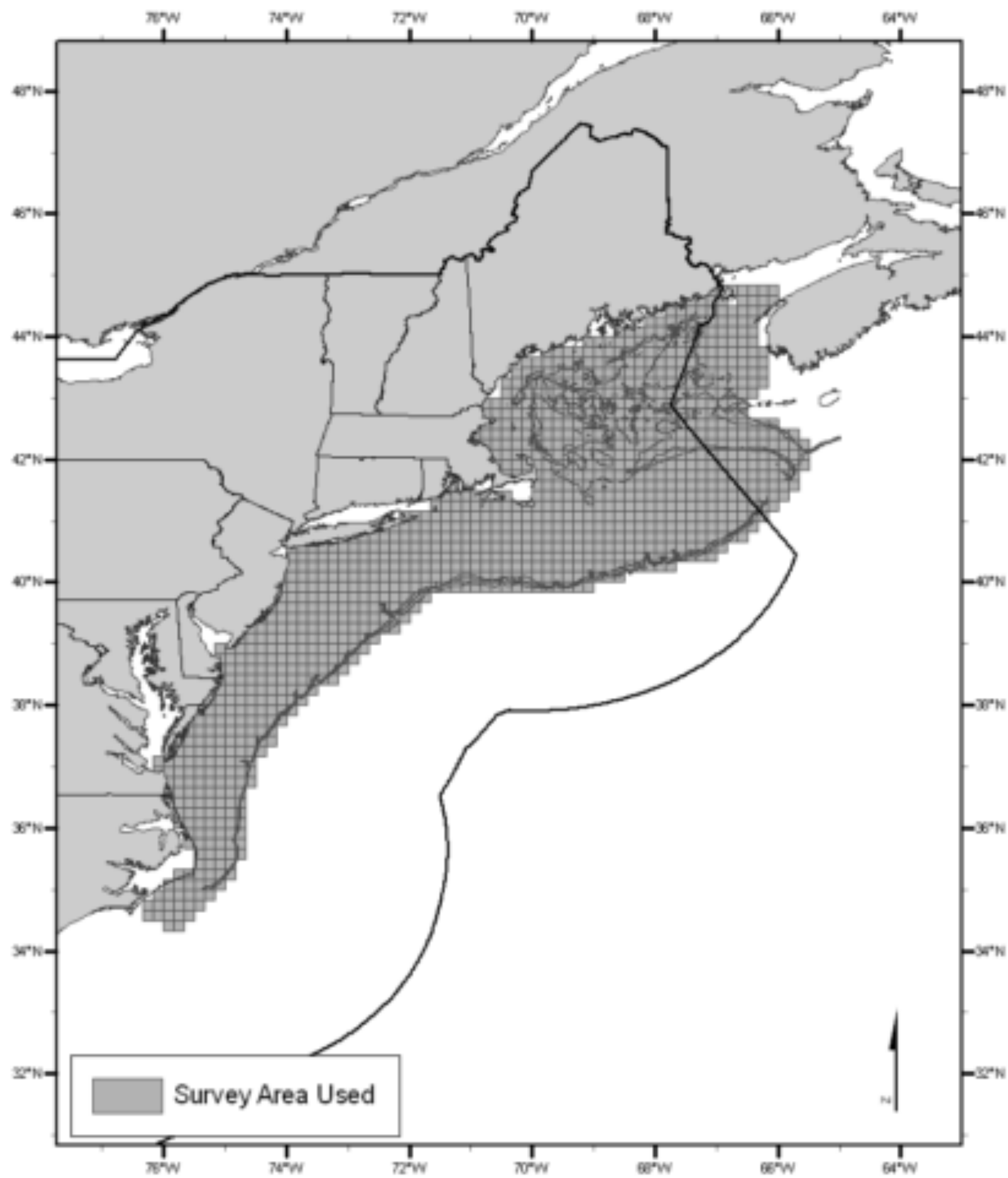
3.0 Alternative 2 – Abundance Only

The Alternative 2 EFH maps were developed using a similar method as described above under Alternative 1 (No Action) except that the time series of NMFS spring and fall bottom trawl survey data for the continental shelf included data from 1968 to 2005. Data collected during 1963-1967 fall surveys were eliminated from the analysis in order to create a more uniform time series that equally represents the two times of year. (No data were collected in the spring in those years). In addition, with regards to many of the demersal species that are sampled in the NMFS bottom trawl survey, any TMS which occurred entirely within poorly sampled survey strata were neither included in the calculations nor mapped. Strata that were excluded from the analysis are located south of Cape Hatteras and in Canadian waters on the southern and eastern Scotian Shelf (Map A-1.) Ten minute squares on the shelf that were included in the analysis for most species are shown in Map A-2. For the five species with stocks in the Gulf of Maine and/or on Georges Bank that are distinct from Canadian stocks on the Scotian Shelf (Atlantic cod, haddock, Atlantic herring, winter flounder, and yellowtail flounder), all TMS entirely within management area 4 (Map A-3) were removed from the analysis, but TMS in Canadian waters on the Northeast Peak of Georges Bank were left in the analysis (but not mapped). With the exception of a few TMS in the entrance to the Bay of Fundy, all of management area 4 is in Canadian waters.

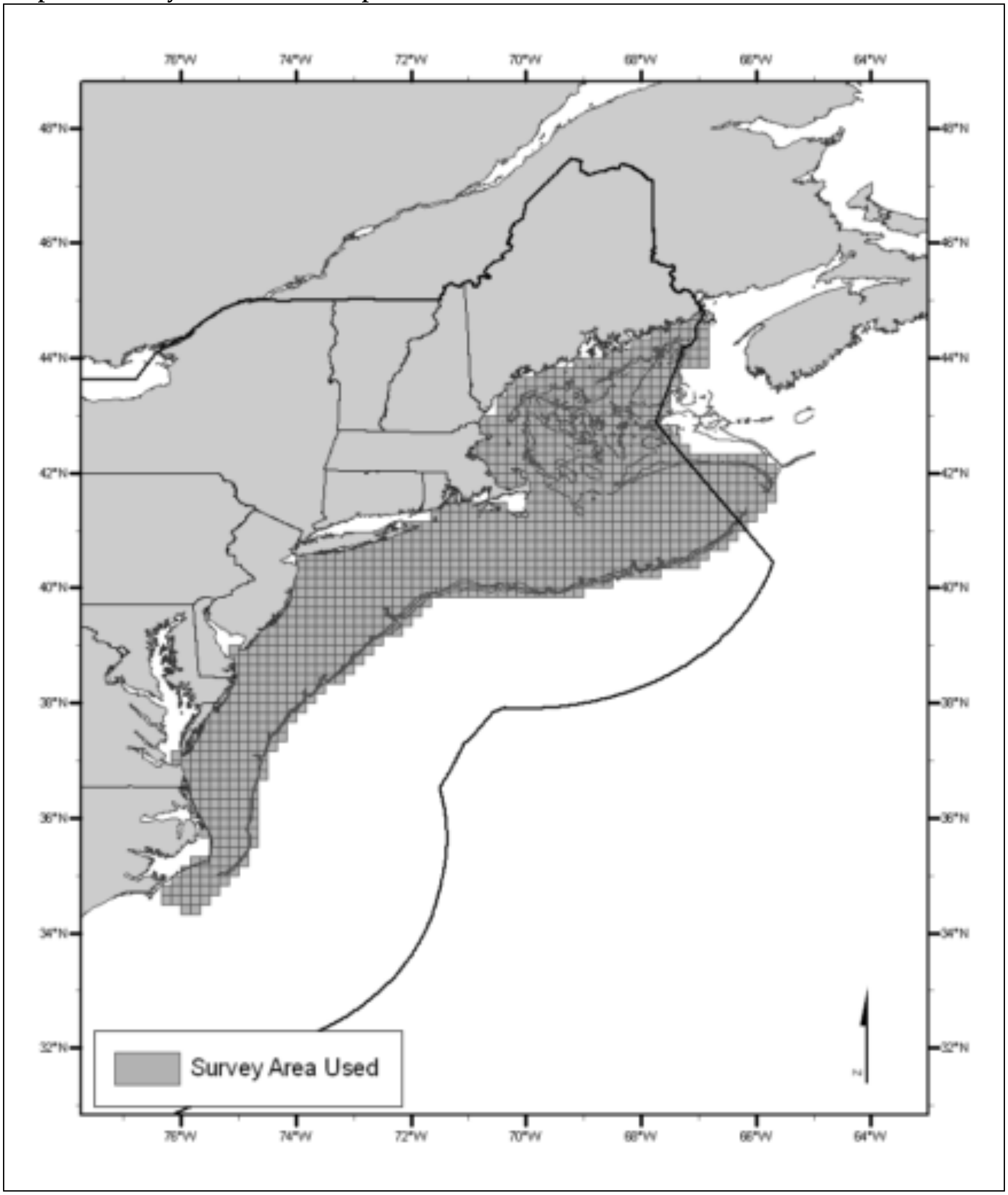
Map A-1. Survey Stratum for Northeast U.S.



Map A-2. Survey Area Utilized for Most Species in EFH Analysis



Map A-3. Survey Strata Used for Species with Distinct Stock Areas in U.S.



The cumulative percent catch rates in this alternative changed from 50%, 75%, 90% and 100% as considered in the No Action alternative to 25%, 50%, 75% and 90% to reflect a wider range of survey-defined species habitats. As in the No Action alternative, EFH maps for benthic life stages were based on cumulative percentages of the average catch rates in each TMS. There are no Alternative 2 designations for the eggs and larvae of species that are based solely on 1977-1987 MARMAP survey data because there is no new information. There are Alternative 2 egg and larval designations for those species which were originally based on distributions of juveniles or adults as "proxies" because there was new survey information (see above). Unlike the No Action alternative, no TMS were added to the EFH maps in this alternative to "fill in" gaps or areas of historical importance that might be under-represented in the trawl survey data.

NMFS survey catch data for the continental shelf were processed slightly differently in order to further reduce the impact of high abundance tows on average catch rates for each ten minute square (see details in Alternative 3). Additionally, state survey data were included, along with ELMR data, in the GIS analysis used to create the inshore portions of the EFH maps. Any ten minute square (TMS) of latitude and longitude that is included within the area surveyed by any of the states in which the percentage of positive tows (i.e., any tow catching at least one fish) for a given species and life stage exceeds 10% of all the tows made in that TMS will be included as EFH. Inshore TMS were identified as EFH in Alternative 3 using the same method. For a complete listing of state surveys used, see the Alternative 3 methods section. The spatial extent of EFH in Alternative 2 does not extend beyond the edge of the continental shelf (depth of approximately 500 meters).

Text descriptions for this alternative differ from the descriptions in the No Action alternative because they are based on an explicit analysis of up-dated NMFS trawl survey data, analysis of inshore survey data, analysis of a greatly expanded USGS marine sediment database that became available in 2005, and new evaluations of habitat-related information in updated versions of the EFH Source Documents. They also do not include any descriptions for a separate spawning adults life stage. Methods used to define habitat characteristics (depth, temperature, and salinity ranges, and substrate types) of EFH were the same for this alternative and for alternative 3, except that the Alternative 2 maps and text descriptions do not include Level 1 information from the continental slope (see methods for Alternative 3 for more details). Information used to develop Alternative 2 EFH designations (maps and text), whenever possible, was level 2 information.

Table A-4. Alternative 2: Sources and Levels of EFH Information for EFH Designations *

Species	eggs	larvae	juvenile	adult
American plaice	NAD	NAD	2	2
Atlantic cod	2[a]	2[a]	2	2
Atlantic halibut	NAD	NAD	1	1
Atlantic herring	1	2	2	2
Atlantic sea scallop	NAD	NAD	2	2
Barndoor skate	NAD	N/A	2	2[b]
Clearnose skate	NAD	N/A	2	2
Haddock	NAD	NAD	2	2
Little skate	NAD	N/A	2	2
Monkfish	0[c]	1[c]	2	2
Ocean pout	0[d]	0	2	2
Offshore hake	NAD	NAD	2	2
Pollock	2[e]	2[e]	2	2
Red hake	NAD	NAD	2	2
Redfish	N/A	NAD	2	2
Rosette skate	NAD	N/A	2	0[b]
Silver hake	2[b]	2[b]	2	2
Smooth skate	NAD	N/A	2	2
Thorny skate	NAD	N/A	2	2
White hake	0[e]	0[e]	2	2
Windowpane flounder	NAD	NAD	2	2
Winter flounder	1[e]	2[e]	2	2
Witch flounder	NAD	NAD	2	2
Winter skate	NAD	N/A	2	2

Species	eggs	larvae	juvenile	adult
Yellowtail flounder	NAD	NAD	2	2

*** ***The numbers represent the highest available level of information available for each life history stage.*
[a]*: indicates that juveniles were used as a proxy in combination with egg and/or larval survey data.*
[b]*: indicates that juveniles were used as a proxy*
[c]*: indicates that adults were used as a proxy in combination with egg and/or larval survey data*
[d]*: indicates that a combination of juveniles AND adults was used as a proxy*
[e]*: indicates that adults were used as a proxy*
*Level "**0**" indicates that there is very little information available for this life history stage.*
***N/A**: indicates that this does not exist as a distinct life history stage for this species.*
***NAD**: indicates No Alternative Designation due to lack of new information*

4.0 Alternative 3 – Abundance + Habitat Considerations

Background

To facilitate and explore a new approach to defining EFH based on peer-reviewed methodolgies, a Habitat Evaluation Review Committee (HERC) was formed and supported by the Habitat Evaluation Working Group, the NMFS Northeast Regional Office and the New England Fishery Management Council staff. The purpose of the peer review exercise was to review the current EFH designation methodology and investigate alternative methods for identifying important habitats and their characteristics for northeast managed species. The goal was to provide tools to the Councils to assist them in identifying and describing EFH. Data used to test and potentially implement the methodology(s) should come from the best available sources, including peer-reviewed literature, unpublished scientific reports, data files of government resource agencies, fisheries landing reports and other sources of information. The information should consider different types of information according to its scientific rigor and data should be used in a manner that is consistent with National Standard 2. The habitat information should be organized according to the four levels described in the EFH Rule (600.815(a)((1)(iii)(A)) and the highest levels of information should be used.

4.1.1 HERC Terms of Reference

1. Inventory tools/models that are readily available to identify important fish habitat

2. Qualitatively evaluate the identified tools for:
    - Ability to evaluate and use in short-term (3-6 months)
    - Scientific defensibility/ Use of best available science (per National Standard 2).
    - Applicability for use in the Northeast region (Northeast Continental Shelf Large Marine Ecosystem)
    - Data needs and availability of data
    - Ability to facilitate an ecosystem approach (per 600.815(a)(1)(iv)(E))
    - Application to estuarine, coastal, and offshore habitats, data-rich vs. data-poor species and life stages, single vs. multi-species, etc.

3. Provide a comparative evaluation among tools.

4. Prepare documentation of the approaches used for evaluation and the results for consideration in the peer review. Evaluation should describe the model/method, data requirements, model output, model implementation considerations, conclusions of the evaluation, recommendations for use (short-term vs. long-term).

5. Provide necessary follow-up from the peer review (e.g., make necessary model changes, provide tools to end-users)

4.1.2 Peer Review Report / Conclusions

An Evaluation of Potential EFH Designation Methodologies in the Northeast:

General Recommendations

- Until a thorough cross-calibration exercise is completed with the candidate EFH methods, the panel recommends the application of a method(s) that requires the minimum assumptions for any species or life-stage in order to stay as close to the available data as possible and provide the least ambiguous interpretation.
- The framework for development and use of EFH methods must be consistent across temporal and spatial scales for comparative analyses, visualization and interpretation of processes.
- The focus on methodological development should move from EFH Levels 1 and 2 data to EFH Levels 3 and 4 data as fast as possible to be consistent with the ecosystem-based management mandate.
- Habitat variables could be enriched by expanded exploratory data analyses to include other abiotic (circulation, salinity, rugosity, turbidity, patchiness, etc.) and biotic (primary productivity, prey availability, predation, etc.) covariates.
- Prioritization of methodologies will be based on the number of assumptions (i.e. simple to complex) required to implement them. For example, Status Quo, to HSI, to GAM, to West Coast, etc. Further, the HSI as a concept is appropriate, but not as analytically powerful as other candidate methods. Therefore the panel recommends that methodologies that are quantitatively robust such as the GAMs should replace the HSI approach as soon as reasonable. However, the panel recognized there are sufficient analytical restrictions on the use of GAM models that some cases might require supplementation by an HSI type approach. In the short term, the West Coast model and bioenergetics methods will be difficult to implement given the apparent lack of available data and analytical requirements. The West Coast method may have greater utility in the longer-term, but the method and results need to be compared and rectified relative to other competing approaches using data of comparable time and space scales. The panel also felt the spatial optimization

methods (e.g. MARXAN) would likely be the downstream recipient of the outputs (e.g. spatial maps of presence-absence, density, and preference) from the comparative analyses and would likely be most useful in the delineation of EFH designations in single or multiple species contexts. The panel did not think GIS should be considered as a stand-alone analytical tool for EFH designation; however, GIS will be a fundamental component of EFH model development, implementation, and visualization.

- To satisfy simultaneous objectives of stock assessment and EFH designation by the fishery-independent survey mechanisms, it would be prudent to develop minimum mapping units for specific habitat types that could also be used as the basis for stratifying the sampling domain in resources surveys conducted by NEFSC and others.
- For each of the short, intermediate, and long-term recommendations, immediate and serious consideration must be given as soon as possible to fiscal and personnel requirements to accomplish these goals.
- The HEWG should continue to provide stewardship role to the iterative process of EFH evaluation and designation in the short and long-term. In the process the stewardship function provided by the HEWG will facilitate development of ecosystem-based methods. This approach would provide an integrated framework that would ultimately lead to ecosystem-based management.

Short-Term Recommendations

- Improve the text descriptions in the Status Quo EFH methodology source documents to be more comprehensive of the habitats that the species utilize.
- The panel believes the utility of evaluating EFH designation for eggs and larval life-stages is questionable at this time and efforts should be focused on EFH designation for juveniles and adults.
- Develop a comprehensive sensitivity analysis strategy to compare the candidate EFH methods that involves the following:
    1. Data: An identification of those species that are sufficiently data rich such that all methods or models could be compared simultaneously in an objective manner (i.e. in space for selected areas, e.g. Eastern Georges Bank, Great Sound Channel, or New York Bight Apex; or in time for selected species, e.g. cod, Atlantic herring, summer flounder, redfish).
    2. Time and space scales: Give high priority to defining the appropriate minimum mapping unit (e.g. at present analyses use 10-minute squares).
    3. Species and life-stages: Develop the appropriate life history and population-dynamic contrasts for method comparisons (e.g., pelagic vs. demersal, fast-growing vs. slow growing, high mortality vs. low mortality).
- Improve the quality of the base maps ("habitat" layers) on which the methods analyses are predicated.
- Develop selection criteria for objectively assessing method performance. This will require a clearer articulation of management needs.

- For the EFH Omnibus Amendment #2, the status quo method should be pursued, with possible inclusion of Habitat Suitability Index- type information, until inter-calibration of models is completed.

Intermediate & Long Term Recommendations

- Attention should be paid to temporal and spatial dynamics of fish distributions and "habitats." For example, recast the data analyses to focus time on intervals (e.g. decades) in response to trends in climate, fishing impacts, shifting habitat, etc.
- Build a relational database that links data from fisheries, fishery-independent resource surveys conducted by various agencies, and biophysical "habitat" information (e.g. remote sensing, physical oceanography, etc.) across institutions, municipalities, states, and federal jurisdictions.
- Serious attention should be paid to revision of sampling designs based on the concept of EFH maps which provide clear covariates for survey stratification. Develop a strong focus on improving base maps and layers at both local and regional levels.
- Use operations research methods to assist in identifying criteria with which EFH is defined, but also to establish thresholds for management actions. Clarification of these definitions would allow greater flexibility in modeling EFH and management decision-making.
- Develop a strategy for improving methods in order to move from descriptive, statistical-based (collected data) presentations to mechanistic, model-based (parameter estimates) forecasts that support ecosystem-based management.

4.1.3 Methods

Based on the general advice provided in the short-term recommendations by the Habitat Evaluation Review Committee, the PDT developed a GIS-based EFH designation methodology that combines the primary elements of Alternative 2 (up-dated survey catch rate data for the continental shelf and ELMR information for inshore areas) with habitat features that are associated with high catch rates of benthic juveniles and adult life stages. To this end, the spatial extent of EFH was divided into four general geographic realms (inshore, shelf, offshelf and seamounts), largely because of the different data sets available within each area. Below is a general description for each spatial realm of the developing method being used to create options under Alternative 3. Additionally, these are the data sources the PDT consulted for the EFH designation Alternative 3 development:

4.1.4 Abundance/ Distribution Data Sources

<u>Inshore</u>

- ME Beam Trawl Survey (2000 - 2004)
- ME/NH Inshore Trawl Survey(2000 – 2004)
- NH Estuarine Seine Survey
- MA Inshore Trawl Survey (1978 – 2005)
- RI Trawl Survey (seasonal and monthly)
- RI Coastal Ponds Survey
- RI Narragansett Bay Juvenile Finfish Survey
- CT Long Island Sound Trawl Survey (1984 – 2004)
- CT Small Mesh Trawl Survey (1991-93, 1996)
- NY Raritan Bay Survey (1992 – 1997)
- NJ Trawl Survey (1988-2004)
- NJ Delaware Bay Trawl Survey (1991 – 2005)
- DE 16ft Trawl Survey (1980-2004)
- DE 30ft Trawl Survey (1966-2004)
- MD Coastal Bays Fisheries Investigation Project
- MD Seine Survey
- VA Juvenile Fish and Trawl Survey
- NC Trawl Survey
- NOAA Estuarine Living Marine Resource information

<u>Shelf</u>

- NMFS bottom trawl survey (1968 - 2005)
- NMFS sea scallop survey (1982-2005)
- NMFS MARMAP ichthyoplankton survey (1977 – 1987)

<u>Offshelf</u>

- NMFS Deep-Sea Survey
- Deep Sea Experimental Fishery project reports
- Smithsonian collection data
- Literature

<u>Seamounts</u>

- Literature

Habitat Data Sources

<u>Shelf</u>

- NGDC 2-Minute Gridded Bathymetry Data (ETOPO2)

- usSEABED Marine Substrate Database
- Bottom temperature derived from NMFS MARMAP, bottom trawl, and hydrographic survey data.

EFH designations include a text description and a map for each life stage of each managed species. The maps produced as part of the exercise are approximate spatial representations of the EFH text descriptions and are used to inform the "geographic extent" item in the text description. This method will be applied to four life stages as described here. Lengths at maturity used to distinguish juveniles from adults were the same as those used in the original EFH designations (see Table A-3). Pertinent information on young-of-the-year juveniles and spawning adults will be included in their respective life stage EFH text description.

The map designations of essential fish habitat identify the geographic extent within which certain types of habitat are considered EFH. EFH must be designated according to the level of information available on the species distribution, abundance, and habitat-productivity relationships. The levels of information, as defined in the Interim Final Rule, are:

- Level 1: Presence / absence data are available for portions of the range of the species. At this level, only presence / absence data are available to describe the distribution of a species (or life history stage) in relation to potential habitats. In the event that distribution data are available for only portions of the geographic area occupied by a particular life history stage of a species, EFH can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior.

- Level 2: Habitat-related densities are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species of life history stage. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.

- Level 3: Growth, reproduction, and survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life history stage. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life history stage).

- Level 4: Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species of life history stage to habitat type, quantity, and location. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem.

Table A-5 displays the level of information available for each species' EFH designation. For most species, the best information consists of relative abundance and distribution data (Level 2) and presence/absence data (Level 1). In a few cases, some Level 3 information is available, but there is a definite lack of detailed and scientific information relating fish productivity to habitat type, quantity, quality and location.

Table A-5. Alternative 3: Sources and Levels of EFH Information*

Species	eggs	larvae	juvenile	adult
American plaice	NAD	NAD	2	2
Atlantic cod	NAD	NAD	2+3	2
Atlantic halibut	NAD	NAD	2[a]	1[a]
Atlantic herring	1	NAD	NAD	NAD
Atlantic sea scallops	NAD	NAD	2+3	2+3
Barndoor skate	NAD	N/A	2[a]	2[a]
Clearnose skate	NAD	N/A	2	2
Haddock	NAD	NAD	2	2
Little skate	NAD	N/A	2	2
Monkfish	NAD	NAD	2[a]	2[a]
Ocean pout	0[b]	NAD	2	2
Offshore hake	NAD	NAD	2[a]	2[a]
Pollock	NAD	NAD	2	2
Red hake???	0[a,c]	2[a,c]	2	2[a]
Redfish	N/A	2[a,c]	2[a]	2[a]
Rosette skate	NAD	N/A	2	0[d]
Silver hake	NAD	NAD	2	2[a]
Smooth skate	NAD	N/A	2[a]	2[a]
Thorny skate	NAD	N/A	2[a]	2[a]
White hake	NAD	NAD	2	2[a]
Windowpane flounder	NAD	NAD	2	2
Winter flounder	1+3	1+2	2+3	2+3
Winter skate	NAD	N/A	2	2
Witch flounder	NAD	NAD	2[a]	2[a]

Species	eggs	larvae	juvenile	adult
Yellowtail flounder	NAD	NAD	2	2+3

[a]: indicates that a Level 1 offshelf realm designation is included in this alternative.
[b]: indicates that the designation was based on source document information on the depth range and fall bottom temperature for spawning adults used in the habitat analysis was derived from the source document information on spawning adults as a proxy
[c] indicates that juveniles were used as a proxy
[cd]: indicates that very little information exists on adult rosette skate and juveniles were used as a proxy
*Level "**0**" indicates that there is very little information available for this life history stage.*
***N/A**: indicates that this does not exist as a distinct life history stage for this species.*
***NAD**: indicates No Alternative Designation due to lack of new information.*

4.1.5 Text Descriptions

The following methods were used to determine substrate types, ranges of depth, temperature, and salinity, and primary prey types associated with all four life stages of each managed species in the inshore, continental shelf, off-shelf (continental slope) and seamount spatial realms. For each species, all relevant information was summarized in a Table A (See Appendix B) and EFH text descriptions were written based on a synthesis of this information. In many cases, the same information was used to map habitat features that were used in the text descriptions of EFH.

4.1.6 Pelagic life stages

No text descriptions (or maps) were developed for pelagic life stages in this alternative because there was no new egg and larval survey data, and because species that utilize benthic adults or juveniles as “proxies” for eggs and larvae were covered in Alternative 2.

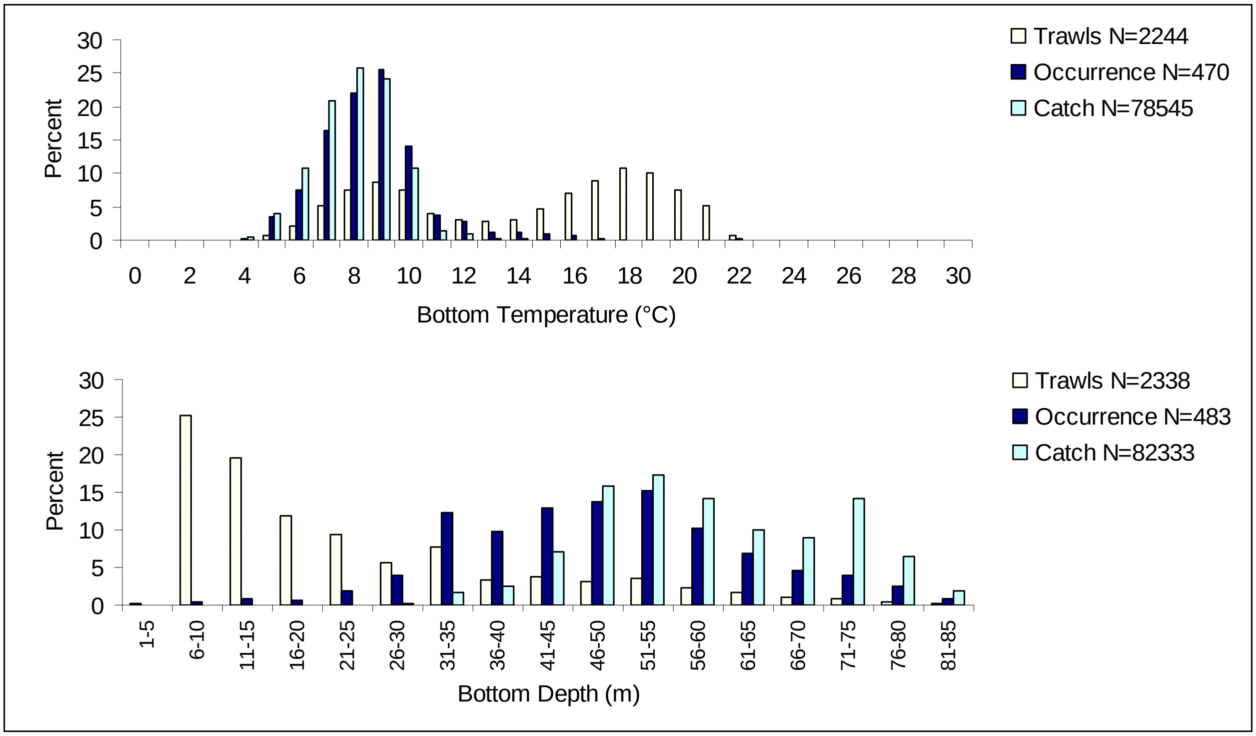
4.1.7 Benthic life stages

Inshore:

Minimum and maximum values of depth, bottom temperature, and salinity were determined from analysis of data collected during all inshore (state) trawl survey tows in ten minute squares where at least 10% of the total number of tows caught any number of the species and life stage under consideration (see Alternative 3 mapping methods). This is also referred to as a "percent frequency of occurrence" or PFO. The method was developed to equate to the reasonable threshold used by ELMR for a species being "common". Many status quo inshore area EFH designations were based on the "common" abundance level. The new method prescribes a PFO threshold at 10%, which implies that any species ranking below this threshold is equivalent to a "rare" EMLR designation. As such, the inshore EFH designation method is considered a Level 2 designation as it is based on a species distribution or relative abundance and not merely on presence or absence.

For coastal areas where a given species and life stage was considered to be "common" or "abundant" in the ELMR database, depth, bottom temperature, and salinity ranges were derived from data (histograms) published in the appropriate EFH Source Document (original version or recent 2nd edition) or Update Memo, or in state survey reports, using the same method used for eggs and larvae. In this example, the depth range is 41-85 meters and the temperature range is 4.5-10.5ºC). For surveys conducted at more than one time a year, the lowest minimum and highest maximum values were selected to represent an annual range. Survey data used for this analysis were from Massachusetts, Raritan Bay, Delaware Bay, and the lower Chesapeake Bay. These ranges were considered to represent habitat conditions that are correlated with relative abundance (Level 2 information), and were used in preference to Level 1 information whenever possible.

Figure A-1. Distributions of juvenile American plaice and trawls in Massachusetts coastal waters.



Relative to bottom water temperature and depth based on fall Massachusetts inshore bottom trawl surveys (1978-2003, all years combined). Light bars show the distribution of all the trawls, dark bars show the distribution of all trawls in which American plaice occurred and medium bars show, within each interval, the percentage of the total number of American plaice caught. (Temperature values on the X-axis are interval mid-points, e.g., "10°C" represents the interval 9.5-10.5°C).

<u>Continental Shelf:</u>

- Frequency distributions of the complete set (U.S. and Canadian strata) of fall and spring NEFSC trawl survey catch rates by depth and bottom temperature were analyzed to determine minimum and maximum values for benthic juveniles and adults during 1963-2003 (Figure A-2), (Note that this time period differs slightly from the time period used to calculate average catch rates by TMS for Alternatives 2 and 3). Salinity ranges were based on the less restrictive percent catch exceeds percent tows method that was used with the egg and larval survey data. For the text descriptions, the minimum and maximum values for the fall and spring were combined to create a single annual range. Additional level 2 or 3 information for the shelf was in some cases obtained from the EFH source documents (see individual species habitat tables in Appendix ???).

- Information on sediment types which overlap spatially with the highest catch rates of juveniles and adults for any given species were included as one of the habitat features in the EFH maps (see explanation of methodology in Section 4.1.8.2). Additional sediment types and substrate features identified in the EFH Source Documents and Update Memos, and in other sources such as Collette and Klein-MacPhee's new edition of the Fishes of the Gulf of Maine, were also included in the text descriptions. For many species, the analysis was not specific enough to identify preferred substrate types.

- Other relevant information on bottom features, depth, bottom temperatures, and salinity was extracted from the EFH Source Documents and Update Memos in order to supplement the information derived from survey data.

- Information on primary prey organisms for each species and life stage was derived from the prey species analysis found in Section ??? of this document.

<u>Continental Slope and Seamounts:</u>

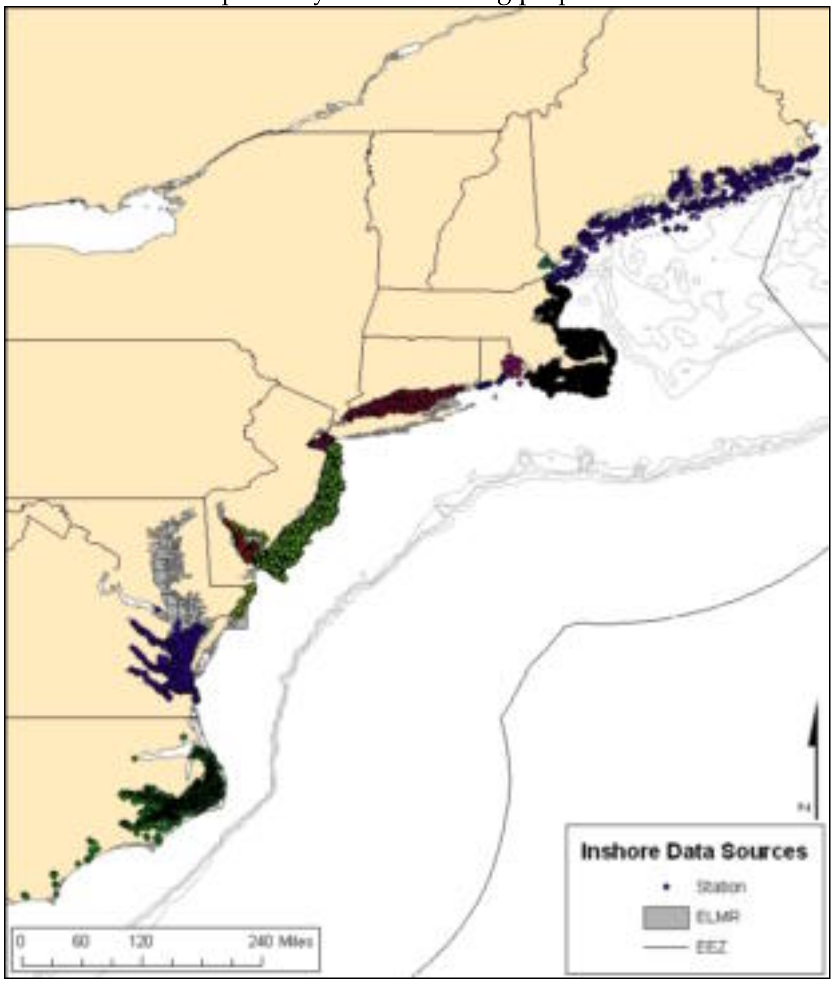
For species and life stages that extend beyond the edge of the continental shelf, the text descriptions for depth extend to a maximum depth that was determined by consulting relevant deep-sea trawl survey reports, the EFH source documents, and other publications.

4.1.8 Map Representations

4.1.8.1 Inshore

The EFH/Inshore analysis will rely on data and reports provided by states where appropriate and in consultation with the EFH Source Documents. If possible, state data will only be used as Level 2 (distribution/abundance) within each state where we have the raw fisheries data and as Level 1 (presence/absence) for those state or inshore waters where we were unable to acquire data or no fisheries data exist (fisheries-independent data). The PDT is recommending the inclusion of areas as EFH for those TMS that exceed a 10% frequency of occurrence for each managed species and life stage individually. Additionally, habitat ranges based on the records that successfully meet the 10% frequency of occurrence will be used in the EFH text descriptions; unless there is better information (see explanation of methods used to produce EFH text descriptions for alternative 3). Map A-4 depicts the data that have been analyzed. ELMR information (see Alternative 1) for individual coastal embayments and estuaries will also be considered as a second source of information.

Map A-4. State fisheries data acquired by PDT and being prepared for use in EFH designations**.**



Benthic + Pelagic Life Stages

Distribution maps will be made using state trawl survey data. The percentage of total positive tows in which juveniles and adults of each species was caught in each survey will be calculated by ten minute square. The distribution map will be those ten minute squares where the frequency of occurrence exceeds 10% for any of the state surveys. For species where ELMR data is available EFH will be designated in the estuaries where that species meets or exceeds a certain level of abundance as shown in Alternative 1.

Geographic extent of EFH alternatives will be mapped as the combined extent of the state trawl survey and ELMR distribution maps.

4.1.8.2 Shelf EFH

Benthic Life Stage - Variables

Distribution:
Distribution maps were made using 1968-2005 NEFSC fall and spring survey data for cumulative catch rates of 25, 50, 75, and 90%. A full description of the methods used to create these maps can be found in Section 0.

Temperature:
The base temperature layers were made from data recorded on the NMFS MARMAP survey in the fall and spring. A variation layer was then made using hydrographic, and bottom trawl surveys temperature data. Once that was applied to the base temperature layers the temperatures were averaged by ten minute square. Spring and fall maps were kept separate. This work was done by NEFSC and provided to the PDT for use in EFH mapping.

Depth:
The NDGC Coastal Relief Model 3 arc-second raster bathymetry was used for the depth habitat layer. On the southern portion of George's Bank nearest the EEZ where the Coastal Relief Model data does not cover the USGS 15 arc-second Gulf of Maine raster bathymetry was used instead.

Sediment:
The sediment habitat layer was created using the U.S. Geological Survey's usSEABED sediment database. Both the extracted (numerical) and parsed (descriptive) data was used to provide as much data as possible, especially for poorly sampled areas. The sediment samples were reclassified into 7 sediment classes that represent a reasonable complexity for the habitat analysis, as seen in Table A-6. The Folk sediment classifications were used as the starting point for the reclassification. Both Folk and Sheppard sediment classification were included in usSEABED. The Folk codes were used because more samples were classified using them. The mean phi size was not used because it does not maintain the character of the whole sediment sample, which is important to habitat analysis.

Table A-6. Sediment Reclassification

New Sediment Class	Folk Codes
Mud	M, (g)M
Sand/Mud	sM, (g)sM, mS, (g)sM
Sand	S, (g)S
Gravelly Sand and/or Mud	gM, gS, gmS
Sandy and/or Muddy Gravel	msG, sG, mG
Gravel*	G
Rocky/Hard Bottom**	H

** For this analysis, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand. "Gravel" therefore includes pebbles, cobbles, and even boulders.*
*** "Rocky bottom" refers to visual identification of bedrock on the seafloor, or to attempts to collect a sediment sample that failed because the bottom was so hard that no sample could be collected. Due to sampling limitations, rocky substrates are under represented in the substrate database.*

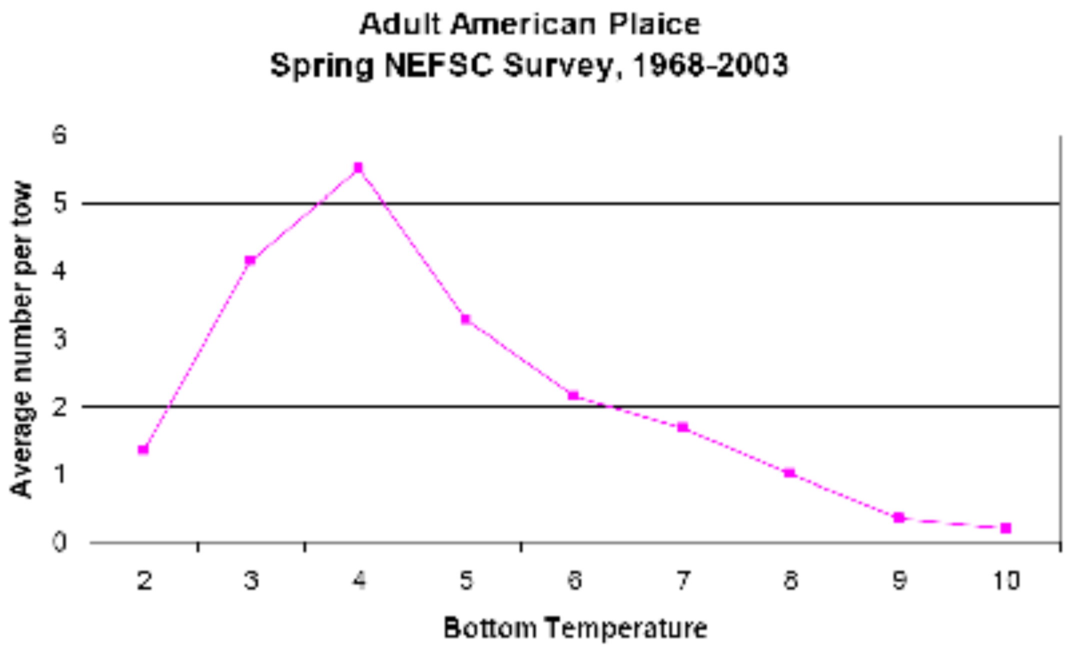
Once reclassified, the sediment data were analyzed by ten minute square. In each ten minute square, the percentage of all samples classified in each of the seven sediment classes was calculated. In the case of samples that fell on a line between two ten minute square the sample was included in the calculations of all ten minute square that it touched.

<u>Benthic Life Stage - Habitat Variable Range Selection</u>

Temperature and Depth:
Minimum and maximum depths and bottom temperatures that are associated with the highest catch rates (number of juvenile and adult fish caught per tow) during the 1963-2003 NEFSC fall and spring trawl surveys were estimated from survey data aggregated by intervals of 20 meters and 1 degree Centigrade. An example frequency distribution curve is shown in Figure A-2. Minimum and maximum values for most life stages and species were determined for the fall and spring (separately) by selecting intervals that each represented approximately 50% or more of the modal value. Analysis showed that using 50% of the modal value captured the core of the distribution without overly restricting the habitat analysis. A habitat analysis was done for all species using 33% of the modal value. The results were either indistinguishable from the 50% ranges, or overly restrictive. Thus, in the example shown in Figure A-3, the temperature range is 3-5 degrees, since the catch rates for each of the temperature classes in that range equals at least 50% (2.75 fish per tow) of the maximum catch rate (5.5 fish per tow) at 3 meters. Some judgment had to be used in the case of frequency distributions that were not uni-modal, or where the data were "noisy" without any clear maxima. In these cases, the 50% criterion had to be somewhat relaxed. These depth and temperature ranges were also considered along with minimum and maximum values derived from state survey data (see explanation of methods for text descriptions for details) and supplementary

information from the EFH Source Documents and Update Memos to determine the ranges used in the EFH descriptions.

Figure A-2. Frequency distribution of average catch rates by 1 degree Centigrade intervals of bottom temperature for adult American plaice during 1968-2003 spring NEFSC trawl surveys.

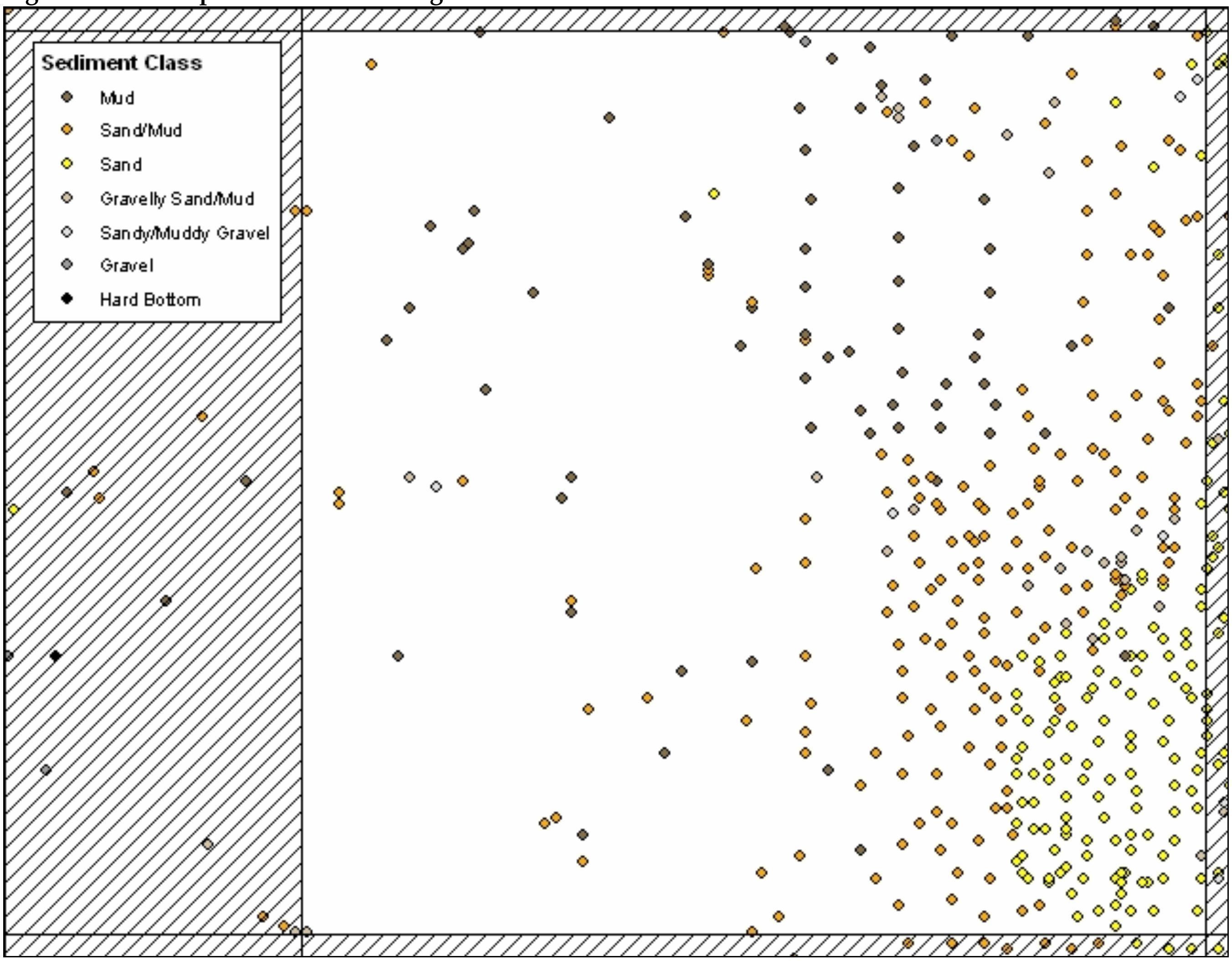


In this example, the temperature range used in the spring GIS temperature coverage was 3-5°C because the catch rates for those three values exceed 50% of the modal value (5.5).

Sediment:

A ten minute square was considered to include any given sediment type if that sediment type accounted for 20% or more of the total number of samples in that ten minute square. Thus, a ten minute square with 100 sediment samples, 25 of which are classified as sand, 22 as mud, and 20 as gravel, was considered to "contain" all three of those sediment types, as seen in Figure A- 3. The 20% threshold was chosen because it provided a balance between several factors. The percentage of samples of a sediment type in a ten minute square and area covered by that sediment type within the ten minute square are not necessarily related. For example in many cases one section of a ten minute square is heavily sampled, while others are not. Additionally, the purpose of the habitat analysis is not to find only ten minute square that are wholly likely habitat, but also those that contain sections of likely habitat. Thus, a threshold of 20% balances the need to pick only ten minute square with a reasonable amount of the important sediments for the species with the uncertainties of the data.

Figure A- 3. Example Sediment Binning.



In this example Sand, Sand/Mud and Gravel samples all represent greater than 20% of the total samples in the TMS. While there are also gravel mixtures, they do not account for 20% of the samples. Thus this TMS would be classified as having Sand, Sand/Mud, and Gravel areas suitable for EFH.

The sediment type or types associated with each species and life stage was determined by analyzing which sediment types are correlated with different levels of abundance from the spring and fall NEFSC trawl surveys, and by examining the information in the EFH source documents. A positive correlation was indicated when the degree of spatial overlap between a sediment type and ten minute square that account for the 25, 50, and 75% cumulative survey catch rates for the life stage and species in question averaged approximately 25%, as seen in 6 and 6
Figure A- 4.
. This value was chosen as the threshold because analysis of the data showed that for many species it captured a natural break in the distribution and for key species it

correctly captured their known sediment affinities. Additional sediment types mentioned in the source documents that are clearly associated with a life stage and species, but were not revealed to be important in the analysis, were added to the sediment GIS layer for mapping. No bottom type maps were produced for life stages and species that do not have a well defined sediment preference, or where the mapping of sediment would add no useful data to the habitat analysis (see Table A-7).

Figure A- 4. Juvenile American Plaice Sediment Analysis

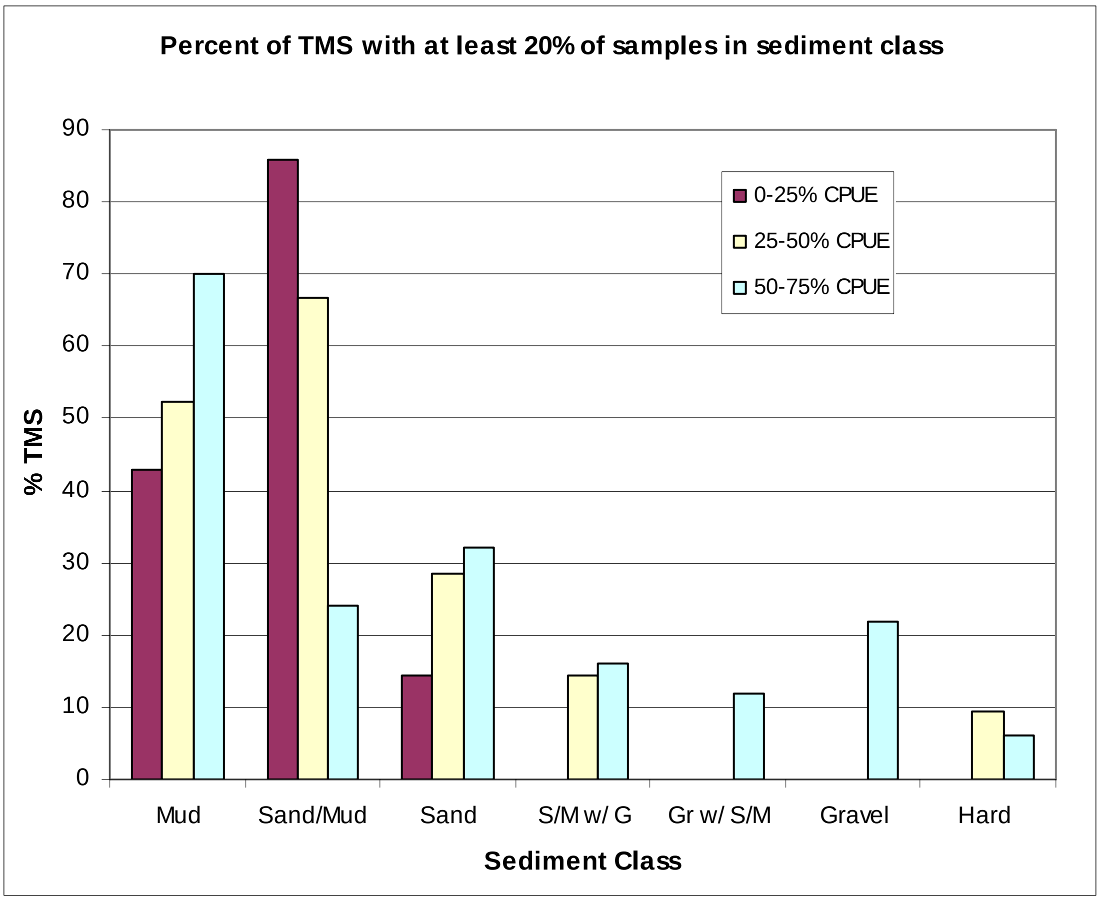


Table A-7. Results of sediment overlap analysis by species and lifestage

Species/Lifestage	**Sample Size**[1]			**Percent Overlap By Sediment Type**[2]							**Sediments Mapped?**		**Comments**
	0-25%	25-50%	50-75%	Mud	M/S	Sand	M/S w Gr	Gr w M/S	Gr	Hard	Yes	No	
American Plaice Juv	7	21	50	**55.1**	**58.8**	**25.0**	10.1	4.0	7.3	5.2	√		Did not use sand
American Plaice Adult	25	41	65	**74.0**	**36.4**	21.4	11.1	3.9	10.7	2.7	√		
Atlantic Cod Juv	7	25	60	18.0	**31.4**	**62.6**	**25.3**	13.1	**26.0**	6.4		√	Area too large
Atlantic Cod Adult	18	46	91	20.8	22.3	**56.4**	**34.1**	17.0	**34.8**	3.7	√		
Atlantic Halibut	1	2	25	**85.3**	4.0	6.7	8.0	4.0	12.0	20.7		√	Low sample size
Barndoor Skate Juv	15	26	42	17.4	**27.4**	**84.7**	**25.0**	6.2	5.9	0.0	√		
Barndoor Skate Adults	2	9	20	**27.4**	**47.8**	**58.1**	**30.7**	8.3	14.1	0.0	√		Low N, used juveniles
Clearnose Skate Juv	11	21	39	17.7	**25.9**	**93.6**	**34.3**	9.0	2.4	0.0	√		
Clearnose Skate Adult	15	25	39	14.1	22.9	**95.7**	**38.2**	3.4	2.2	0.0	√		Same as juveniles
Goosefish Juvs	56	92	140	**61.5**	**38.7**	**44.4**	13.5	3.2	6.4	1.7		√	
Goosefish Adults	63	103	171	**63.7**	**45.0**	**40.0**	11.2	3.0	5.7	0.5		√	
Haddock Juv	16	34	73	7.4	9.5	**79.1**	**34.8**	15.2	19.5	0.5	√		Same as adults
Haddock Adult	8	20	71	10.8	15.2	**54.6**	**40.6**	**33.9**	**38.2**	0.9	√		
Little Skate Juv	44	73	115	8.3	12.9	**95.4**	14.6	4.1	9.0	3.9	√		
Little Skate Adult	32	53	85	10.2	10.0	**90.1**	17.4	13.0	17.1	0.8	√		
Ocean Pout Juvs	24	47	81	**26.9**	**30.5**	**67.0**	22.8	9.1	10.7	3.6		√	Area too large
Ocean Pout Adults	32	62	124	22.1	**29.1**	**80.8**	20.0	4.8	8.2	4.7		√	Add mud, area too large
Offshore Hake Juv	3	10	20	**52.8**	**83.3**	**44.4**	1.7	1.7	0.0	0.0		√	Low N, area too large
Offshore Hake Adult	3	11	21	**57.9**	**88.9**	**48.5**	6.2	0.0	0.0	0.0		√	Low N, area too large
Pollock Juv	13	30	59	**44.8**	**29.2**	**26.9**	20.2	15.3	**31.6**	9.6		√	Area too large
Pollock Adult	11	36	73	**39.6**	**31.2**	**29.1**	**37.2**	22.5	**24.8**	0.5		√	Area too large
Red Hake Juv	60	116	193	**44.3**	**30.4**	**61.6**	17.7	6.4	8.1	1.6		√	Area too large
Red Hake Adult	41	79	130	**65.3**	**40.7**	**40.0**	15.9	5.8	6.2	1.3		√	Area too large
Redfish Juv	15	34	56	**61.3**	**28.8**	21.9	22.8	14.8	21.5	3.2		√	Assume same as adults, area too large
Redfish Adult	8	21	44	**53.4**	**28.5**	**27.9**	**26.1**	23.5	23.2	0.8		√	Area too large
Rosette Skate Juv	7	11	20	**31.6**	**44.1**	**74.5**	**27.3**	1.7	0.0	0.0		√	Low N, area too large

Species/Lifestage	Sample Size[1]			Percent Overlap By Sediment Type[2]							Sediments Mapped?		Comments
Rosette Skate Adult	1	2	1									√	Used juveniles
Sea Scallop	6	19	45	1.8	0.0	**83.2**	**30.9**	**28.9**	**31.9**	0.0	√		
Silver Hake Juv	43	84	141	**75.8**	**31.4**	22.5	14.2	7.4	11.2	2.8		√	Add sand, area too large
Silver Hake Adult	46	84	149	**69.7**	**35.5**	**28.1**	18.5	6.1	7.6	1.4		√	Area too large
Smooth Skate Juv	26	38	74	**62.2**	**30.3**	19.0	27.1	13.2	15.8	1.8		√	Add sand etc, area too large
Smooth Skate Adult	14	27	46	**45.7**	**30.3**	**34.9**	**35.3**	12.9	21.0	0.7		√	Area too large
Thorny Skate Juv	27	58	87	**62.6**	**27.7**	24.9	**26.8**	13.2	20.1	0.4		√	Area too large
Thorny Skate Adult	23	35	57	**75.9**	**30.6**	20.0	16.0	8.7	13.5	2.7		√	Add sand etc, area too large
White Hake Juv	26	47	97	**73.3**	24.7	22.1	12.9	6.7	15.4	8.1	√		
White Hake Adult	28	52	84	**75.9**	**30.5**	11.6	18.5	8.3	8.5	1.6	√		
Windowpane Juv	28	47	72	11.7	10.8	**94.9**	11.1	5.4	9.8	3.7	√		
Windowpane Adult	30	51	95	6.8	8.7	**97.3**	16.9	5.0	10.0	2.8	√		
Winter Flounder Juv	7	21	53	20.6	24.4	**80.1**	2.5	3.8	10.8	18.4		√	Add mud, sand/mud, area too large
Winter Flounder Adult	13	36	78	18.4	15.4	**82.9**	13.7	11.1	21.4	8.8	√		Add gravel
Winter Skate Juv	19	36	59	2.1	1.5	**94.5**	19.9	9.7	**25.7**	2.1	√		
Winter Skate Adult	11	24	40	1.7	2.2	**93.3**	23.6	13.0	**39.0**	0.0	√		
Witch Flounder Juv	13	29	64	**82.6**	**31.3**	14.6	3.8	4.1	10.4	7.5	√		
Witch Flounder Adult	22	40	75	**77.8**	**25.1**	20.3	16.7	9.0	13.6	1.7	√		
Yellowtail Juv	21	46	82	8.2	16.2	**96.1**	21.0	2.4	4.6	1.1	√		
Yellowtail Adult	28	47	81	7.5	21.5	**91.7**	19.9	3.7	5.0	0.7	√		

[1] Number of ten minute squares of latitude and longitude within three categories of decreasing abundance (average number of fish caught per tow)
[2] Averages of the percentages of ten minute squares with at least 20% of sediment samples in each sediment category across abundance categories (see example in Table B???)

Note: Numbers in bold are greater than 25%, shaded cells indicate sediment types that were used in EFH designation alternative 3 maps

Geographic extent of EFH alternatives will be mapped using the methods described in this section.

Pelagic Life Stages

Because there is no new information available for species with pelagic eggs and larvae, or for the pelagic larval, juvenile, and adult life stages of Atlantic herring, there are no alternative 3 designation options for these life stages. New text descriptions for the pelagic life stages were developed, however, and will apply to the alternative 2 designation options.

Note: Alternative 3 EFH maps were produced for benthic eggs of winter flounder, Atlantic herring, and ocean pout.

4.1.8.3 Off-Shelf EFH

Available information regarding depths occupied by juvenile and adult life stages on the continental slope and rise was derived from survey data, EFH source documents and other sources. Information was obtained from all available sources. For text descriptions, the focus was on the maximum depths not represented in data for the shelf. All off-shelf distribution information is Level 1 presence only information.

Benthic Life Stages

Distribution maps will be made of the presence of managed species using all available sources.

Geographic extent of EFH was mapped from the edge of the continental shelf out to the maximum depth and within the latitudinal range which the species is believed to occupy based on an evaluation of available deep-sea survey reports and data, and relevant publications. The off-shelf depth will be defined by the NGDC Coastal Relief Model bathymetry where possible (from approx. the southern edge of George's Bank to Cape Hatteras) and ETOPO2 where it is not. The higher resolution and improved accuracy at greater depths will aid in the identification of important features, such as deep-sea canyons.

Pelagic Life Stages

No additional data on egg and larvae distribution is available for the off-shelf area. All EFH designation options for pelagic eggs and larvae are limited to alternatives 1, 2, and 4.

4.1.8.4 Seamount EFH

Deep-sea red crabs hve been observed on two of the four seamounts within the EEZ. Available information regarding the maximum depths at which this species has been observed was obtained from all available sources. All seamount distribution information is Level 1 presence only information.

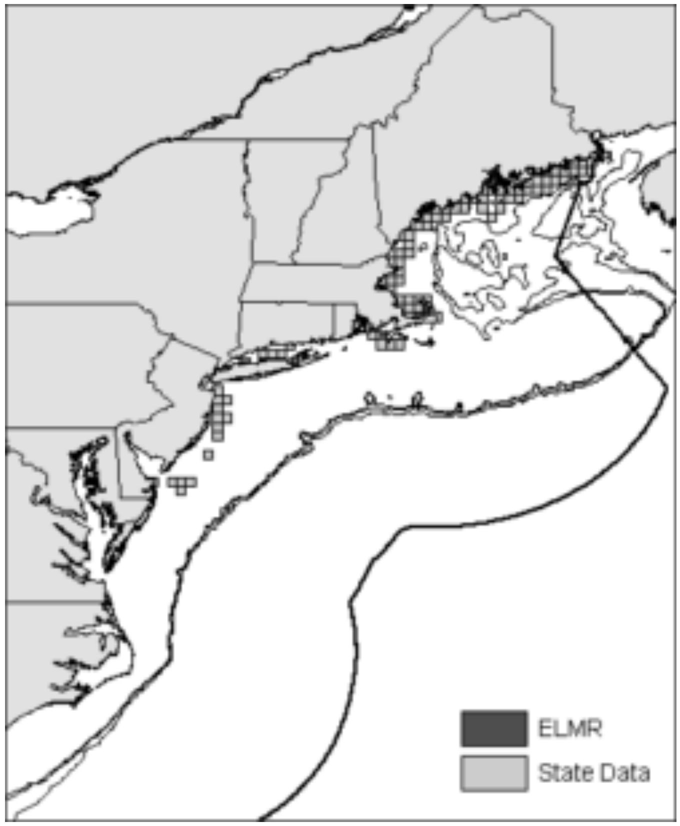
Distribution maps for red crabs were developed using all available sources.

Geographic extent of EFH for juvenile and adult red crabs was be mapped as the maximum depth which the species is believed to occupy. Seamount bathymetry was defined using the UNH Center for Coastal and Ocean Mapping/ Joint Hydrographic Center Law of the Sea multi-beam bathymetry dataset. This data provides the most accurate available bathymetric data for the seamount complex.

4.1.9 Alternative 3 Map Creation

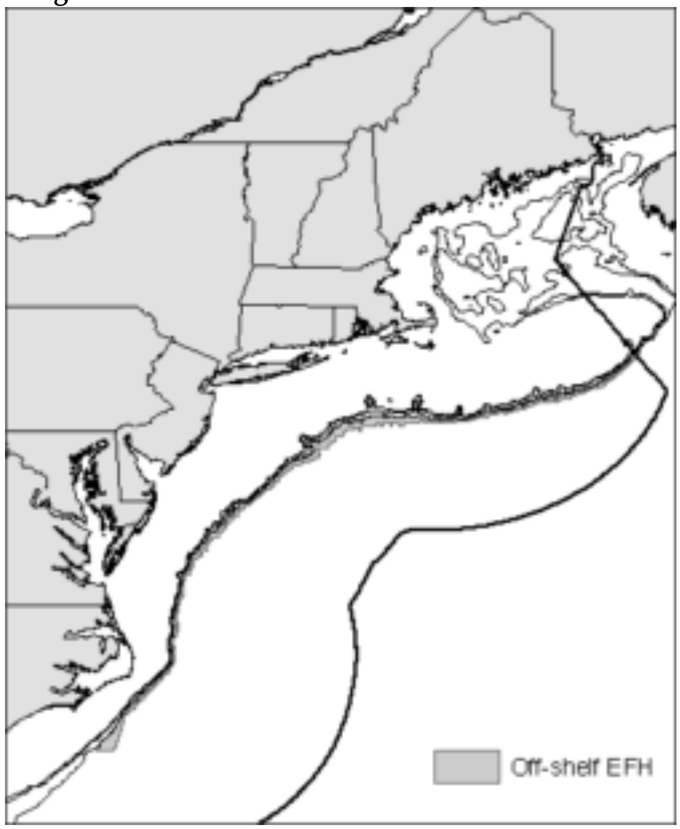
Step 1: The inshore data is created by overlaying the state survey data and the ELMR data for species which occur inshore.

Map A-5. Inshore Data



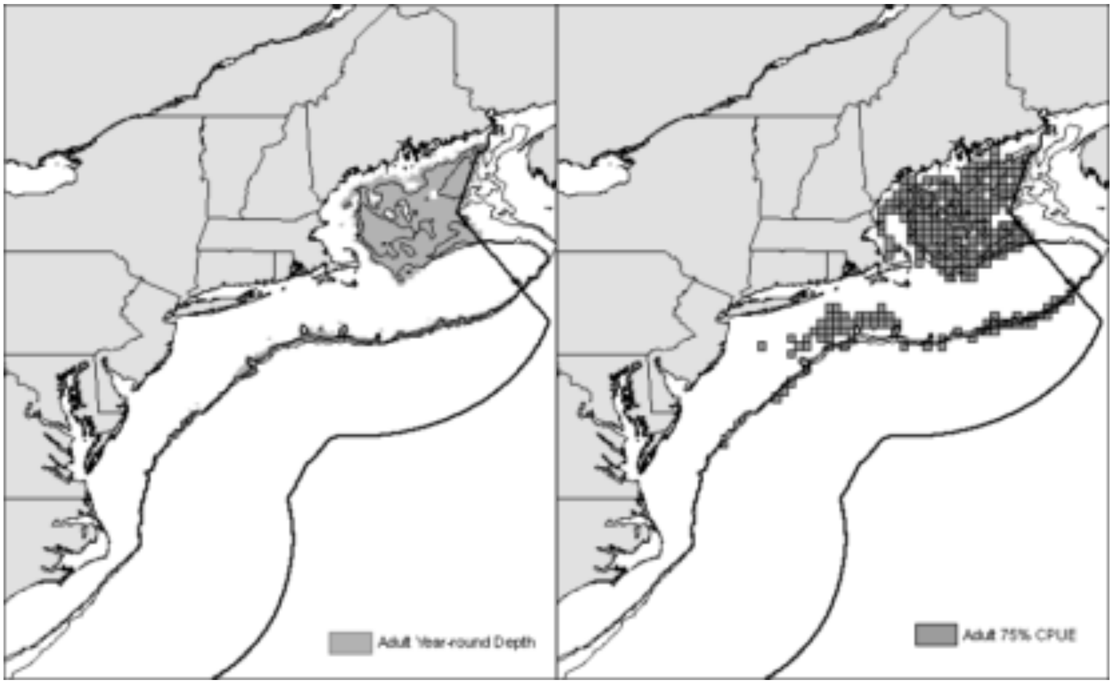
Step 2: The offshelf map is created by selecting the depth range below 500m at which the species has been documented. In the case that data is available about abundance is available that is taking into account when selecting the depth range for the species.

Map A-6. Offshelf Designation

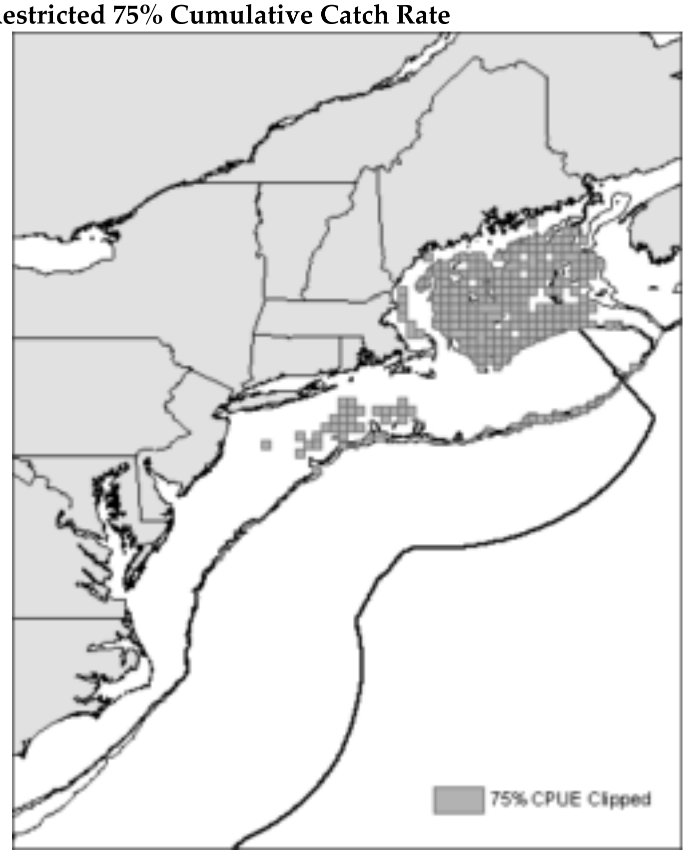


Steps 3 - 6: The 25, 50, 75, 90 percent cumulative catch rates are selected from the NMFS trawl survey data. In the TMS that contain depths within the ranges determined in the analysis described above all areas that are outside of that range are removed.

Map A-7. Year-round Depth Layer and 75% Cumulative Catch Rate

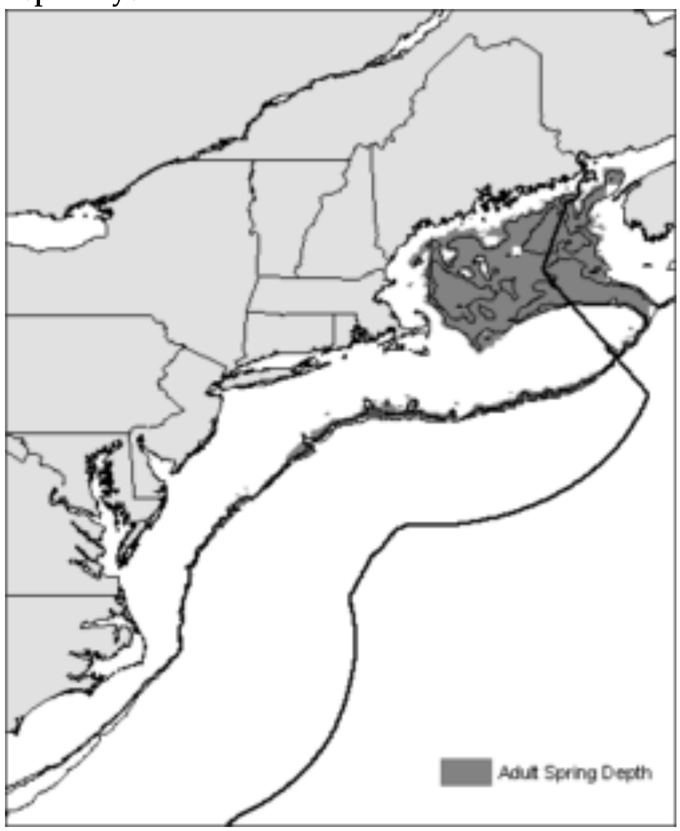


Map A-8. Depth-Restricted 75% Cumulative Catch Rate



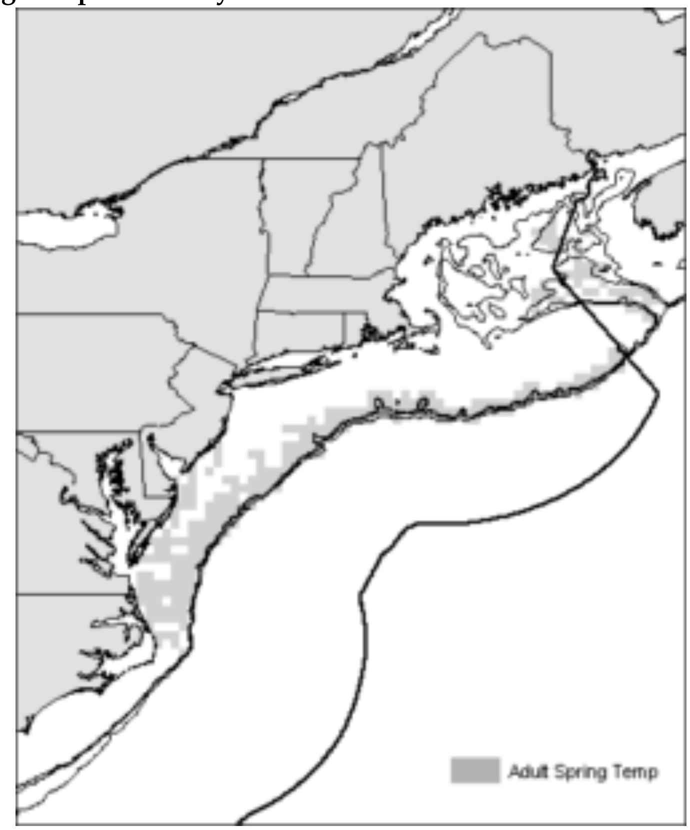
Steps 7 – 8: The fall and spring depth ranges determined in the analysis described above are selected from the depth habitat layer.

Map A-9. Spring Depth Layer



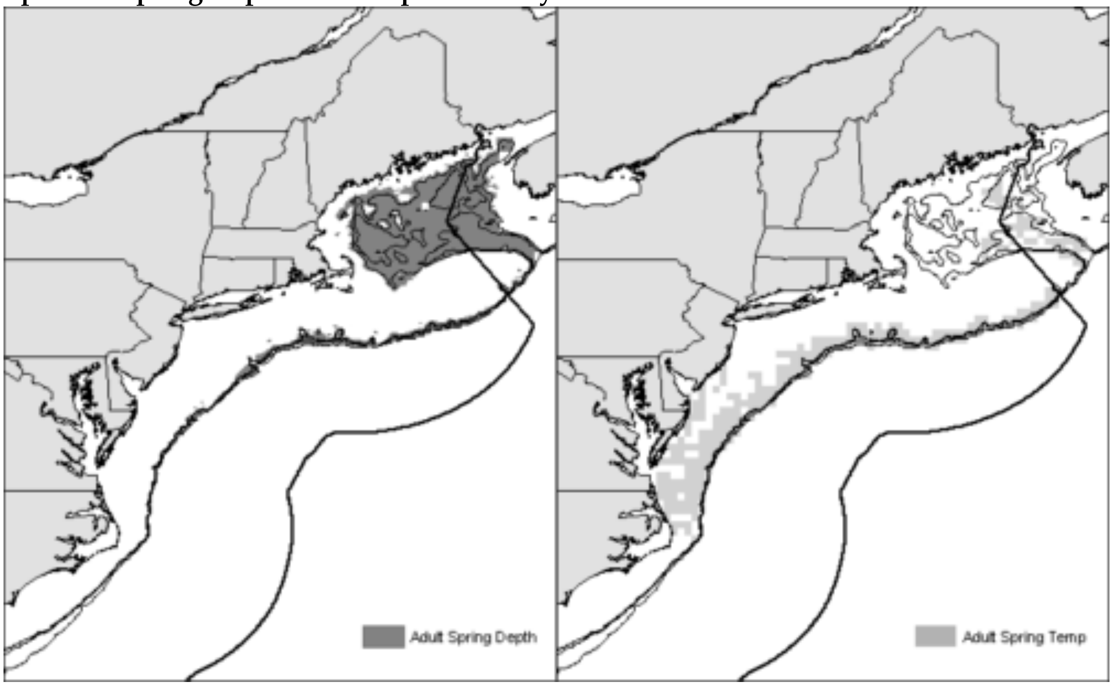
Steps 9 – 10: The fall and spring temperature ranges determined in the analysis described above are selected from there respective habitat layers.

Map A-10. Spring Temperature Layer

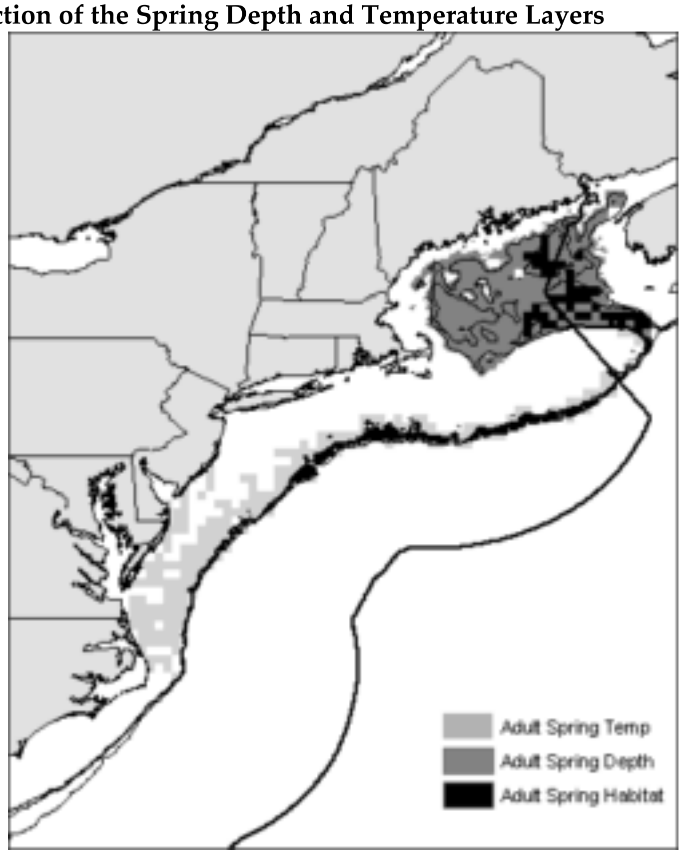


Steps 11 – 12: The intersection of the fall depth and temperature layer is found. This is repeated with the spring layers.

Map A-11. Spring Depth and Temperature Layers

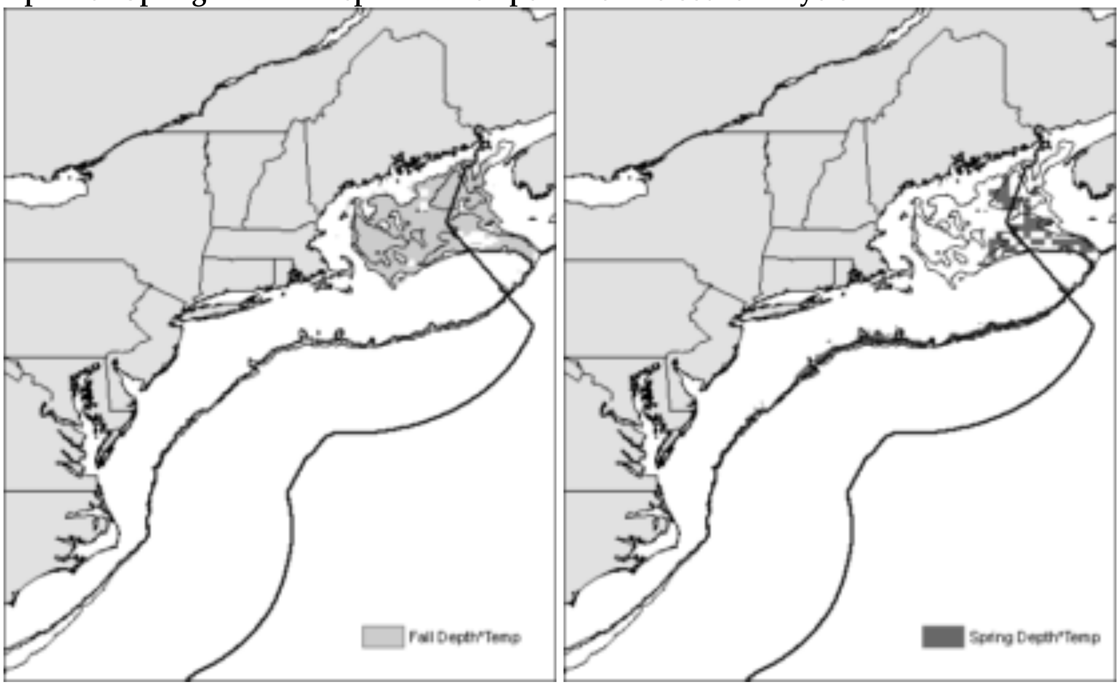


Map A-12. Intersection of the Spring Depth and Temperature Layers



Step 13: The fall and spring depth and temperature intersection layers are overlaid to create a year round map.

Map A-13. Spring and Fall Depth and Temperature Intersection Layers



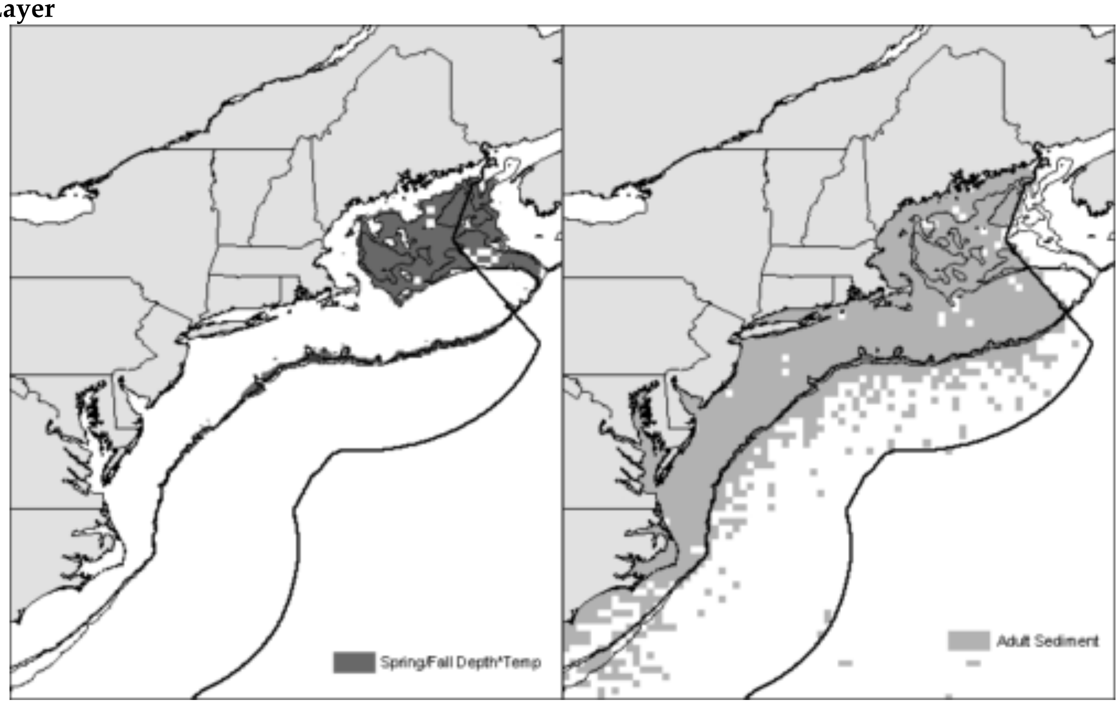
Map A-14. Year-round Depth and Temperature Intersection Layer

Step 14: The TMS where the combination of all correlated sediment classes for the species exceeds 20% of the total samples are selected.

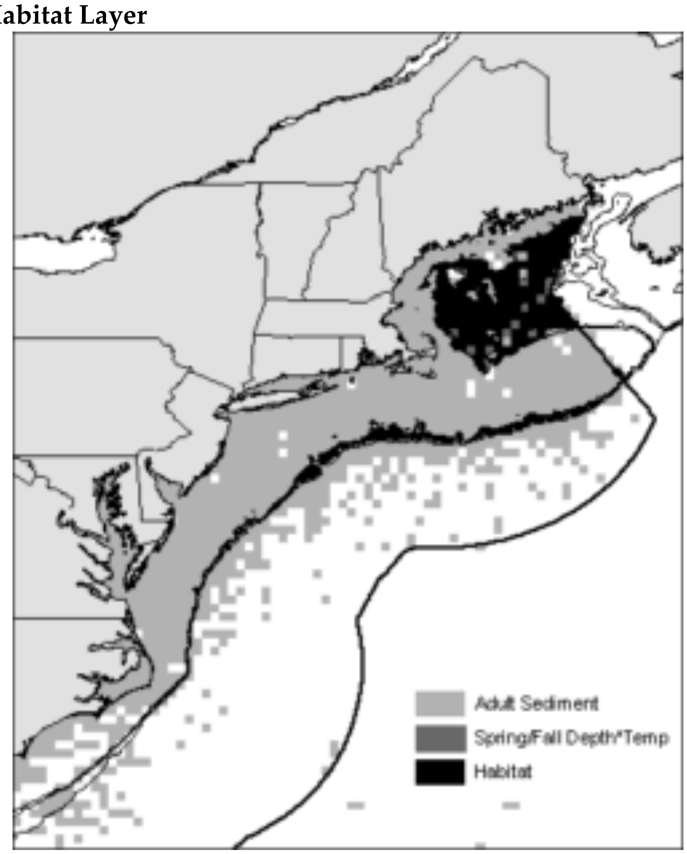
Map A-15. Sediment Habitat Layer

Step 15: The intersection of the year round depth and temperature intersection and the selected sediment TMS creates the final habitat layer.

Map A-16. Year-round Depth and Temperature Intersection Layer and Sediment Habitat Layer



Map A-17. Final Habitat Layer

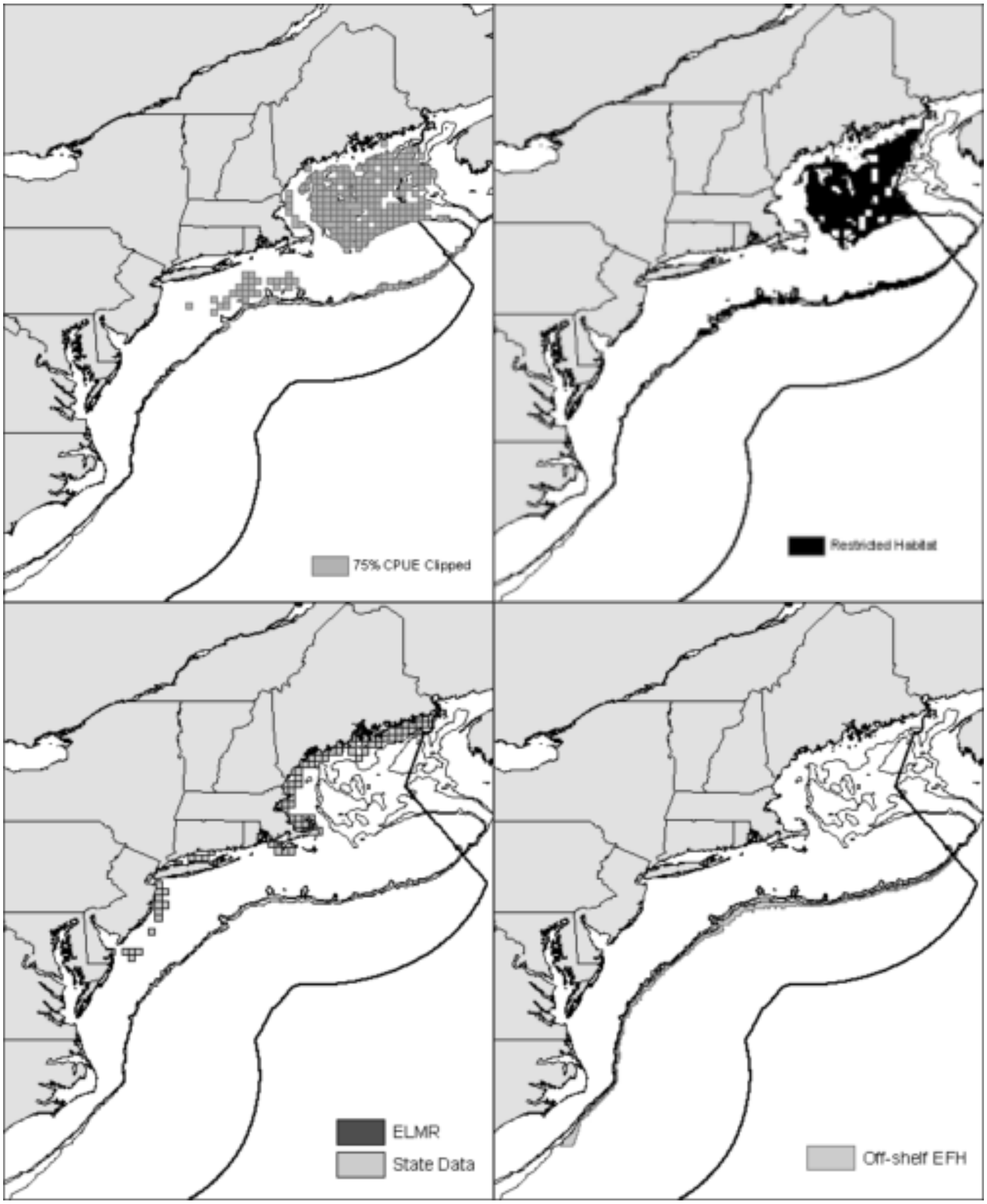


Step 16: The 25% cumulative catch rate NMFS trawl survey layer is overlaid with the portions of the final habitat layer that fall within the 50% cumulative catch rate NMFS trawl survey layer. The result is overlaid with the inshore and offshelf data where appropriate to create Alternative 3A.

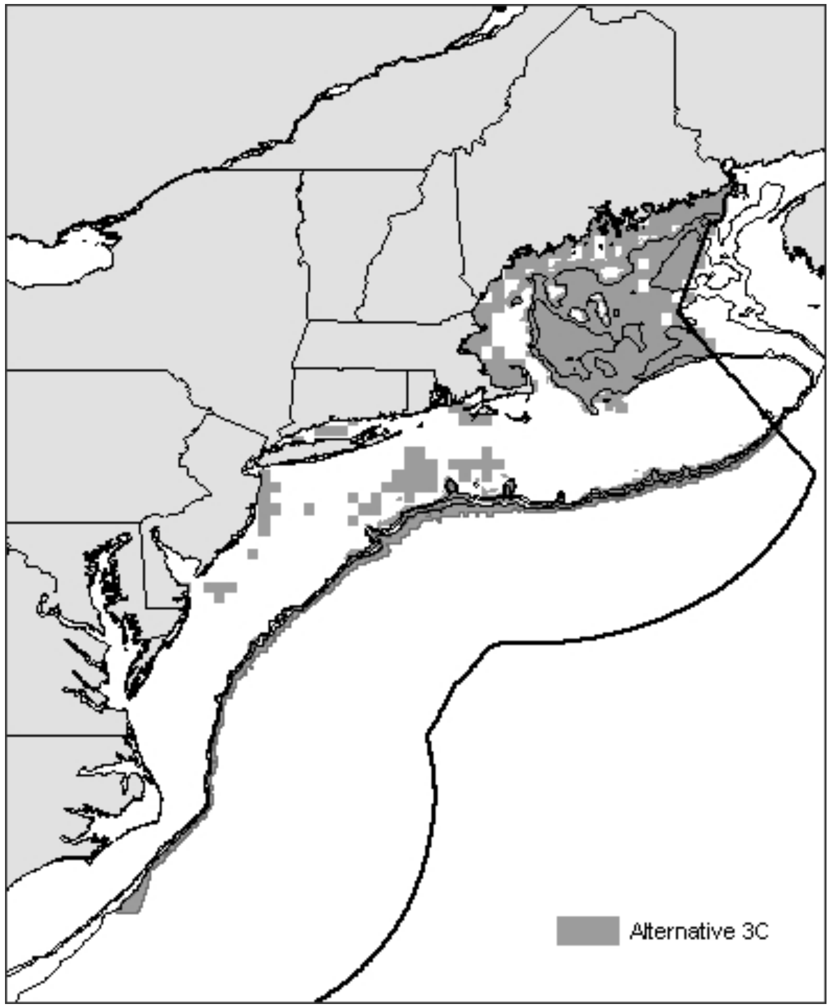
Step 17: The 50% cumulative catch rate NMFS trawl survey layer is overlaid with the portions of the final habitat layer that fall within the 75% cumulative catch rate NMFS trawl survey layer. The result is overlaid with the inshore and offshelf data where appropriate to create Alternative 3B.

Step 18: The 75% cumulative catch rate NMFS trawl survey layer is overlaid with the portions of the final habitat layer that fall within the 90% cumulative catch rate NMFS trawl survey layer. The result is overlaid with the inshore and offshelf data where appropriate to create Alternative 3C.

Map A-18. Depth Restricted 75% Catch Rate, Habitat Restricted to 90% Catch Rate, Inshore and Off-shelf



Map A-19. Alternative 3C



Step 19: The 90% cumulative catch rate NMFS trawl survey layer is overlaid with the portions of the final habitat layer that fall within the 100% cumulative catch rate NMFS trawl survey layer. The result is overlaid with the inshore and offshelf data where appropriate to create Alternative 3D.

5.0 Alternative 4 – Species Range

The alternative designates EFH as the entire range of the species. The spatial extent of EFH for any given life stage and species combines the GIS coverage for the inshore area developed for alternatives 2 and 3, the off-shelf coverage for alternative 3, and the ten minute squares on the continental shelf that represent 100% of the catch rate data from the 1968-2005 spring and fall NMFS trawl surveys. No habitat-defined GIS coverages were included in the EFH maps for this alternative. Since this alternative utilizes Level 1 information to map EFH, the text descriptions were modified to include broad ranges of depth, temperature, and salinity where a given lifestage and species is known to occur.

Table A-8. Alternative 4: Sources and Levels of EFH Information for EFH Designations *

Species	eggs	larvae	juvenile	adult
American plaice	NAD	NAD	2	2
Atlantic cod	2[b]	2[b]	2	2
Atlantic halibut	NAD	NAD	1[a]	1[a]
Atlantic herring???	NAD	NAD	2	2
Atlantic sea scallop	NAD	NAD	2	2
Barndoor skate	NAD	N/A	2[a]	2[a]
Clearnose skate	NAD	N/A	2	2
Haddock	NAD	NAD	2	2
Little skate	NAD	N/A	2	2
Monkfish	0[a,d]	1[a,d]	2[a]	2[a]
Ocean pout	0[e]	NAD	2	2
Offshore hake	NAD	NAD	2[a]	2[a]
Pollock	2[f]	2[f]	2	2
Red hake	0[a,c]	2[a,c]	2	2[a]
Redfish	N/A	2[a,c]	2[a]	2[a]

Rosette skate	NAD	N/A	2[a]	0[a],[b]
Silver hake	2[c]	2[c]	2	2[a]
Smooth skate	NAD	N/A	2[a]	2[a]
Thorny skate	NAD	N/A	2[a]	2[a]
White hake???	0[a,f]	0[a,f]	2	2[a]
Windowpane flounder	NAD	NAD	2	2
Winter flounder	1[f]	2[f]	2	2
Witch flounder	NAD	NAD	2[a]	2[a]
Winter skate	NAD	N/A	2	2
Yellowtail flounder	NAD	NAD	2	2

**   The numbers represent the highest available level of information available for each life history stage.*
[a]: indicates that a Level 1 offshelf realm designation is included in this alternative.
[b] indicates that juveniles were used as a proxy in combination with egg and/or larval survey data
[c]: indicates that juveniles were used as a proxy
[d]: indicates that adults were used as a proxy in combination with egg and/or larval survey data
[e]: indicates that a combination of juveniles AND adults were used as a proxy
[f] indicates that adults were used as a proxy
*Level "**0**" indicates that there is very little information available for this life history stage.*
***N/A**: indicates that this does not exist as a distinct life history stage for this species.*
***NAD**: indicates No Alternative Designation due to lack of new information.*

6.0 Alternative 5

Additional alternatives were developed for Atlantic herring, Atlantic sea scallop, offshore hake and winter flounder. In each case, the method is explained at the beginning of the alternative description.

6.1 Atlantic sea scallop

This alternative employs the text description from Alternative 4. The map is based on the Alternative 4 map representation with the addition of historic scallop areas.

6.2 Offshore hake

This alternative employs the text description from Alternative 3. The map is based on the juvenile Alternative 3D map representation with ten-minute-squares removed plus Alternative 3D for adults.

6.3 Winter flounder

This alternative employs the text description from Alternative 3. Alternative 5A map is based on Alternative 3 plus area bounded by 20m isobath and Alternative 5B map is based on Alternative 3 plus the area bounded by 20m isobath with ELMR data removed.

7.0 Alternative 6

Additional alternatives were developed for winter flounder. In each case, the method is explained at the beginning of the alternative description.

7.1 Winter flounder

This alternative employs the text description from Alternative 3. The map description is based on Alternative 3 but includes the depth range of 0-72 meters.

8.0 Atlantic Salmon

8.1 Alternative 1 - No Action

Essential fish habitat for Atlantic salmon is described as all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut that meet the habitat requirement in the text description for each life stage. The EFH designations of estuaries and embayments under the No Action Alternative are based on the NOAA Estuarine Living Marine Resources (ELMR) program as supporting Atlantic salmon eggs, larvae, juveniles and adults at the "abundant", "common" or "rare" level.

8.2 Alternative 2– Ten (10) Year Presence

Under this alternative, those rivers and estuaries that are “current(ly)” or have “recent(ly)” supported Atlantic salmon (e.g. have been documented in the system in the last ten (10) years (1996-2005)) are included in the EFH designation. Rivers and streams are identified on U.S. Geologic Survey Hydrologic Unit Codes (HUC).

8.3 Alternative 3 - Three (3) Year Presence (Current)

Under this alternative, those rivers and estuaries that are “current(ly)” supporting Atlantic salmon (e.g. have been documented in the system in the last three (3) years (2003-2005)) are included in the EFH designation. Rivers and streams are identified on U.S. Geologic Survey Hydrologic Unit Codes (HUC).

9.0 Deep-Sea Red Crab

Table A-9. Summary of Deep-Sea Red Crab EFH Designation Alternatives

Alternative	Spatial Realm →	→	→	→	
↓	Shelf (GOM)	Off-Shelf/Slope	Observed Seamounts (depth-defined)	Observed Seamounts (feature-defined)	All EEZ Seamounts
1		X			
2		X			
3A		X	X		
3B		X		X	
4	X	X			
5A	X	X	X		
5B	X	X		X	
6	X	X			X

9.1 Alternative 1 – No Action

The No Action EFH designations cover the geographic area included in the depth zones where deep-sea red crab is found. There are slight differences in the method for defining this depth zone between the life stages:

Eggs: Based on known depth zone affinities for female adults.

Larvae: Based on the known depth zones as defined by the union of the full (female and male) adult and juvenile depth ranges

Juveniles: Based on known depth zone affinities for juveniles.

Adults: Based on known depth zone affinities for all adults.

9.2 Alternative 2 – Refined Status Quo

Alternative 2 includes the Status Quo text descriptions as revised for refined slope depth occurrences of deep-sea red crab and modifies the map representations to illustrate the new depth ranges.

9.3 Alternative 3 – Refined Status Quo Plus Observed Seamounts

Alternative 3 includes the refined slope definitions in Alternative 2 as well as the areas in the "seamount" realm where deep-sea red crabs have been observed. Alternative 3 only includes parts of the seamounts that fall within the depth range given in the EFH text descriptions below.

9.4 Alternative 4 – Refined Status Quo Plus Gulf of Maine

Alternative 4 includes the Alternative 2 off-shelf/slope designations as well as the occurrences deeper than 40 meters in the Gulf of Maine.

9.5 Alternative 5 – Refined Status Quo, Observed Seamounts and Gulf of Maine

Alternative 5 includes the Alternative 2 off-shelf/slope definition, the Alternative 3 seamounts definition and the Alternative 4 Gulf of Maine definition.

9.6 Alternative 6 – Species Range

Alternative 6 includes the 100% observed range of deep-sea red crab in addition to an extended seamount range (those seamounts in the EEZ that meet the depth criteria) by analogy.

10.0 Special Exceptions

Due to the varying life history patterns between the life stages of the twenty-seven (27) species under management by the Council, distinct methods or new alternatives outside the general methods were employed. These special method exceptions are documented in Table A-10.

Table A-10. Special method exceptions for EFH designation alternatives.

Species	Life Stage	Alternative	Basis
Atlantic cod	juveniles	2E	Alternative 2D (juv) with southern boundary set at 38 North
	adults	2E	Alternative 2D (adults) with southern boundary set at 38 North
	juveniles	3E	Alternative 3D juveniles plus coastal areas in MA/ME/NH filled
	adults	3E	Alternative 3C juveniles plus coastal areas in MA/ME/NH filled
Atlantic halibut	Juveniles/adults	3	Only 1 Alternative 3 map was made. It shows the 90% CPUE and habitat layer bounded by the historic range of the species, rather than the 100% CPUE
Atlantic herring	eggs	2	Alternative 1 eggs plus updated herring egg bed sightings
	juveniles	2E	Alternatives 2C juveniles plus historic areas along CT/RI coasts
	adults	2E	Alternatives 2C adults plus historic areas along CT/RI/ME coasts
Atlantic sea scallops	juveniles/adults	3E	An Alternative 3E combines the 90% CPUE with an unbounded habitat (no restricting to TMS where the species was caught in the

Species	Life Stage	Alternative	Basis
			survey)
	juveniles/adults	5	Alternative 4 juveniles/adults plus historic areas
Barndoor skate	adults	2, 3, 4	Due to low catch rates of adults, juveniles were used as a proxy
Deep-sea red crab	larvae, juveniles and adults	2A	The depth range appropriate for the lifestage plus those parts of the 2 seamounts with observed red crab that are within the depth range used for EFH designation (2000m).
	larvae, juveniles and adults	2B	The depth range appropriate for the lifestage plus those parts of all the seamounts that are within the depth range used for EFH designation.
	larvae, juveniles and adults	3A	The depth range appropriate for the lifestage plus polygons which include the 2 seamounts with observed red crab in their entirety.
	larvae, juveniles and adults	3B	The depth range appropriate for the lifestage plus polygons which include each of the seamounts in their entirety.
Haddock	adults	3E	Alternative 3D juveniles plus Alternative 3D adults with range limited to Alternative 3D adults
Little skate	eggs	2, 4	No survey data exists for little skate eggs, adults are used as a proxy for EFH designation maps
	juveniles	3E	Alternative 3C juveniles plus historic areas
	adults	3E	Alternative 3C juveniles plus historic

Species	Life Stage	Alternative	Basis
			areas
Ocean pout	eggs, larvae	3	The area defined by water temperatures less than or equal to 10ºC and depths less than 50m.
	eggs, larvae	2, 4	The union of juvenile, adult and ELMR areas supporting ocean pout eggs and larvae at a "common" or "abundant" levels was used for EFH designation mapping.
Offshore hake	juveniles	3E	Alternative 3D juveniles with ten-minute-squares in Gulf of Maine removed
	juveniles/adults	5	Alternative 3D juveniles with TMS in GOM removed plus Alternative 3D adults
Pollock	eggs, larvae		The union of adult maps and ELMR areas supporting pollock eggs and larvae at a "common" or "abundant" levels was used for EFH designation mapping
Redfish	larvae	2, 4	Adult redfish were used as a proxy for larvae for EFH designation mapping.
Red hake	larvae	5	100% of the MARMAP data + ELMR (potential no EFH designation for eggs due to a lack of life stage)
Rosette skate	adults	2, 3, 4	Due to low catch rates of adults, juveniles were used as a proxy.
Silver hake	eggs, larvae	2, 4	The union of juvenile maps and ELMR areas supporting silver hake eggs and larvae at a "common" or "abundant" levels was used for EFH designation mapping.
White hake	eggs, larvae	2, 4	The union of adult maps and ELMR areas supporting white

Species	Life Stage	Alternative	Basis
			hake eggs and larvae at a “common” or “abundant” levels was used for EFH designation mapping.
Windowpane flounder	juveniles	3E	Alternative 3D juveniles plus historic areas
	adults	3E	Alternative 3D adults plus historic areas
Winter flounder	eggs, larvae	3	0-20m bottom depth along the coast from the Canadian border to Delaware Bay, the George’s Bank portion of the Winter Flounder Adult Alternative 3D and ELMR areas supporting winter flounder eggs at “common” or “abundant” levels.
	eggs, larvae	4	The union of adult maps and ELMR areas supporting winter flounder eggs and larvae at a “common” or “abundant” levels was used for EFH designation mapping
	eggs/larvae	5A	Alternative 3 plus area bounded by 20m isobath
	eggs/larvae	5B	Alternative 3 plus area bounded by 20m isobath with ELMR data removed.
	eggs/larvae	6	Alternative 3 using 0-72m depth range
Winter skate	juveniles	3E	Alternative 3D juveniles plus historic areas
	adults	3E	Alternative 3D adults plus historic areas
	juveniles	3	Mapped depth range of 0-50m to include important coastal waters.
	adults	3	Mapped depth range of 2-60 meters to include important coastal waters.

Species	Life Stage	Alternative	Basis
Witch flounder	adults	3E	Alternative 3D juveniles used as a proxy

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ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

PHASE 1

APPENDIX B
"EFH DESIGNATION SUPPLEMENTARY TABLES"

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LIST OF TABLES

Table B-1. Summary of Habitat Information for American Plaice

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Present 21-240 on shelf, common 41-140	Present 1.5-8.5 on shelf, common 2.5-7.5 Highest growth and survival rates 2-6	No information
Larvae	Pelagic, in water column	Present 21-220 on shelf, common 41-120	Present 3.5-13.5 on shelf, common 4.5-8.5	No information
Juveniles	Pelagic habitats during settlement Benthic habitats with substrates composed of mud, and sand-mud mixtures	Present 7-85 inshore, common 41-85 (MA) Present 1-500 on shelf, common 51-180	Present 1-16 inshore, common 2.5-10.5 (MA) Present 0.5-16.5 on shelf, common 2.5-6.5	Present 28-34 inshore Present 30.5-35.5, on shelf, common 31.5-34.5
Adults	Benthic habitats with substrates composed of mud, and sand-mud mixtures	Present 8-85 inshore, common 41-85 (MA) Common 101-200 on shelf Present 1->500 on and off shelf	Present 1-14 inshore, common 2.5-10.5 (MA) Present 0.5-17.5 on shelf, common 2.5-7.5 Optimum spawning 3-6 Develop 1.7-7.7,	Present 28-34 inshore Present 30.5-35.5 on shelf, common 31.5-34.5

		Normally occur 25-180, abundant 54-90 (GOM) Spawn <90	but tolerate -1.5 Upper limit 10-13	

* *Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data in EFH Source Document (2nd ed); additional temperature data from EFH Source Doc (2nd ed).

Larvae: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data in EFH Source Document (2nd ed).

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in EFH Source Doc (2nd ed.). Continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data; depth, temperature, and salinity ranges derived from NEFSC trawl survey data.

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in EFH Source Doc (2nd ed.). Continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data; depth, temperature, and salinity ranges derived from NEFSC trawl survey data. Other information from EFH Source Document (2nd ed.) and from Klein-MacPhee (2002).

Table B-2. Summary of Habitat Information for Atlantic Cod

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Present 21-140 on shelf, common 21-140 Present 500-1000 off-shelf	Collected -2 to 20 inshore Present 1.5-15.5 on shelf, common 3.5-13.5 Lab studies: 5-8.3 optimum for hatching, high mortalities at 0; 2-8.5 optimum for incubation; upper limit for development 12; highest survival at hatching 2-10	Most collected 32-33 (GB, Nantucket Shoals) Lab studies: highest survival at hatching 28-36; high mortality 10-12.5
Larvae	Pelagic, in water column	Present 1-350 on shelf, common 21-120 Present 500-1000 off-shelf Abundant on southern flank GB in 50-100	Present 1.5-15.5 on shelf, common 3.5-12.5 Lab study: growth increased from 4 to 10	Most collected 32-33 (GB, NS)
Juveniles	Pelagic habitats during settlement Benthic habitats with substrates composed of *gravel*, sand, mud and sand, and/or mud and sand with *gravel* Inshore: more abundant in or near seagrass and macroalgae beds YOY: highest growth in seagrass, highest survival in cobble and rock reef habitats	Present 4-85, common 6-55 (MA) Present 1-400 on shelf, common 31-120 YOY most abundant <27 in spring, 27-55 in fall; age 1+ most abundant 18-55 spring and 37-55 fall (MA) YOY 1-10 (inshore ME)	Present 1.5-19, common 5.5-12.5 (MA) Present 0.5-17.5 on shelf, common 2.5-11.5 Growth optimal near 10 YOY common 7-12 (inshore ME)	Present 28-34 (ME) Present 30.5-35.5 on shelf, common 32.5-33.5

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	YOY on sand, gravelly sand, and pebble-gravel substrate (GB) Lab studies: YOY prefer sand or gravel-pebble, cobble when predator present Decreased YOY mortality in high density sponge habitat vs. flat sand			
Adults	Benthic habitats with substrates composed of sand, *gravel*, and mud and sand with *gravel* Lab studies: prefer coarse sediments to mud Typically found along rocky slopes and ledges (SS) Also see juveniles	Present 5-85, common 21-75 (MA) Present 1-500, on and off shelf, common 31-140 Most abundant 10-150 Spawn near bottom, usually <73 (GB, GOM); also spawn in nearshore areas	Present 1.3-14.2, common 3.5-12.5 (MA) Present 0.5-19.5 on and off shelf, common 2.5-9.5 Can occur from near 0 to 20, usually <10 except in fall Spawn -1 to 12, optimum 5-7 (GB,GOM)	Present 31.2-34 (ME) Present 29.5-35.5 on shelf, common 32.5-33.5 Lab study: first mortalities at 2.7 Average 32 at spawning

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

<u>Note</u>: As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

Eggs: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data in EFH Source Document (2nd ed), all other information from EFH Source Doc (2nd ed).

Larvae: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data in EFH Source Document (2nd ed), all other information from EFH Source Doc (2nd ed).

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in EFH Source Doc (2nd ed.). For the continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and from information summarized in Stevenson et al. (2004); depth, temperature, and salinity ranges derived from NEFSC trawl survey data. Other information from EFH Source Document (2nd ed) and M. Lazzari (Maine DMR, pers. comm.).

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in EFH Source Doc (2nd ed.). Continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and from information in EFH Source Document (2nd ed.); depth, temperature, and salinity ranges derived from NEFSC trawl survey data. Other information from EFH Source Document (2nd ed) and from Klein-MacPhee (2002).

Table B-3.Summary of Habitat Information for Atlantic Halibut

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	No information (Assume same as juveniles and adults)	Lab study: optimum 5-7 (Assume same as juveniles and adults)	No information (Assume same as larvae)
Larvae	Pelagic, in water column	No information (Assume same as juveniles and adults)	No information (Assume same as juveniles and adults)	Prefer 30-35
Juveniles	Benthic habitats (for substrates types, see adults)	Present 21-400 on shelf, common 61-140 (juvs and adults) Most common 20-60 (Canada)	Present 1.5-14.5 on shelf, common 2.5-12.5 (juvs/adults) Survive sub-zero, but prefer >2	Present 31.5-35.5 on shelf, common 31.5-34.5 (juvs/adults)

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
		Occur as deep as 700 off-shelf (juvs/adults)		
Adults	Benthic habitats, usually on sand, gravel or clay, not on soft mud or rock Spawn over rough or rocky bottom	Range 37-1000, depth limit uncertain Spawn as deep as 700 Believed to spawn on continental slope and on offshore banks at depths of at least 183 Found mainly on banks (SS) and head of Bay of Fundy 165-229	Found -0.5 to 13.6, avoid <2.5; most caught 3-9, average 5-6 Spawn 4-7	Found 30.4-35.3 (SS) Spawn at 35 or less

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: *As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders*

Sources of information:

Eggs and Larvae: All information from EFH Source Document Update Memo.

Juveniles: Depth and temperature ranges based on NEFSC trawl survey data in EFH Source Doc Update Memo; all other information also from EFH Source Doc Update Memo.

Adults: All information from EFH Source Doc Update Memo.

Table B-4.Summary of Habitat Information for Atlantic Herring

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Benthic habitats with	5-90 inshore	Bottom	Spawn 32-33 in

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	boulders, coarse sand, cobble/pebble, gravel, and/or macroalgae Not on mud or fine sand Strong bottom currents enhance survival	and on shelf	temperatures over egg beds 7-15 Normal development 1-22	GOM/GB
Larvae	Pelagic, in water column	Present 1-1500 on and off shelf, common 41-220 Inshore: minimum 20	Present -0.5 to 14.5 on and off shelf, common 1.5-12.5 Lab study: tolerate -1.8 to 24	Lab study: survived 2.5-52.5 for 7 days (assume max=35)
Juveniles	Pelagic, in water column	Present 4-99 inshore, common 11-65 (MA), 9-17 (RBay), 9-21 (DBay), 4-16 (CBay) Present 1-400 on shelf, common 21-300 on shelf YOY caught in beach seines	Present 0-28 inshore, common 3.5-14.5 (MA), 13.5-21.5 (RBay), 5-13 (DBay), 10-22 (CBay) Common 2.5-10.5 on shelf Can survive -1.1 Lab study: prefer 8-12	Present 5-36.5 inshore, common 20.5-31.5 (RBay), 11-26 (DBay), 18-28 (CBay) Common 30.5-34.5 on shelf YOY can tolerate salinities as low as 5 for a short time; older juveniles avoid brackish water Lab study: prefer 28-32
Adults	Pelagic, in water column; spawn on bottom	Present 4-84 inshore, common 31-85 (MA), 7-16 (RBay), 10-21 (DBay) Present 1-400 on shelf,	Present 0-20 inshore, common 1.5-10.5 (MA), 1.5-9.5 (RBay), 0-11 (DBay) Common 2.5-10.5 on shelf	Present 16-36, common 18.5-33.5 (RBay), 11-29 (DBay) Common 29.5-35.5 on shelf Rarely found in

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
		common 11-300 Spawn 5-90 (see eggs)	Prefer 5-9 during spawning season (GB)	low salinities; lower limit 28 Spawn 32-33

* *Depth to bottom*

*** Bottom water temperatures and salinities for eggs and water column temperatures and salinities for larvae, juveniles, and adults*

<u>Note</u>: Information based on bottom trawl survey data cited in this table were not used to map EFH for this species, since it is a pelagic species.

Sources of information:

Eggs: All information on eggs obtained from EFH Source Document (2nd ed).

Larvae: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document (2nd ed.); other information from EFH Source Document (2nd ed.) and Lazzari and Stevenson (1992).

Juveniles: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl surveys in areas mapped as EFH; depth, temperature, and salinity ranges ("common") from analysis of MA, Chesapeake Bay, and Raritan Bay trawl survey data in EFH Source Doc (2nd ed.) and Delaware Bay trawl survey data in Morse (2000). <u>Continental shelf</u>: depth and temperature ranges derived from NEFSC bottom trawl survey data. All other information from EFH Source Document (2nd ed.) and from reports on seine surveys conducted in NH, RI, MD, and VA.

Adults: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl surveys in areas mapped as EFH; depth, temperature, and salinity ranges ("common") from analysis of MA and Raritan Bay trawl survey data in EFH Source Doc (2nd ed.) and Delaware Bay trawl survey data in Morse (2000). <u>Continental shelf</u>: depth and temperature ranges derived from NEFSC bottom trawl survey data. All other information from EFH Source Document (2nd ed.) and Munroe (2002).

Table B-5. Summary of Habitat Information for Atlantic Sea Scallop

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Benthic habitats	No information	No information	No information
Larvae	Pelagic and benthic habitats Spat survival enhanced on sedentary branching plants or animals, or any hard surface (e.g., shells, small pebbles); do not survive on shifting sand	No information	Lab study: viable 12-18 (mass mortalities >18)	Lab study: viable as low as 10.5, 16.9-30 preferred
Juveniles	Benthic habitats associated with sand, gravel, and mixtures of gravel, mud, and sand Attach to shells and bottom debris, including gravel and small rocks, most abundant on gravel Currents stronger than 10 cm/s retard feeding and growth	Common 41-120 on shelf (not including GOM), present 21-160 Typically 18-110, but also found as shallow as 2 inshore (GOM) (also adults) Most abundant 62-91 (GB) Found primarily 45-75 in south, less common 25-45 (too warm) Not common >110, but occur as deep as 170-180 in GOM	Present 0.5-20.5, common 5.5-10.5, on shelf (in summer) Lab studies: maximum survival 1.2-15 or <18	Lab study: maximum survival **>**25
Adults	Benthic habitats associated with sand, gravel, and mixtures of gravel, mud, and sand Found on firm sand, gravel,	Same as juveniles Common or abundant in coastal GOM bays and estuaries (ELMR) (juveniles and adults)	Optimal growth 10-15, >21 lethal Spawn 6.5-16 Otherwise, same as juveniles	Prefer full strength seawater, <16.5 lethal

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	shells, and rock, most abundant on gravel Strong tidal currents (> 25 cm/s) inhibit feeding	Found from low tide level to ~100 m		

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Larvae: All information obtained from EFH Source Document (2nd ed.)

Juveniles: Shelf depth and temperature ranges derived from NEFSC summer scallop dredge survey data (all sizes); sediment associations based on GIS overlap analysis of USGS USSeabed sediment data and NEFSC scallop dredge survey data; other information on substrates, depths, temperatures, and salinities from EFH Source Document (2nd ed.).

Adults: Sediment associations based on analysis of USGS USSeabed sediment data and NEFSC scallop dredge survey data; other information on substrates, temperatures, and salinities from EFH Source Doc (2nd ed.).

Note: Eggs are slightly heavier than seawater and probably remain on the sea floor as they develop into free-swimming larvae which settle to bottom (as "spat") before metamorphosing into juveniles. Juveniles and adults inhabit similar habitats, so information on depth and bottom temperatures in the table is common to both life stages. The NEFSC scallop dredge survey does not include the Gulf of Maine and is only done in summer.

Table B-6.Summary of Habitat Information for Barndoor Skate

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Benthic habitats with	Present 21-400	Present 2.5-18.5	Present 31.5-36.5

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	substrates composed primarily of sand, but also sand and mud, and sand and mud with *gravel* Also see adults	on shelf, common 51-160 Assumed present 400-750 (see adults)	on shelf, common 2.5-11.5	on shelf, common 32.5-34.5
Adults	Found on mud as well as sand and gravel	Present 21-400 on shelf, common 61-400 Range from shoreline to about 750, most abundant <150	Present 3.5-16.5 on shelf, common 4.5-16.5	Present 31.5-36.5 on shelf, common 32.5-34.5 Observed in mouth of CBay where salinity is 21-24 and in "brackish" water in Delaware R

**   Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: *As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders*

Sources of information:

Juveniles and adults: Depth, temperature, and salinity ranges based on NEFSC trawl survey data in EFH Source Document; sediment types derived from analysis of NEFSC trawl survey and USGS USSeabed sediment data plus information in EFH Source Document; other information from EFH Source Document.

Table B-7. Summary of Habitat Information for Deep-Sea Red Crab

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Table B-8. Summary of Habitat Information for Clearnose Skate

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Juveniles	Benthic habitats with substrates composed primarily of sand, also mud and sand with and without *gravel* Found on soft bottoms, but also on rocky or gravelly bottoms	Present 2.7-76 inshore, common min 5 (RB) Present 1-300 on shelf, common 1-30	Present 2.8-27.2 inshore, common 14.5-22.5 (RB) Present 3.5-27.5 on shelf, common 14.5-21.5	Present 19-35 inshore, common 19.5-31.5 (RB) Present 25.5-36.5 on shelf, common 30.5-36.5
Adults	Benthic habitats with substrates composed primarily of sand, also mud and sand with and without *gravel* Found on soft bottoms, but also on rocky or gravelly bottoms	Present 4-76 inshore, common min 5 (RB) Present 1-300 on shelf, common 1-30	Present 4-25.4 inshore, common 14.5-22.5 (RB), 11.5-22.5 (j/a DB), 10-24 (j/a CB) Present 3.5-25.5 on shelf, Common 13.5-21.5 Found 9-30, mostly 9-20 in north, 19-30 NC	Present 19.6-35 inshore, common 19.5-31.5 (RB), 21.5-34.5 (j/a DB), 22-32 (j/a CB) Present 25.5-36.5 on shelf, common 30.5-36.5

* Depth to bottom

** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages

Note: As used in the analysis of sediment associations, the term "*gravel*" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay trawl survey data in EFH Source Document. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and from information in EFH Source Doc.

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay, Delaware Bay, and Chesapeake Bay trawl survey data in EFH Source Document. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and from information in EFH Source Doc.

Note: Delaware Bay and Chesapeake Bay temperature and salinity data were applied to juveniles and adults – clearnose skates caught during these two surveys were not distinguished by life stage. Also, the substrate information in the EFH Source Document is common to both life stages.

Table B-9. Summary of Habitat Information for Haddock

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Present 1-1000 on and off shelf, common 41-200	Present 0.5-12.5 on and off shelf, common 3.5-7.5 Lab study: highest survival 4-10	Found 34-36
Larvae	Pelagic, in water column	Present 1-350 on shelf, common 41-160 Assume 1000 max (same as eggs)	Common 3.5-11.5 on shelf	Assume same as eggs
Juveniles	Pelagic habitats during settlement Benthic habitats composed of sand, and sand and mud with *gravel* Pebble gravel bottom	Present 7-84 inshore, common 31-85 (MA) Present 21-400 on shelf, common 41-120	Present 3-14.5 inshore, common 4.5-10.5 (MA) Present 0.5-15.5 on shelf, common 4.5-12.5	Present 31-34 inshore Present 30.5-35.5 on shelf, common 31.5-35.5, 32 optimal
Adults	Benthic habitats composed of *gravel*, sand, sand and mud with *gravel*, and *gravel*	Present 31-83 inshore Present 21-	Present 3.2-11.5 inshore Present 0.5-15.5	Present 31-34 inshore Present 31.5-

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	with sand and mud Prefer gravel, pebbles, clay, broken shells, and smooth, hard sand, esp between rocky patches Not common on rocks, ledges, kelp or soft mud	400 on shelf, common 61-140	on shelf, common 3.5-8.5 Spawn 2-7, optimum 4-6	35.5 on shelf, common 32.5-33.5 Spawn 31.5-34

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: *As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders*

Sources of information:

Eggs: Depth and temperature ranges derived from MARMAP and GLOBEC data in EFH Source Document (2nd ed), other information from EFH Source Doc (2nd ed).

Larvae: Depth and temperature ranges derived from MARMAP and GLOBEC data in EFH Source Document (2nd ed.).

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in EFH Source Doc (2nd ed.). Continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data; additional substrate information from EFH Source Document (2nd ed.); depth, temperature, and salinity ranges derived from NEFSC trawl survey data. Other information from EFH Source Document (2nd ed.) and Mark Lazzari (Maine DMR, pers. comm.).

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in EFH Source Doc (2nd ed.). Continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data; additional substrate information from EFH Source Document (2nd ed.); depth, temperature, and salinity ranges derived from NEFSC trawl survey data. Other information from EFH Source Document (2nd ed.) and Klein-MacPhee (2002).

Table B-10. Summary of Habitat Information for Little Skate

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Sandy benthic habitats	<27 (GOM)	Embryos begin growing >7-8	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Sandy benthic habitats Also see adults	Present 4-80 inshore, common 16-30 (MA), at min 8 (RB) Present 1-400 on shelf, common 11-70	Present 0-24 inshore, common 7.5-18.5 (MA), 3.5-18.5 (RB) Present 0.5-24.5 on shelf, common 1.5-21.5	Present 15-36 inshore, common 22.5-32.5 (RB) Present 25.5-36.5 on shelf, common 29.5-33.5
Adults	Sandy benthic habitats Generally on sandy or gravelly bottoms, but also on mud (GOM) Biogenic depressions and flat sand (SNE) Sand and sand-mud (LIS)	Present 4-78 inshore, common 16-30 (MA), 7-19 (j/a DB) Present 1-400 on shelf, common 31-100 Generally found <111, occ >183, 15-46 (SNE), as deep as 329 on GB, 384 off NJ	Present 2.2-21.6 inshore, common 6.5-16.5 (MA), 7.5-22.5 (j/a DB) Present 1.5-21.5 on shelf, common 1.5-15.5 Generally found 1-21, most 2-15	Present 13.4-35 inshore, common 24.5-34.5 (j/a DB) Present 28.5-36.5 on shelf, common 32.5-33.5

*   *Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs: EFH Source Document

Juveniles: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay and MA trawl survey data in EFH

Source Document. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data.

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Delaware Bay and MA trawl survey data in EFH Source Document. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and from information in EFH Source Doc. Other information obtained from EFH Source Document.

Table B-11. Summary of Habitat Information for Monkfish

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in upper water column	18-40 (NJ) Collected within 1 meter of shore See larvae	Most at 10-20 Upper limit for normal development 17-18	No information
Larvae	Pelagic, in water column	Found in surf zone and near-shore habitats (NJ) Present 1-1500 on and off shelf, common 1-160 on shelf	Present 6.5-20.5 on shelf, common 8.5-17.5 on shelf	No information
Juveniles	Pelagic habitats during settlement Benthic habitats with substrates composed of mud, sand, and mixtures of mud and sand Also see adults	Present 8-100 inshore, common 31-85 (MA) Present 1-1000 on and off shelf (YOY at 900), common 51-400 on shelf Common 91-182 (GOM)	Present 1.5-13 inshore, common 3.5-10.5 (MA) Present 1.5-24.5 on shelf, common 4.5-13.5	Present 31-33.6 inshore Present 29.5-36.5 on shelf, common 30.5-36.5
Adults	Benthic habitats with	Present 8-84	Present 1.9-16.5	Present 30-34

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	substrates composed of mud, sand, and mixtures of mud and sand Found on hard sand, pebbly bottoms, gravel and broken shells, and soft mud Prefer clay and mud over sand and gravel (SS)	inshore, common 21-65 (MA) Present 1-1000 on and off shelf, common 51-400 on shelf	inshore, common 5.5-11.5 (MA) Present 0.5-21.5 on shelf, common 4.5-15.5	inshore Present 29.5-36.5, common 33.5-35.5 on shelf

*   *Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs: Depth information from EFH Source Document (2nd ed.) and Caruso (2002); temperature data from EFH Source Document (2nd ed.)

Larvae: Shelf depth and temperature ranges derived from MARMAP survey data in EFH Source Document; other information from EFH Source Document (2nd ed.)

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in EFH Source Doc (2nd ed.). Continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data; depth, temperature, and shelf salinity ranges from NEFSC trawl survey data. Other depth information derived from EFH Source Document (2nd ed.) and Moore et al. (2003).

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in EFH Source Doc (2nd ed.). Continental shelf: sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data; depth, temperature, and shelf salinity ranges from NEFSC trawl survey data. Other depth and substrate information derived from EFH Source Document (2nd ed.) and Moore et al. (2003).

Table B-12. Summary of Habitat Information for Ocean Pout

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Benthic habitats in sheltered nests, sometimes in rocky crevices	No information (Assume same as spawning adults)	No information (Assume same as spawning adults)	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Benthic habitats composed primarily of sand, with some mud and mud-sand Variety of substrates, including shells, rocks, algae, soft sediments, sand, and gravel	Present 7-82 inshore, common 21-65 (MA) Present 1-400 on shelf, common 41-70 Found along the shore at low tide (BOF) Few YOY 1-10 (ME)	Present 1.3-20.2 inshore, common 2.5-10.5 (MA) Present 1.5-18.5 on shelf, common 2.5-11.5	Present 31.8-33.1 inshore Present 30.5-36.5 on shelf, common 31.5-33.5
Adults	Benthic habitats composed primarily of sand, with some mud-sand Also see juveniles Spawn on hard bottom in sheltered areas	Present 5-86 inshore, common 26-80 (MA) Present 1-400 on shelf, common 41-100 Occur 27-363 on SS and in Bay of Fundy, (juvs and adults) Spawn <50	Present 1.3-18 inshore, common 3.5-10.5 (MA) Present 0.5-17.5 on shelf, common 1.5-11.5 Prefer 6-9, can tolerate 0-16 Spawn 10 or less	Present 3.3-33 inshore Present 29.5-36.5 on shelf, common 31.5-33.5 Prefer 32-34, but enter rivers in deeper, more saline water

* *Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: *This species has no larval stage - ocean pout hatch as juveniles*

Sources of information:

Eggs: All information from EFH Source Document.

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA inshore trawl survey data in EFH Source Doc Update Memo. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey data and USGS USSeabed sediment data and from information in EFH Source Document and Update Memo. Additional information from EFH Source Document and Update Memo, Klein-MacPhee and Colette (2002), and M. Lazzari (Maine DMR, pers. comm.).

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA inshore trawl survey data in EFH Source Doc Update Memo. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey data and USGS USSeabed sediment data and from information in EFH Source Document and Update Memo. Additional information from EFH Source Document and Update Memo and Klein-MacPhee and Colette (2002).

Table B-13. Summary of Habitat Information for Offshore Hake

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Present 21-1500, common 101-1500, on continental shelf and slope	Present 4.5-20.5, common 7.5-19.5, on continental shelf and slope	No information
Larvae	Pelagic, in water column	Present 21-1500, common 61-1500, on continental shelf and slope	Present 4.5-19.5, common 4.5-18.5, on continental shelf and slope	No information
Juveniles	Pelagic habitats (at night) Benthic habitats with substrates composed of mud, sand, and sand-mud mixtures	Present 21-500, common 201-500, on continental shelf and slope Found 200-750	Present 2.5-16.5, common 8.5-12.5, on continental shelf and slope	Present 31.5-36.5, common 34.5-36.5, on continental shelf and slope

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Adults	Pelagic habitats (at night) Benthic habitats with substrates composed of mud, sand, and sand-mud mixtures	Present 11->500, common 201-500, on continental shelf and slope Found 200-750 Spawn 330-550	Present 3.5-16.5, common 6.5-12.5, on continental shelf and slope	Present 31.5-36.5, common 34.5-36.5, on continental shelf and slope

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs: Shelf and off-shelf depth and temperature ranges derived from MARMAP data in EFH Source Doc Update Memo.

Larvae: Shelf and off-shelf depth and temperature ranges derived from MARMAP data in EFH Source Doc Update Memo.

Juveniles: Depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey data and USGS USSeabed sediment data; other information from Haedrich and Merrett (1988).

Adults: Depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey data and USGS USSeabed sediment data; other information from EFH Source Document and Haedrich and Merrett (1988).

Table B-14. Summary of Habitat Information for Pollock

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Present 1-280 on shelf, common 41-120 Usually found 50-250	Present 2.5-13.5 on shelf, common 2.5-13.5 Optimum development 3.3-8.9	No information

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Larvae	Pelagic, in water column	Present 1-280 on shelf, common 21-160 Normally from shore to 200, reported as deep as 1550	Present 1.5-17.5 on shelf, common 3.5-11.5 Larvae strong and active 3.3-8.9	No information
Juveniles	Pelagic habitats Benthic habitats with substrates composed of mud, sand, mixtures of mud and sand, and *gravel* Wide variety of substrates, including sand, mud, and rocky bottom with eelgrass and macroalgae	Present 4-83 inshore, common at min 6, max 70 (MA) Present 11-400 on shelf, common 41-180 YOY and age 1 utilize inshore subtidal and intertidal zones; common 1-10 in ME estuaries and bays Age 2+ move offshore to 130-150	Present 1.6-17 inshore, common at min 5, max 12 (MA) Present 0.5-17.5 on shelf, common 2.5-9.5 Found 0-16	Present 28-33.7 inshore (ME) Present 31.5-35.5 on shelf, common 31.5-34.5 Prefer 31.5
Adults	Pelagic habitats Benthic habitats with substrates composed of mud, sand, mixtures of mud and sand, mud and sand mixed with *gravel*, and *gravel* Little preference for bottom type Spawn over hard, stony or rocky bottom	Present 1-400 on shelf, common 81-180 Range 35-365, most <137, prefer 100-125 Found further offshore than juveniles	Present 1.5-16.5 on shelf, common 5.5-9.5 on shelf Found 0-14, tend to avoid >11 and <3 Spawning begins <8, peaks 4.5-6 (MA Bay)	Common 32.5-35.5 on shelf Found 31-34 (SS) Spawn 32-32.8 (MA Bay)

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

Eggs: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document; other information from EFH Source Doc and Update Memo.

Larvae: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document; other information from EFH Source Doc and Update Memo.

Juveniles: Inshore: depth, temperature, and salinity ranges (present and "common") based on MA and ME inshore trawl survey data in areas mapped as EFH in EFH Source Doc Update Memo. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey data and USGS USSeabed sediment data and EFH Source Document and Update Memo. Other information also obtained from EFH Source Document and Update Memo.

Adults: Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey data and USGS USSeabed sediment data and EFH Source Document and Update Memo. Other information also obtained from EFH Source Document and Update Memo.

Table B-15.Summary of Habitat Information for Red Hake

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	No information	No information	No information
Larvae	Pelagic, in water column	Present 1-1500 on shelf, common 21-120 Found 10-200 Most abundant 40-120 (MAB)	Present 7.5-23.5 on shelf, common 11.5-20.5 8-23, most 11-19 (MAB, Aug-Sept)	No information
Juveniles	Pelagic habitats during settlement	Present 4-99 inshore, common 26-65 (MA), 10-	Present 0.4-25 inshore, common 2.5-11.5 (MA), min	Present 1-36 inshore, common 26.5-33.5 (RB),

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	Benthic habitats with substrates composed of mud, sand, and mud-sand mixtures YOY in depressions on open seabed and associated with eel grass and macroalgae Shelter is critical for older juveniles (e.g., shells, biogenic structure, bottom depressions, inside live scallops)	24 (RB), min 7 (DB), min 13 (CB) Present 1-500 on shelf, common 1-80 YOY 1-10 (ME)	4.5, max 21.5 (RB), 4.5-12.5 (DB), 4-14 (CB) Present 1.5-22.5 on shelf, common 3.5-17.5	6.5-30.5 (DB), 22-32 (CB) Present 28.5-36.5 on shelf, common 31.5-33.5
Adults	Benthic habitats with substrates composed of mud, sand, and mud-sand mixtures Most common on soft sediments or shell beds, much less common on gravel or hard bottoms	Present 6-99 inshore, common 21-75 (MA) Present 1->500 on shelf, common 61-300 Present 400-750 off-shelf	Present 1.3-19.7 inshore, common 4.5-10.5 (MA) Present 1.5-21.5 on shelf, common 5.5-12.5 Spawn 5-10	Present 23-34.5 inshore Present 30.5-36.5 on shelf, common 32.5-34.5

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

<u>Note</u>: Red hake eggs were not differentiated from eggs of spotted and white hake in MARMAP survey.

Sources of information:

Larvae: Depth and temperature ranges for shelf derived from MARMAP survey data and other information in EFH Source Doc (2nd ed).

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA and Raritan Bay trawl survey data in EFH Source Document Update Memo, Delaware Bay trawl survey data in Morse (2000), and Chesapeake Bay trawl survey data in Geer (2002). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and from information in EFH Update Memo. Other information on depth (for YOY juveniles) provided by M. Lazzari (Maine DMR, pers. comm.).

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth and temperature ranges ("common") based on MA trawl survey data in EFH Source Document. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and from information in EFH Source Doc Update Memo. Other information taken from EFH Update Memo and Haedrich and Merrett (1988).

Table B-16. Summary of Habitat Information for Redfish

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Larvae	Pelagic, in water column	Present 41->2000 on and off shelf, common 81-260	Present 2.5-13.5 on shelf, common 3.5-9.5	No information
Juveniles	Pelagic habitats during settlement Benthic habitats with a wide variety of sediment types, primarily mud YOY on boulder reefs; also associated with cerianthid anemone patches when larger (also adults)	Present 16-86 inshore Present 31-400 on shelf, common 101-200 Present 400-600 off-shelf	Present 1.5-12.6 inshore Present 1.5-19.5 on shelf, common 2.5-9.5	Present 30.6-34 inshore Present 30.5-36.5 on shelf, common 32.5-34.5
Adults	Benthic habitats with a wide variety of sediment types,	Present 35-99 inshore	Present 1.9-11 inshore	Present 31.7-33.6 inshore

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	primarily mud Most abundant over silt, mud, or hard bottom, rare over sand Boulders, deep-water corals, other epifauna	Present 21-500 on shelf, common 141-200 Present 400-600 off-shelf	Present 0.5-21.5 on shelf, common 3.5-9.5 on shelf	Present 31.5-35.5 on shelf, common 32.5-34.5

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: Redfish bear live young (no egg stage). Also, the information in this table refers primarily to the Acadian redfish (Sebastes fasciatus) – which is more common in U.S. waters of the GOM and on GB, but deep-water redfish (Sebastes mentella) are also caught in trawl surveys and are not distinguished from Acadian redfish in the database.

Sources of information:

Larvae: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document Update Memo.

Juveniles and Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore trawl survey data in areas mapped as EFH (MA and ME). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and information in EFH Update Memo. Off-shelf depth information taken from and Moore et al. (2003).

Table B-17. Summary of Habitat Information for Rosette Skate

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Benthic habitats primarily composed of sand, with some mud, mud and sand, and mud and sand with *gravel*	Present 10-500 on shelf, common 71-300	Present 4.5-25.5 on shelf, common 9.5-17.5 Found 5.3-15	Present 30.5-36.5 on shelf, common 34.5-36.5

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	Sand to mud bottoms	Found 33-530, most common 74-274		
Adults	Assume same as juveniles	Not caught in trawl surveys, see juveniles	Not caught in trawl surveys, see juveniles	Not caught in trawl surveys, see juveniles

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

Juveniles: Shelf depth, temperature, and salinity ranges derived from NEFSC trawl survey data; information on substrates from GIS overlap analysis of NEFSC survey and USGS USSeabed sediment data and from EFH Source Document; other information also from EFH Source Document.

Table B-18. Summary of Habitat Information for Silver Hake

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Common 41-200 on shelf Present 1-1500 on and off shelf	Collected 14.8-21.4 (NBay) and 13-22 (MAB) Present 4.5-26.5 on and off shelf, common 5.5-23.5	No information
Larvae	Pelagic, in water column	Present 1-1500 on and off shelf Common 41-140 on shelf	Collected 12-22.4 (NBay) Present 4.5-26.5 on and off shelf, common 9.5-17.5	No information

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Juveniles	Pelagic habitats (at night) Benthic habitats associated with mud, sand, and sand-mud mixtures Found mostly on flat sand, also sand wave crests, shells and depressions created by benthic organisms (MAB/SNE) YOY more abundant on silt-sand with amphipod tubes (NYB/MAB)	Present 5-99 inshore, common 41-80 (MA), 10-25 (RBay), 12-26 (CBay), and at 11-22 (DBay) Present 1->500 on and off shelf, common 41-400 YOY most abundant 55 (MAB)	Present 0.2-22 inshore, common 1.5-11.5 (MA), 4.5-21.5 (RBay), 7-13 (CBay), and 5-16 (DBay) Present 0.5-22.5 on and off shelf, common 4.5-10.5	Present 13.4-36 inshore, common 26.5-33.5 (RB) and 26-33 (DB) Present 19.5-36.5 on and off shelf, common 32.5-34.5
Adults	Pelagic habitats (at night) Benthic habitats associated with mud, sand, and sand-mud mixtures Juvs/adults most abundant on mud and mud-sand (LIS) Found mostly on flat sand, also sand wave crests, shells and depressions created by benthic organisms (MAB/SNE)	Present 6-99 inshore, common 36-80 (MA) and at min 10 (DBay) Present 1->500 on and off shelf, common 121-500 Prefer 40-200 (GB), 60-100 (MAB) Limited inshore spawning	Present 1.3-18 inshore, common 4.5-11.5 (MA) and at max 16 (DBay) Present 1.5-21.5 on and off shelf, common 5.5-13.5	Present 24-36 inshore, common 26.5-33.5 (RB) and 24-30 (DB) Present 31.5-36.5 on and off shelf, common 33.5-34.5

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs and Larvae: Shelf and slope depth and temperature ranges derived from MARMAP data in EFH Source Document (2nd ed.), other information obtained from EFH Source Doc (2nd ed.).

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, salinity, and temperature ranges ("common") from analysis of MA, Raritan Bay, Delaware Bay, and Chesapeake Bay trawl survey data in EFH Source Doc (2nd ed.) and Morse (2000). Continental shelf and slope: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFCS trawl survey data and USGS USSeabed sediment data and information in EFH Source Doc (2nd ed.). Other information from EFH Source Document (2nd ed.)

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, salinity, and temperature ranges ("common") from analysis of MA, Raritan Bay, and Delaware Bay trawl survey data in EFH Source Doc (2nd ed.) and Morse (2000). Continental shelf and slope: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFCS trawl survey data and USGS USSeabed sediment data, and information in EFH Source Doc (2nd ed.). Other information from EFH Source Document (2nd ed.)

Table B-19. Summary of Habitat Information for Smooth Skate

Life Stage	Habitat	Depth (m)*	Temperature (°C)**	Salinity (ppt)**
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Benthic habitats associated primarily with mud, but also mud and sand, and mud and sand mixed with *gravel* Found mostly on soft mud in deeper areas, but also on sand, broken shells, gravel, and pebbles on offshore banks in GOM	Present 12-99 inshore Present 31-500 on shelf, common 121-400 Found 31-874, most abundant 110-457, min 46 on offshore banks (GOM) Occurs 46-956 NC to Grand	Present 3.2-10 inshore Present 1.5-16.5 on shelf, common 3.5-9.5 Found 2-10 southern Nova Scotia to GB	Present 32.1-33.3 inshore Present 31.5-35.5, common 32.5-35.5

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
		Banks		
Adults	Benthic habitats associated with mud, sand, mud and sand, and mud and sand mixed with *gravel* Also see juveniles	Present 31-400 on shelf, common 121-300 Also, see juveniles	Present 2.5-21.5 on shelf, common 3.5-8.5	Present 31.5-35.5 on shelf, common 32.5-35.5

* *Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) derived from ME trawl survey data in areas mapped as EFH. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data plus information in EFH Source Document. Other information obtained from EFH Source Document. Presence on shelf slope based on NEFSC deep-water trawl survey data and information in Moore et al. (2003)

Adults: depth, temperature, and salinity ranges for continental shelf derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data.

Note: Information on off-shelf depth distribution in Moore et al. (2003) is not specific to juveniles or adults, nor is substrate information in the EFH Source Document.

Table B-20. Summary of EFH Information for Thorny Skate

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Benthic habitats associated primarily with mud, also mud and sand, sand, and mud and sand mixed with *gravel* Found on wide variety of bottom types from sand, gravel, broken shell, pebbles, to soft mud	Present 11.5-84 inshore, common 36-75 (MA) Present 11-500 and >500 on and off shelf, common 71-400 Also see adults	Present 2.5-13.4 inshore, common 2.5-10.5 (MA) Present 0.5-25.5 on shelf, common 0.5-8.5	Present 31.7-34 inshore (ME) Present 30.5-36.5, common 32.5-34.5
Adults	Benthic habitats associated primarily with mud, also mud and sand Also see juveniles	Present 31-500 on shelf, common 121-300 Found 18-183 on shelf, as deep as 786-896 off NY, to 699 off SNE, 300-1200 off VA	Present 1.5-14.5 on shelf, common 2.5-7.5	Present 31.5-35.5 on shelf, common 32.5-34.5

* *Depth to bottom*

** *Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on ME and MA trawl survey data from areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA trawl survey data in EFH Source Document. Continental shelf and slope: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data plus information in EFH Source Document.

Adults: Depth, temperature, and salinity ranges for continental shelf and slope derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data plus information in EFH Source Document; other information also from EFH Source Doc.

Note: Information on maximum depths and substrates in EFH Source Document is not specific to life stage. Adults of this species are not caught in inshore trawl surveys.

Table B-21. Summary of Habitat Information for White Hake

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	No information	No information	No information
Larvae	Pelagic, in water column	No information	No information	No information
Juveniles	Pelagic habitats during settlement Benthic habitats with substrates composed of mud and/or eel grass Prefer fine grained, muddy substrates	Present 5-99 inshore, common 21-80 (MA) Present 1-500 on and off shelf, common 61-300 YOY utilize estuarine nursery areas (1-10 coastal ME)	Present 1.3-20.7 inshore, common 2.5-12.5 (MA) Present 0.5-18.5 on shelf, common 3.5-15.5	Present 13.4-34 inshore Present 29.5-35.5 on shelf, common 32.5-34.5
Adults	Benthic habitats with substrates composed of mud and sand-mud Prefer fine grained, muddy substrates	Present 25-84 inshore (36-84 in ME) Present 11- >500 on and off shelf, common 101-400 On slope to 2250 Spawn primarily on slope	Present 1.9-13.1 inshore (3.5-16.5 ME) Present 1.5-21.5 on shelf, common 4.5-10.5 on shelf	Present 32-34 inshore Present 28.5-36.5 on shelf, common 33.5-35.5

* Depth to bottom

** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages

Note: White hake eggs and larvae were not differentiated from eggs and larvae of red, spotted, and longfin hake in the MARMAP survey

Sources of information:

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data from areas mapped as EFH; depth and temperature ranges ("common") derived from MA trawl survey data in EFH Source Document Update Memo. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and information in EFH Source Document. Additional information provided by M. Lazzari (Maine DMR, pers. comm.).

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data from areas mapped as EFH; depth and temperature ranges ("common") derived from ME trawl survey data. Continental shelf and slope: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and information in EFH Source Document; off-shelf depth data from Haedrich and Merrett (1988).

Table B-22. Summary of Habitat Information for Windowpane

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Present 1-200 on shelf, common 1-80	Present 2.5-24.5 on shelf, common 4.5-20.5	Found 18.2-30
Larvae	Pelagic, in water column	Present 1-200 on shelf, common 1-80	Present -0.5 to 25.5 on shelf, common 8.5-19.5	No information
Juveniles	Sandy benthic habitats Also mud (LIS, GOM) Lab study: prefer sand over mud	Present 3-82 inshore, common 8-24 (RBay), 6-18 (CBay), and 16-55 (MA) Present 1-300 on shelf, common 1-60	Present 0.1-30 inshore, common 13.5-23.5 (RB), 14-26 (CBay), and 7-19 (MA) Present 0.5-28.5 on shelf, common 2.5-18.5	Present 1-36 inshore, common 14.5-24.5 (RB), 24-32 (CBay) Present 26.5-35.5 on shelf, common 30.5-33.5

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Adults	Sandy benthic habitats Also mud (LIS,GOM)	Present 4-82 inshore, common 10-24 (RBay), 10-26 (CBay) and 6-35 (MA) Present 1-400 on shelf, common 1-70	Present 0.1-25, common 6.5-20.5 (RB), 4-18 (CBay), 3-15 (DBay), and 9-18 (MA) Present 0.5-25.5 on shelf, common 2.5-18.5 Tolerate 0-27 Spawn 6-21, mostly 8.5-13.5	Present 1-36 inshore, common 26.5-31.5 (RB), 22-32 (CBay), and 23-30 (DBay) Present 23.5-35.5 on shelf, common 30.5-33.5

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document; salinity data from Klein-MacPhee (2002).

Larvae: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document.

Juveniles: <u>Inshore</u>: depth, salinity, and temperature ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth, temperature, and salinity ranges ("common") derived from Raritan Bay and MA trawl survey data in EFH Source Doc, and Chesapeake Bay trawl survey data in Geer (2002). <u>Continental shelf</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and information in EFH Source Doc and Gottschall et al. (2002). Additional information obtained from EFH Source Document.

Adults: <u>Inshore:</u> depth, salinity, and temperature ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth, temperature, and salinity ranges ("common") derived from Raritan Bay and MA trawl survey data in EFH Source Doc and Chesapeake Bay trawl survey data in Geer (2002). <u>Continental shelf:</u> depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data and on information in EFH Source Document and Gottschall et al. (2002). Additional information obtained from EFH Source Document.

Table B-23. Summary of Habitat Information for Winter Flounder

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Benthic habitats, attached to mud, sand, muddy sand, gravel, and submerged aquatic vegetation	Collected 0.3-8 inshore Spawn as deep as 72 (GB)	Collected 1-10 inshore Maximum survival at hatching 0-10	Found 10-32
Larvae	Pelagic, in water column	Present 1-180 on shelf, common 1-80	Most abundant 2-15 inshore, found 1-19.5 (NJ) Present 2.5-12.5 on shelf, common 2.5-12.5	Found 4-30 inshore, higher on GB (assume max is 33)
Juveniles	Pelagic habitats during settlement YOY found inshore on a variety of muddy and sandy substrates, with and without eelgrass and macroalgae (*Ulva* sp.), and in marsh creeks (NJ) Prefer muddy sediments with debris (shell, wood, leaves) to sandy sediments (CT) More abundant on mud and mud-sand than sand (LIS) Older juveniles in sandy benthic habitats on continental shelf	Present 0-86 inshore, common 7-24(RB), 16-50 (MA), and at min 7 (DBay) Present 1-300 on shelf, common 11-50 YOY collected 0.5-12 inshore, age 1+ to 27	Present 0-32 inshore, common 7.5-24.5 (RB) and 3.5-15.5 (MA), 1-14 (DB) Present 0.5-22.5 on shelf, common 1.5-16.5 Lab study: age 1+ prefer 18.5 (select 8-27) Maximum growth in field 16-18	Present 3-40 inshore, common 23.5-33.5 (RB) and min 9 (DB) Present 28.5-34.5 on shelf, common 31.5-33.5 Collected 19-21 (YOY 23-33) Optimum growth for YOY <24 (NJ) Lab study: avoid salinities <10 (YOY <5)
Adults	Sandy benthic habitats on continental shelf More abundant on mud and mud-sand than sand (LIS) Spawn on sandy bottom	Present 2-86 inshore, common 7-24 (RB), 16-60 (MA), and at min 8 (DBay) Present 1- >500	Present 0-24 inshore, common 5.5-12.5 (RB), 1-13 (DB), 5.5-15.5 (MA) Present 0.5-23.5 on shelf, common 1.5-12.5	Present 8-36 inshore, common 23.5-33.5 (RB), and min 9 (DB) Found 15-34.5, common

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	Also see eggs	on and off shelf, common 11-60 Spawn as deep as 72 on GB and as shallow as 2-6 inshore Also see eggs	Prefer 13.5 (lab), 12-15 (field) Major egg production <3.3 in New England	31.5-33.5 on shelf

*   *Depth to bottom*
** *Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs: All information from EFH Source Doc and Update Memo.

Larvae: Temperature and depth ranges for continental shelf derived from MARMAP survey data in EFH Source Doc; other information from EFH Source Document.

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA and Raritan Bay trawl survey data in EFH Source Document and Update Memo and Delaware Bay trawl survey data in Morse (2000). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data. Other information obtained from EFH Source Doc, Update Memo, Gottschall et al. (2002), and Manderson et al. (2002).

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA and Raritan Bay trawl survey data in EFH Source Document and Update Memo and Delaware Bay trawl survey data in Morse (2000). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data. Other information obtained from EFH Source Doc, Update Memo, and Gottschall et al. (2002).

Table B-24. Summary of Habitat Information for Winter Skate

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Benthic habitats with sand and *gravel* substrates Also see adults	Present 4-81 inshore, common 6-25 (MA) Present 1-400 on shelf, common 11-80 Also see adults	Present 0.1-21.8 inshore, common 8.5-16.5 (MA) and 3.5-13.5 (RB) Present 0.5-21.5 on shelf, common 1.5-17.5 Also see adults	Present 15-36 inshore, common at min 15.5 (RB) Present 28.5-35.5 on shelf, common 31.5-33.5
Adults	Benthic habitats with sand and *gravel* substrates Sandy and gravelly bottoms, also on mud in Penobscot Bay (GOM) Most abundant on sand (j/a LIS)	Present 5-65 inshore, common 6-45 (MA), 7-19 (j/a DB) Present 1-400 on shelf, common 31-60 Most abundant 46-64 (GOM), found 15-46 (SNE) and 33-113 (MAB), rare <2-7	Present 2.4-19.4 inshore, common 7.5-15.5 (MA), min 4.5 max 17.5 (j/a DB) Present 0.5-20.5 on shelf, common 1.5-16.5 Found 2-15 (southern NS to Cape Hatteras), 20 in summer to 1-2 in winter (coastal MA), 10-12 (MAB in winter)	Present 27.2-36 inshore, common 20.5-34.5 (j/a DB) Present 29.5-36.5 on shelf, common 31.5-33.5

* Depth to bottom
** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages

Note: As used in the analysis of sediment associations, the term "*gravel*" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data for areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay and MA trawl survey data in EFH Source Document. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; information on substrates derived from GIS overlap analysis of NEFSC survey and USGS USSeabed sediment data.

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data for areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay, Delaware Bay, and MA trawl survey data in EFH Source Document. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in EFH Source Document; information on substrates from analysis of NEFSC survey and USGS USSeabed sediment data and from information in EFH Source Doc. All other information from EFH Source Document.

Note: Delaware Bay data were applied to juveniles and adults – winter skates caught during survey were not distinguished by life stage.

Table B-25. Summary of Habitat Information for Witch Flounder

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water column	Present 1-1500 on and off shelf, common 1-160	Present 3.5-17.5 on and off shelf, common 4.5-12.5	No information
Larvae	Pelagic, in water column	Present 1-1500 on and off shelf, common 41-100	Present 3.5-20.5 on shelf, common 5.5-13.5 Maximum survival 15	No information
Juveniles	Benthic habitats with substrates composed of mud and mud mixed with sand	Present 5-99 inshore, common 51-85 (MA) Present 21-1500 on and off shelf, common 81-400	Present 1.5-12.6 inshore, common 3.5-10.5 (MA) Present 0.5-19.5 on shelf, common 3.5-13.5	Present 31.2-34 inshore Present 30.5-36.5 on shelf, common 32.5-34.5
Adults	Benthic habitats with substrates composed of mud and mud mixed with sand Mud, clay, silt, muddy sand substrates, rarely on	Present 6-99 inshore, common 36-85 (MA) Present 21-1500 on and off shelf, common 121-	Present 0.2-16.3 inshore, common 3.5-10.5 (MA) Present 0.5-21.5 on shelf, common 2.5-8.5	Present 32.1-34 inshore Present 30.5-36.5 on shelf, common 32.5-35.5

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	other bottom types (also juveniles)	400 Found 20-1569, most 90-330 in U.S. waters (also juveniles)	Found 0-15, most 2-9 (also juveniles) Spawn 0-10	Found 31-36 (also juveniles)

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document

Larvae: Shelf depth and temperature ranges derived from MARMAP data in EFH Source Document; additional information also from EFH Source Document.

Juveniles: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges ("common") from MA inshore trawl survey data in EFH Source Doc Update Memo. <u>Continental shelf and slope</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; additional depth information for slope from Moore et al. (2003); sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data.

Adults: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges ("common") from MA inshore trawl survey data in EFH Source Doc Update Memo. <u>Continental shelf and slope</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; additional depth information for slope from EFH Source Document and Update Memo and from Moore et al. (2003); sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data, and information in EFH Source Doc and Update Memo.

Table B-26. Summary of Habitat Information for Yellowtail Flounder

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
Eggs	Pelagic, in water	Present 1-400	Present 1.5-15.5 on	No information

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
	column	on shelf, common 21-100 Present 500-1000 off-shelf	shelf, common 3.5-10.5	
Larvae	Pelagic, in water column	Present 1-260 on shelf, common 21-120 Present 1000-1500 off-shelf	Present 4.5-17.5 on shelf, common 6.5-12.5 on shelf	No information
Juveniles	Sandy benthic habitats	Present 4-85, common 21-50 (MA) Present 1-400 on shelf, common 31-70 YOY: prefer 56-87 on shelf	Present 1.3-18, common 2.5-13.5 (MA) Present 0.5-18.5 on shelf, common 1.5-13.5	Present 28-33 inshore Present 30.5-35.5 on shelf, common 32.5-33.5
Adults	Sandy benthic habitats Occur on any sandy bottom or mixture of sand and mud, but avoid rocks, stony ground, and soft mud	Present 4-85, common 26-65 (MA) Present 1-400 on shelf, common 31-80 Common 9-64 off Cape Cod	Present 1.3-17, common 4.5-12.5 (MA) Present 0.5-19.5 on shelf, common 2.5-12.5 Lab study: tolerate -1 to 18, max survival 8-14 Spawn 5-12	Present 28-35 inshore Present 30.5-36.5 on shelf, common 32.5-33.5 Lab study: maximum survival 32-38

**   Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

Eggs and Larvae: Shelf depth and temperature ranges, and off-shelf depths, derived from MARMAP and GLOBEC data in EFH Source Document and Update Memo.

Juveniles: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges ("common") from MA inshore trawl survey data in EFH Source Doc Update Memo. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data; other information from EFH Source Document.

Adults: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges ("common") from MA inshore trawl survey data in EFH Source Doc Update Memo. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types based on GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data, and from EFH Source Document, Update Memo, and Klein-MacPhee (2002). Additional information obtained from EFH Source Document, Update Memo, and Klein-MacPhee (2002).

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ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

PHASE 1

APPENDIX C
"MAJOR PREY SPECIES MAPS FOR SPECIES IN NEFMC FISHERY MANAGEMENT UNITS"

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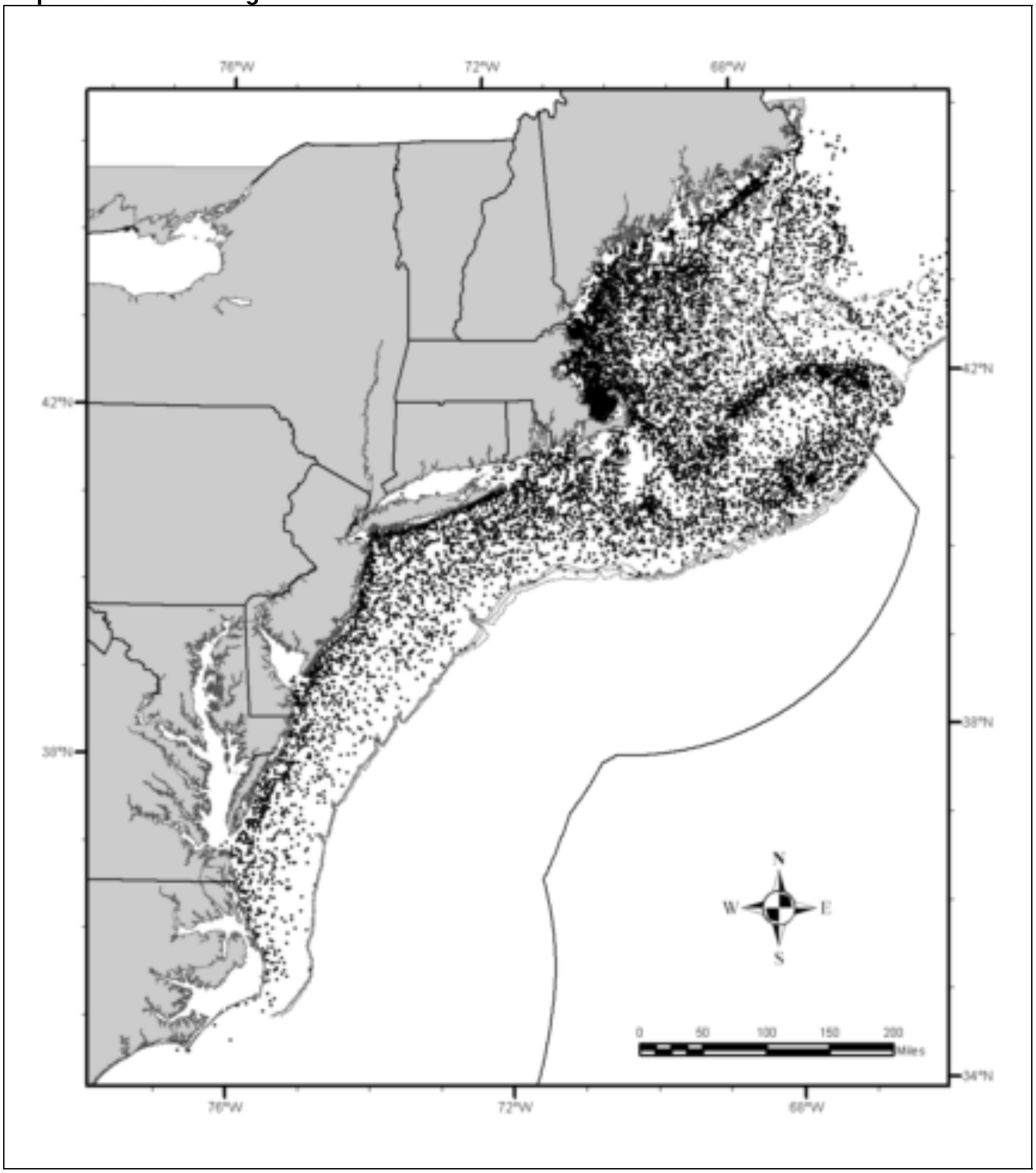
LIST OF MAPS

One of two sources was used to produce the major prey species maps. Only those species which exceeded 5% occurrence in a managed species stomach were mapped. All fish species and squids maps were created using the NMFS Bottom Trawl Survey database for 1963-2205. These points represent catches of the prey species themselves. The data used was geographically limited to north of the border between North Carolina and Georgia and west of the eastern most extent of U.S. waters. This was done to captures the entire designated ranges of all NEFMC managed species without including extraneous data. All other invertebrate prey were mapped from data in the Northeast Fisheries Science Center Bottom Trawl Survey Food Habits Database from 1973-2005. These are not actual catches of the species, but the location of any predator species (not limited to managed species) caught with the prey present in their stomachs.

Map 1. Anchioves

Map 2. Atlantic herring

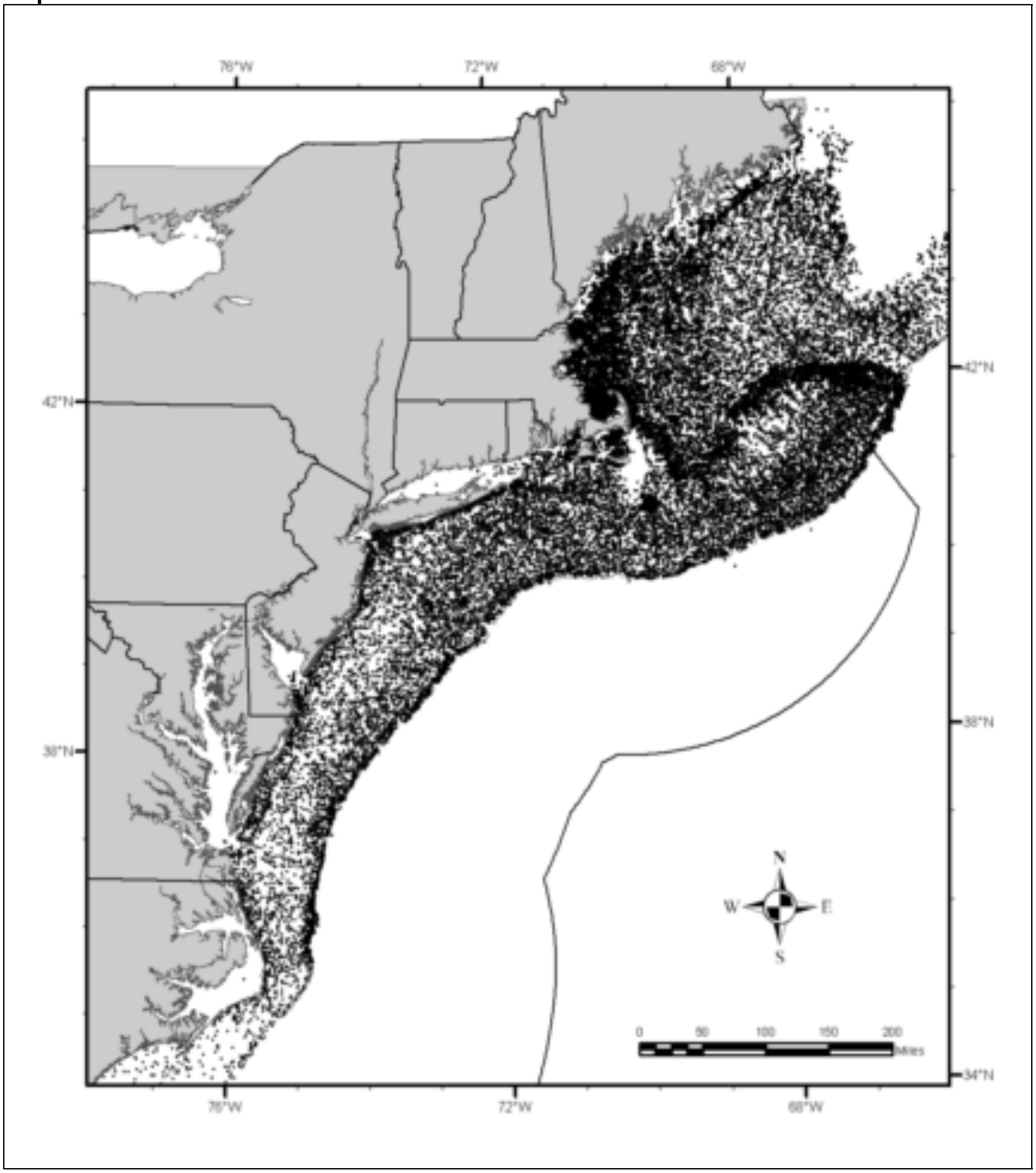


Map 3. Bivalves

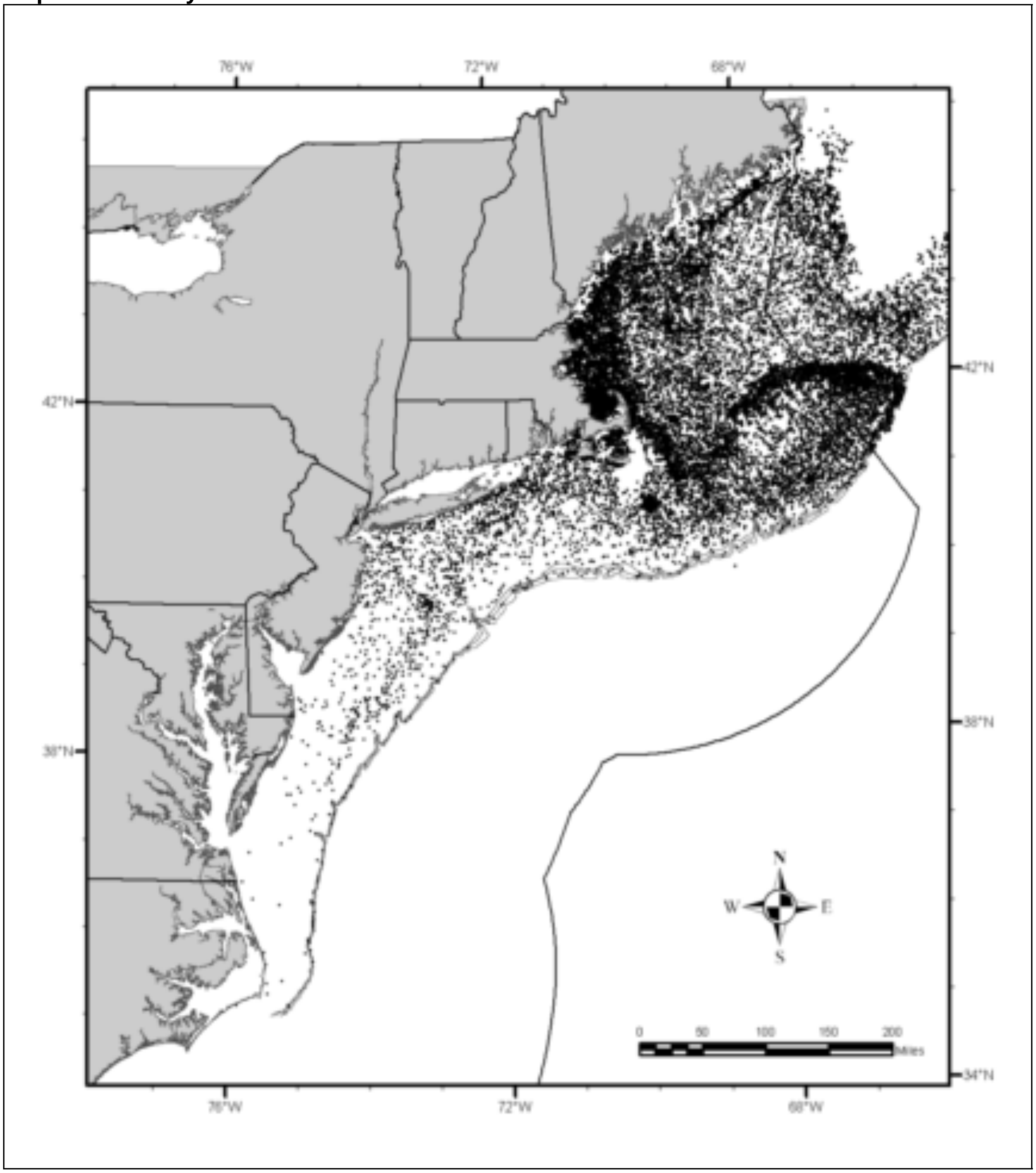
Map 4. Butterfish

Map 5. Cancer crabs

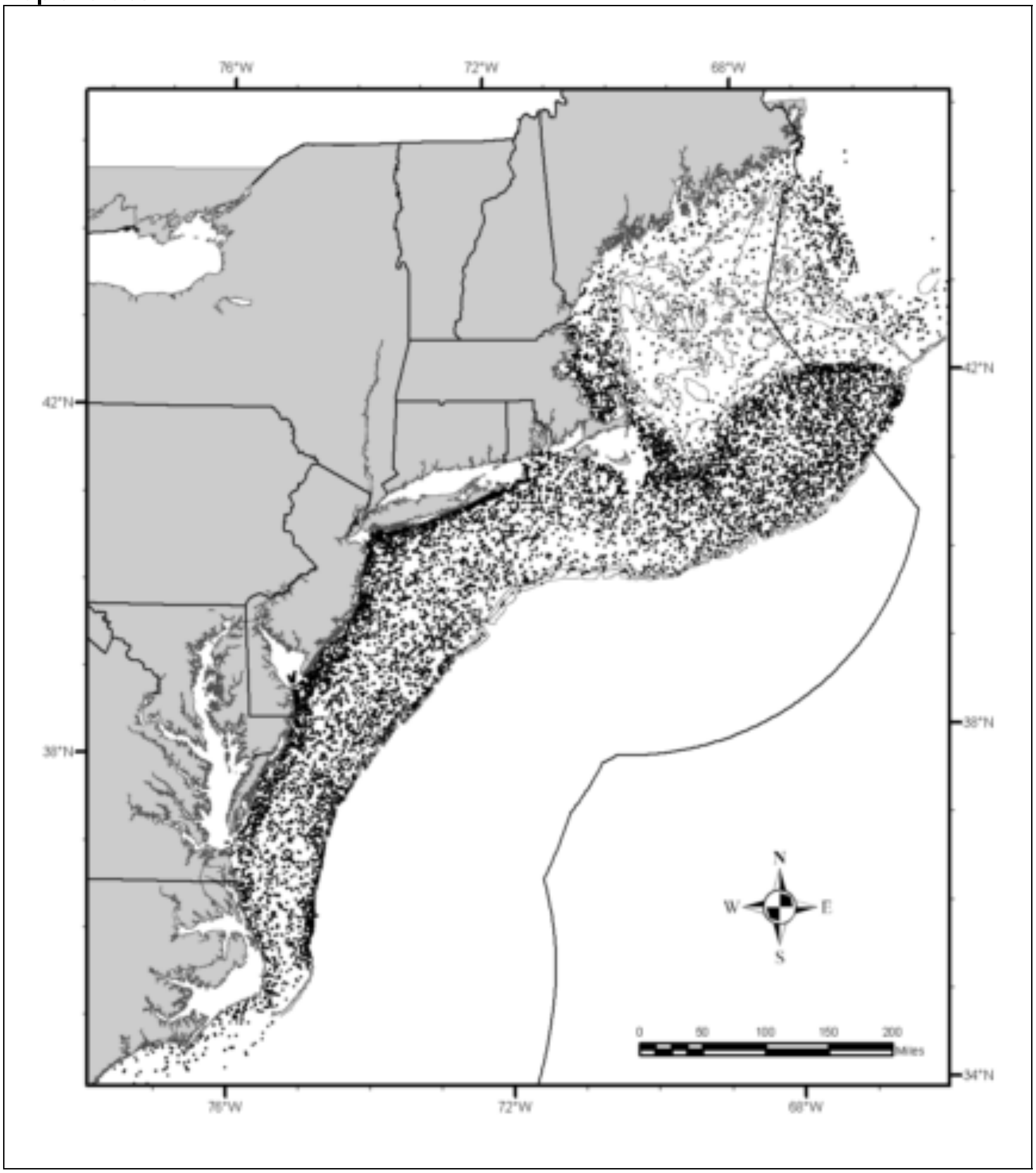
Map 6. Cods



Map 7. Cods only

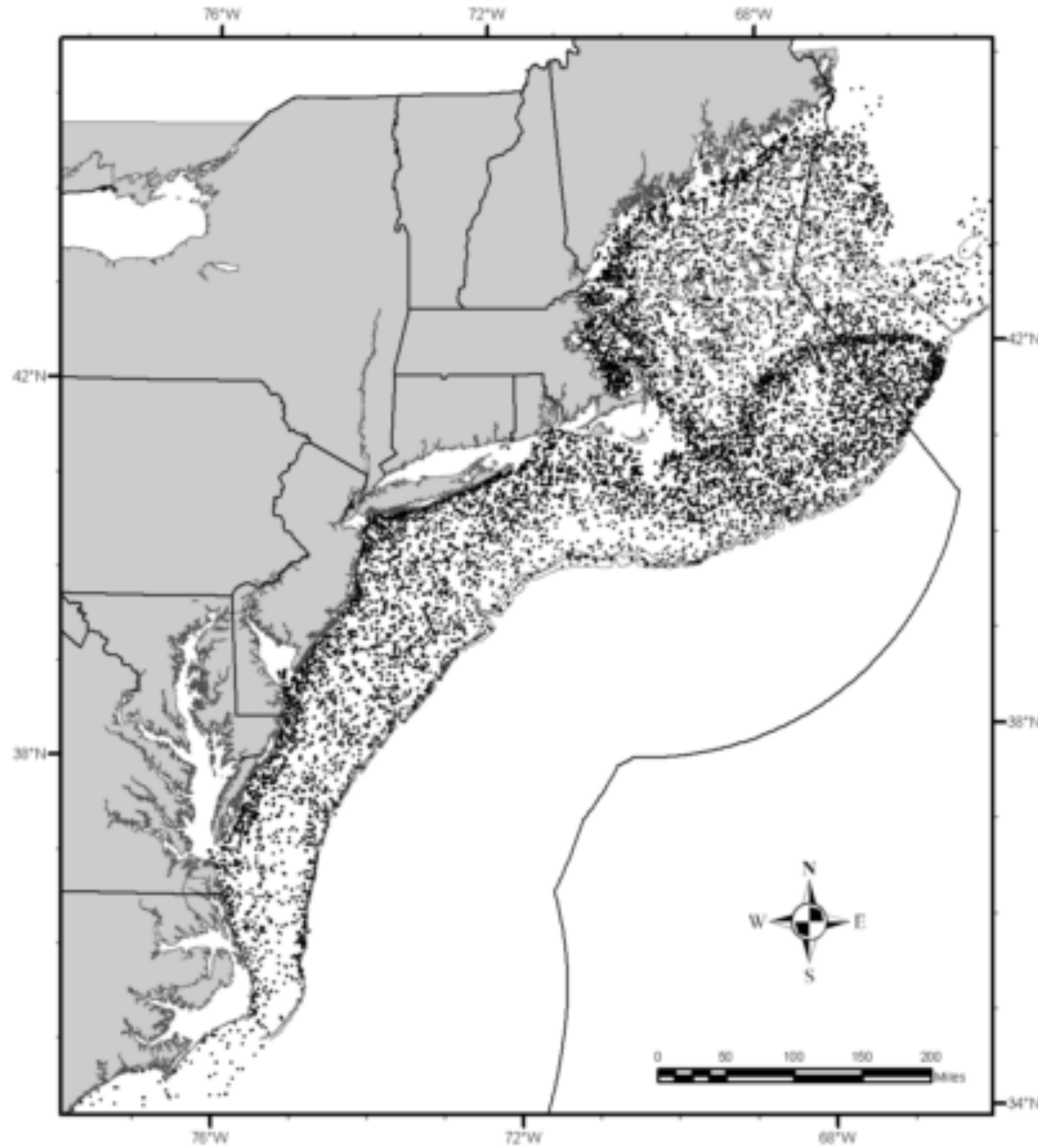


Map 8. Crabs

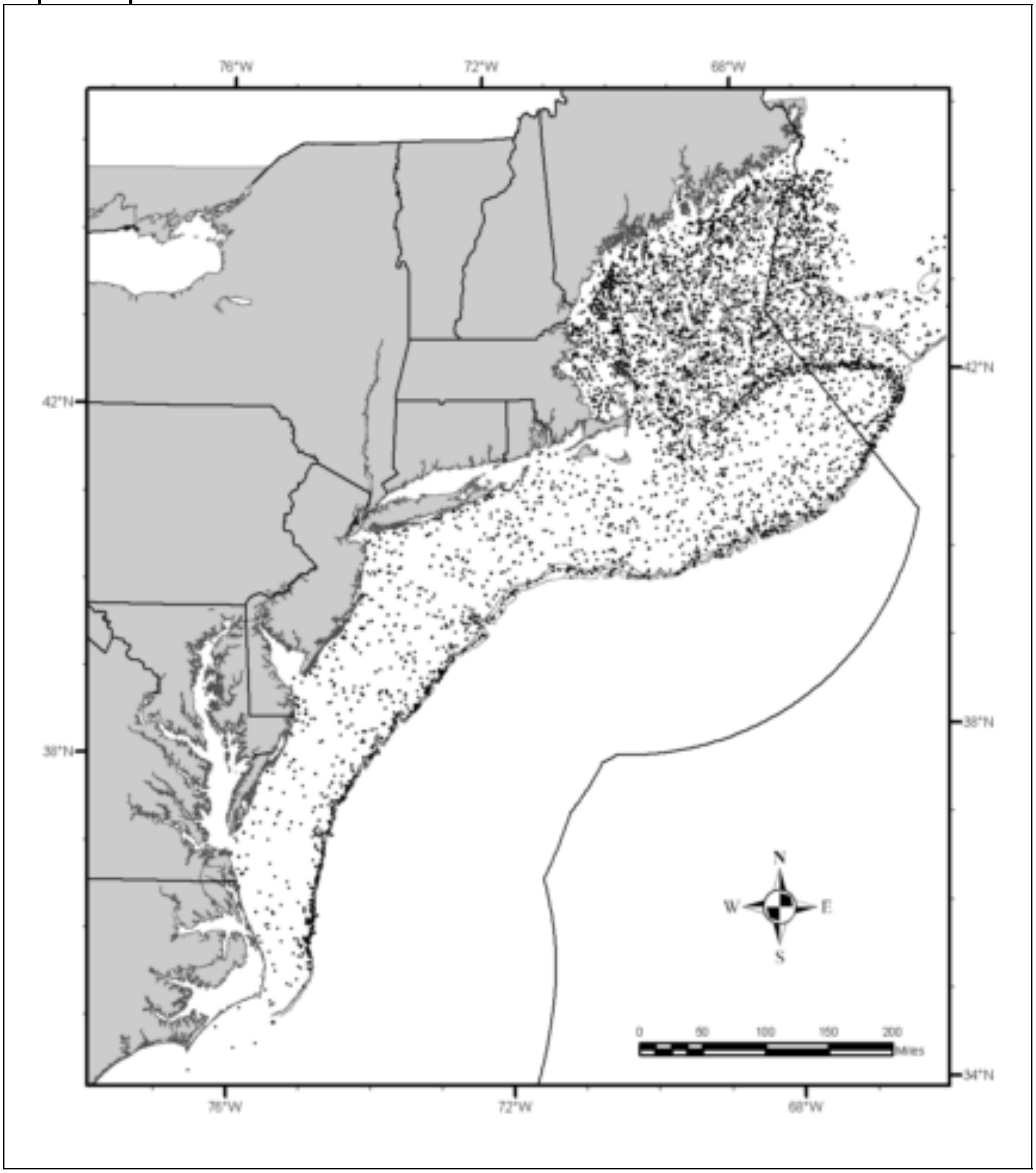


Map 9. Cumaceans

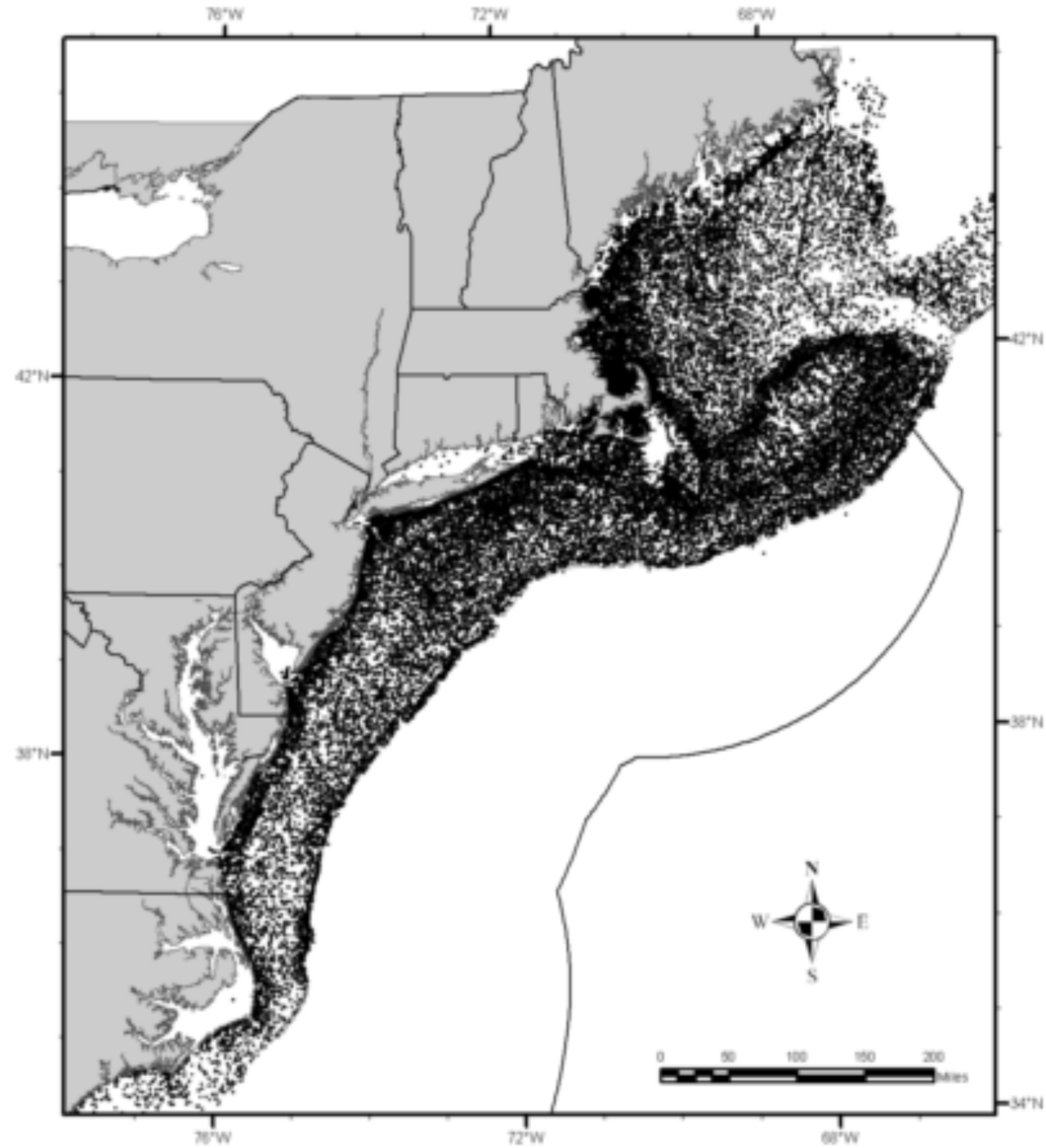
Map 10. Decapod shrimp



Map 11. Euphuasiids



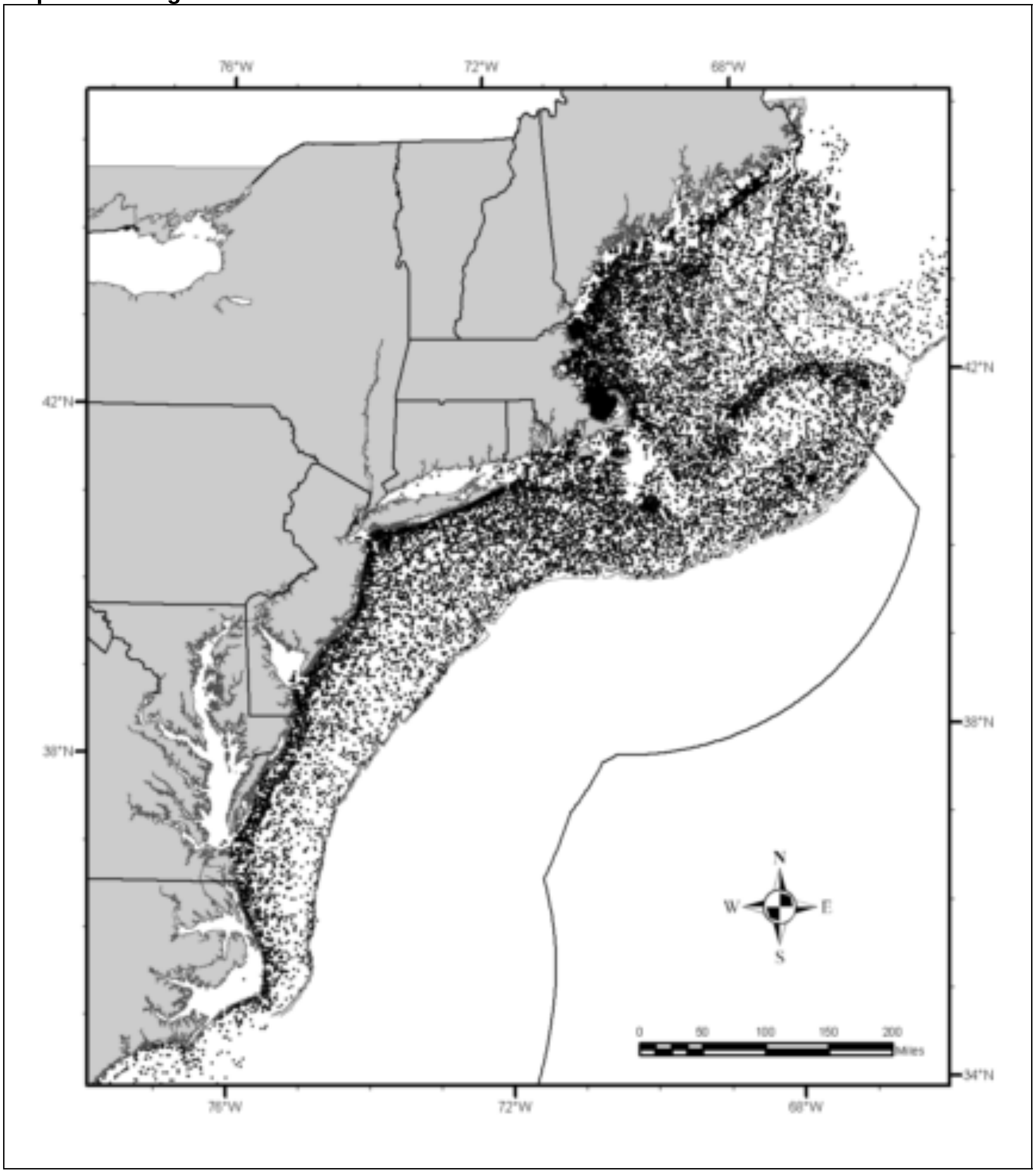
Map 12. Flatfish



Map 13. Gammarids

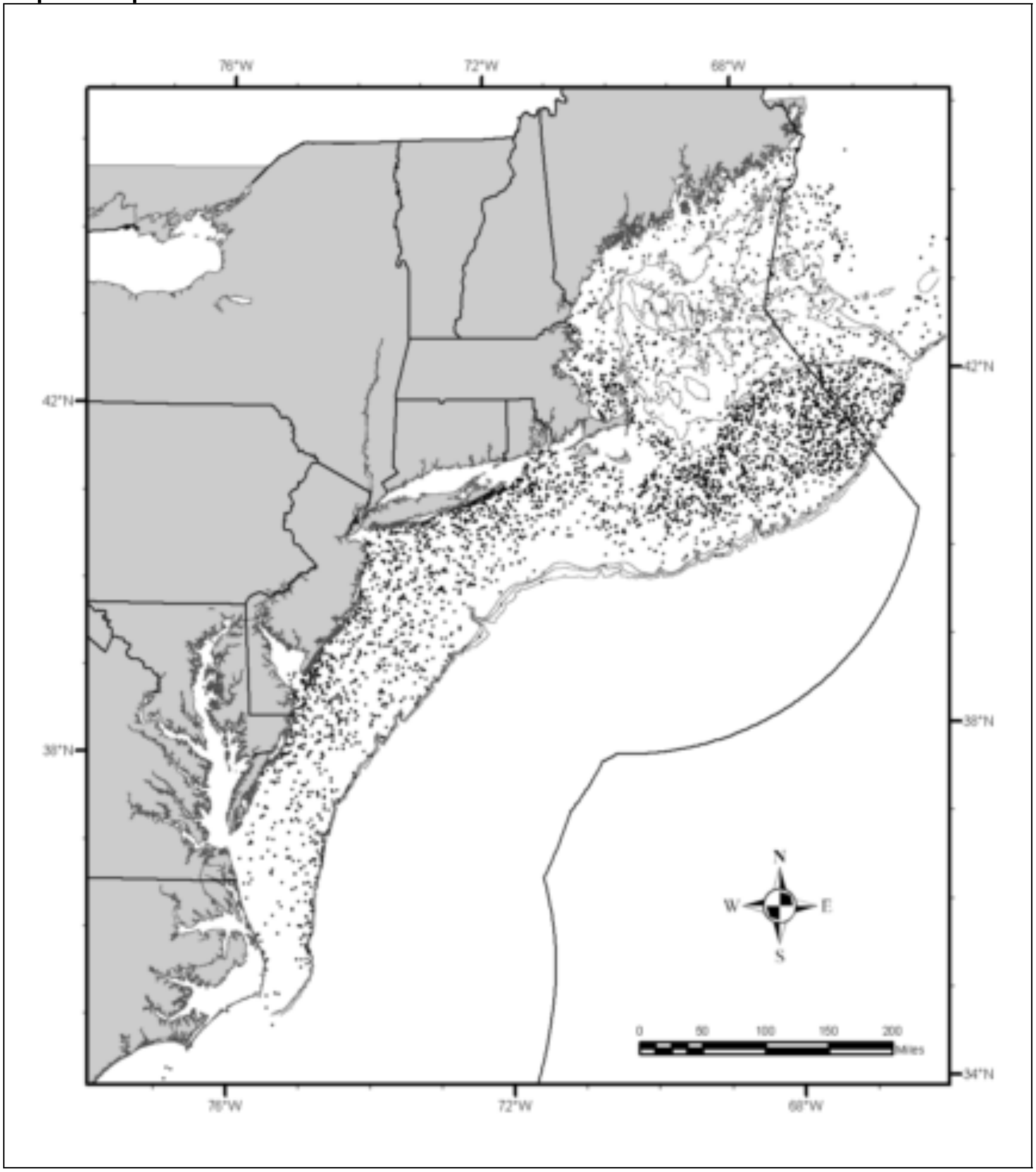
Map 14. Hermit crabs

Map 15. Herrings

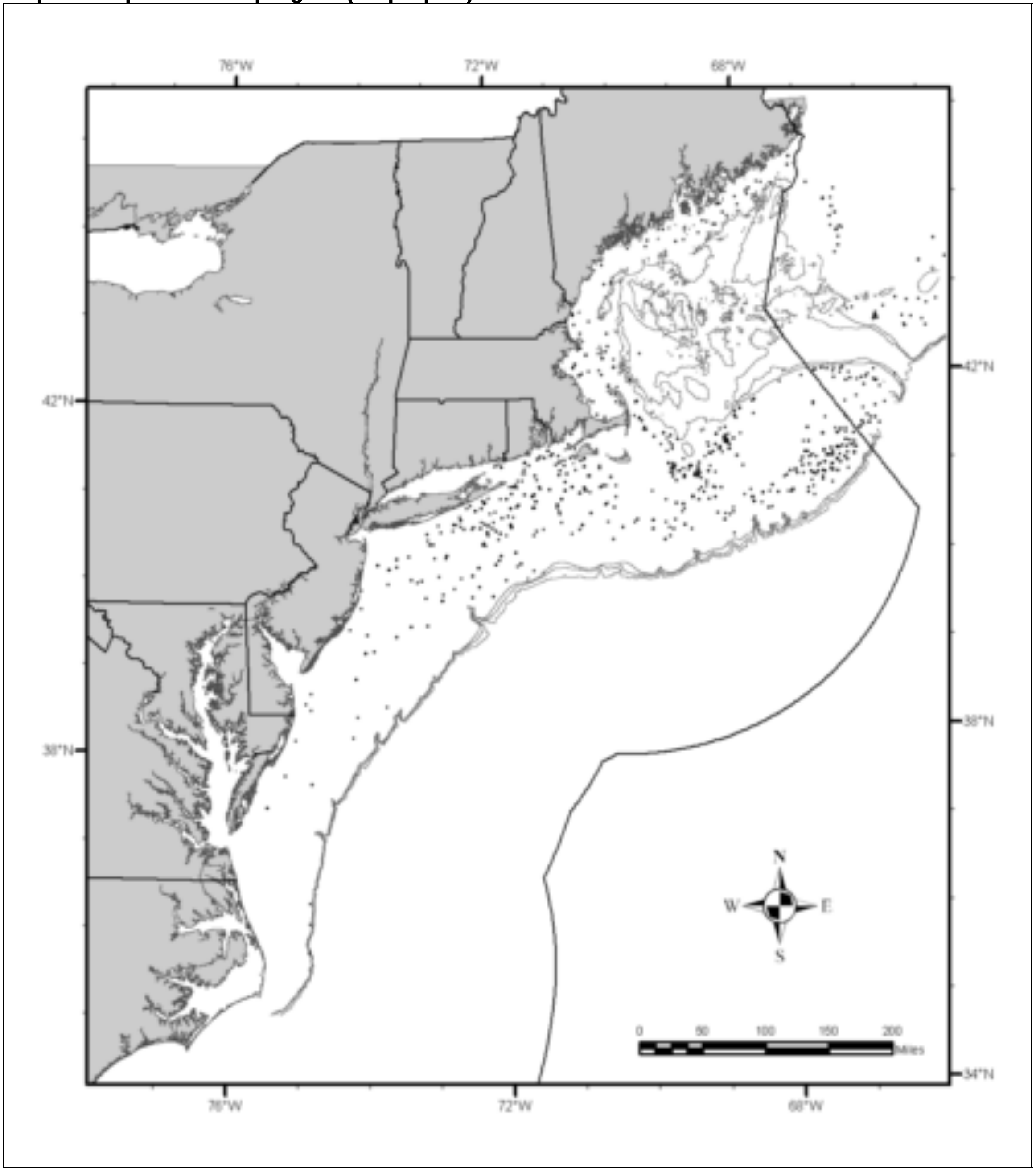


Map 16. Hyperiids

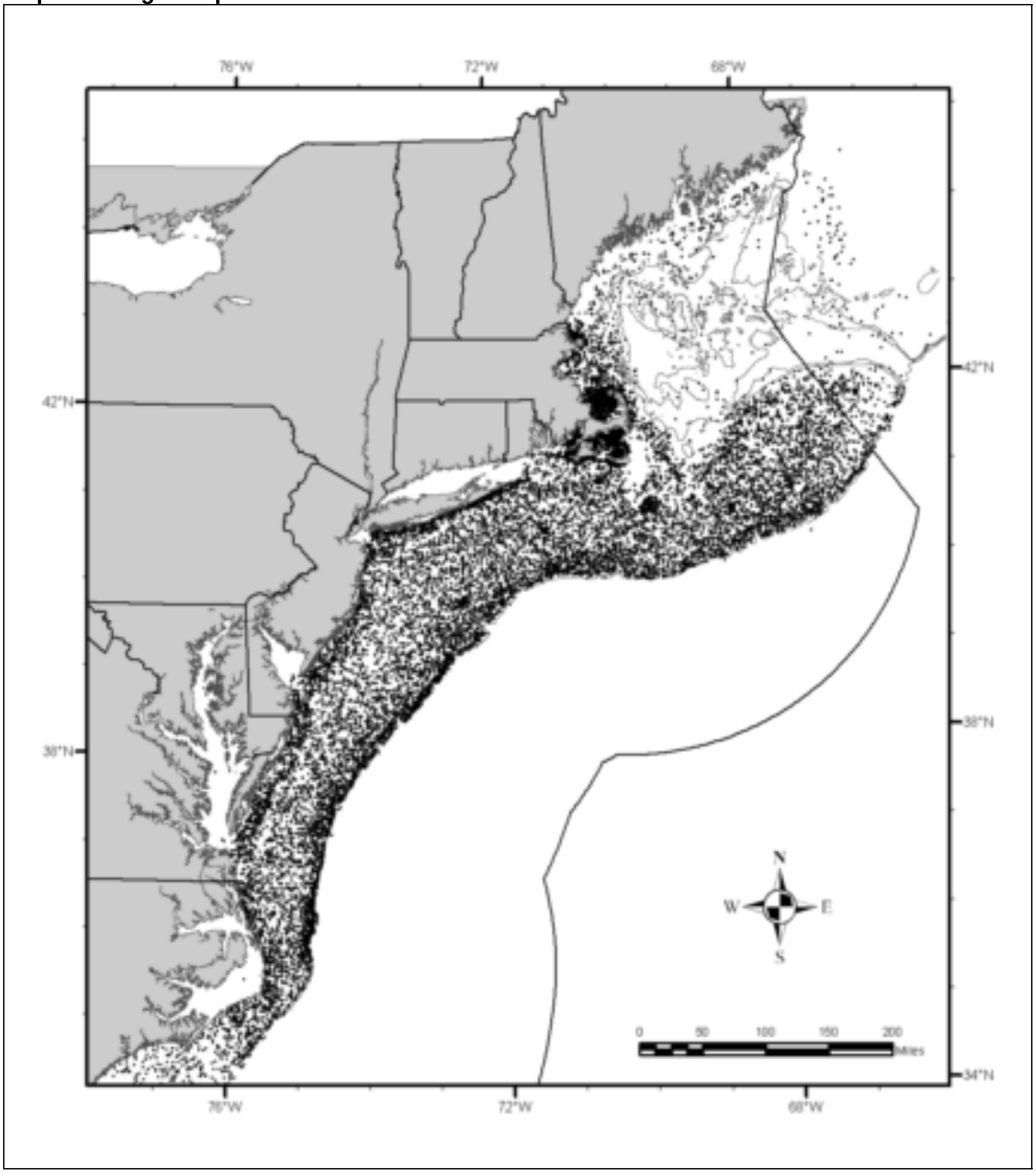
Map 17. Isopods



Map 18. Leptocheirus-pinguis (amphipod)



Map 19. Longfin Squid

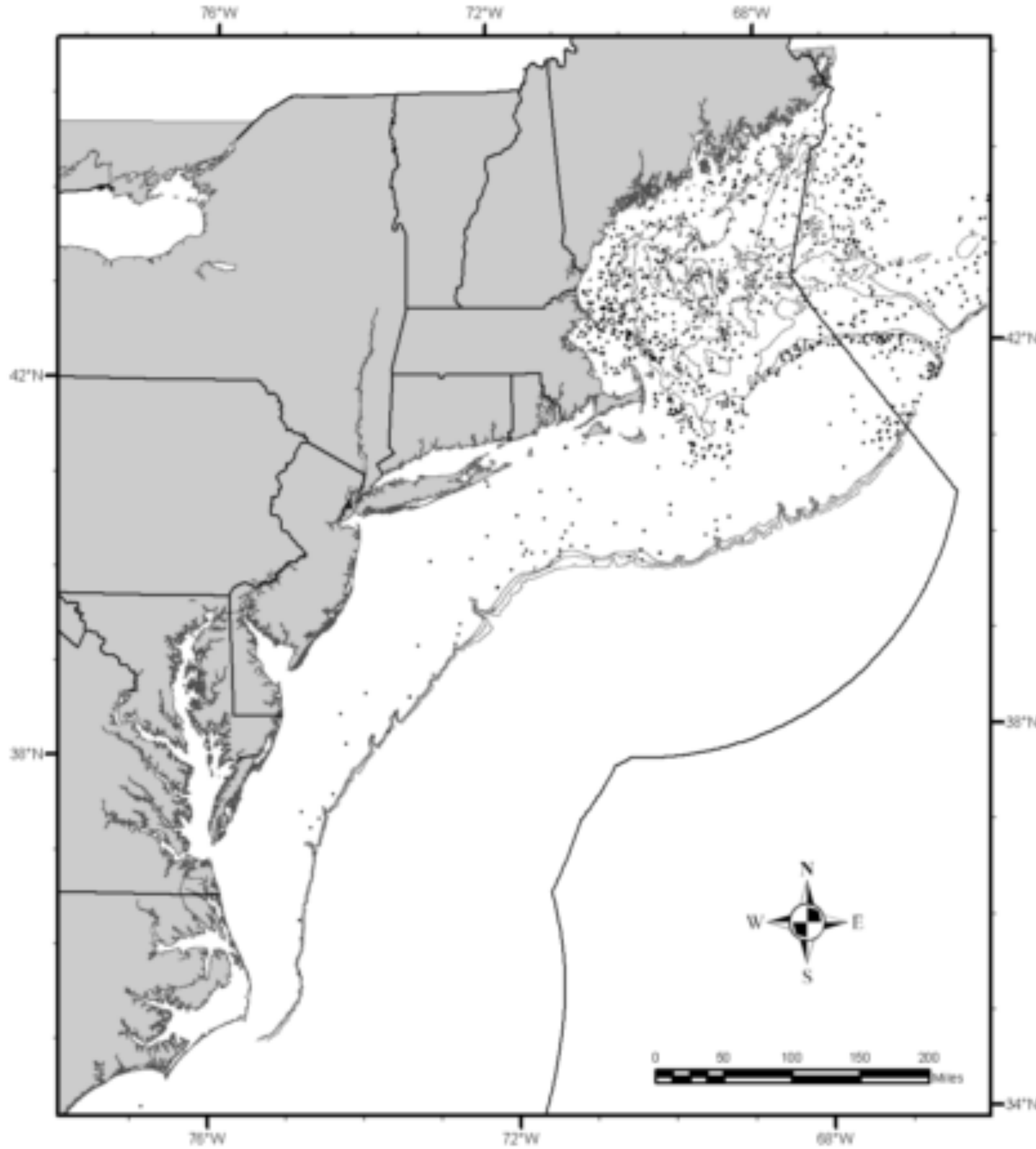


Map 20. Mackerels

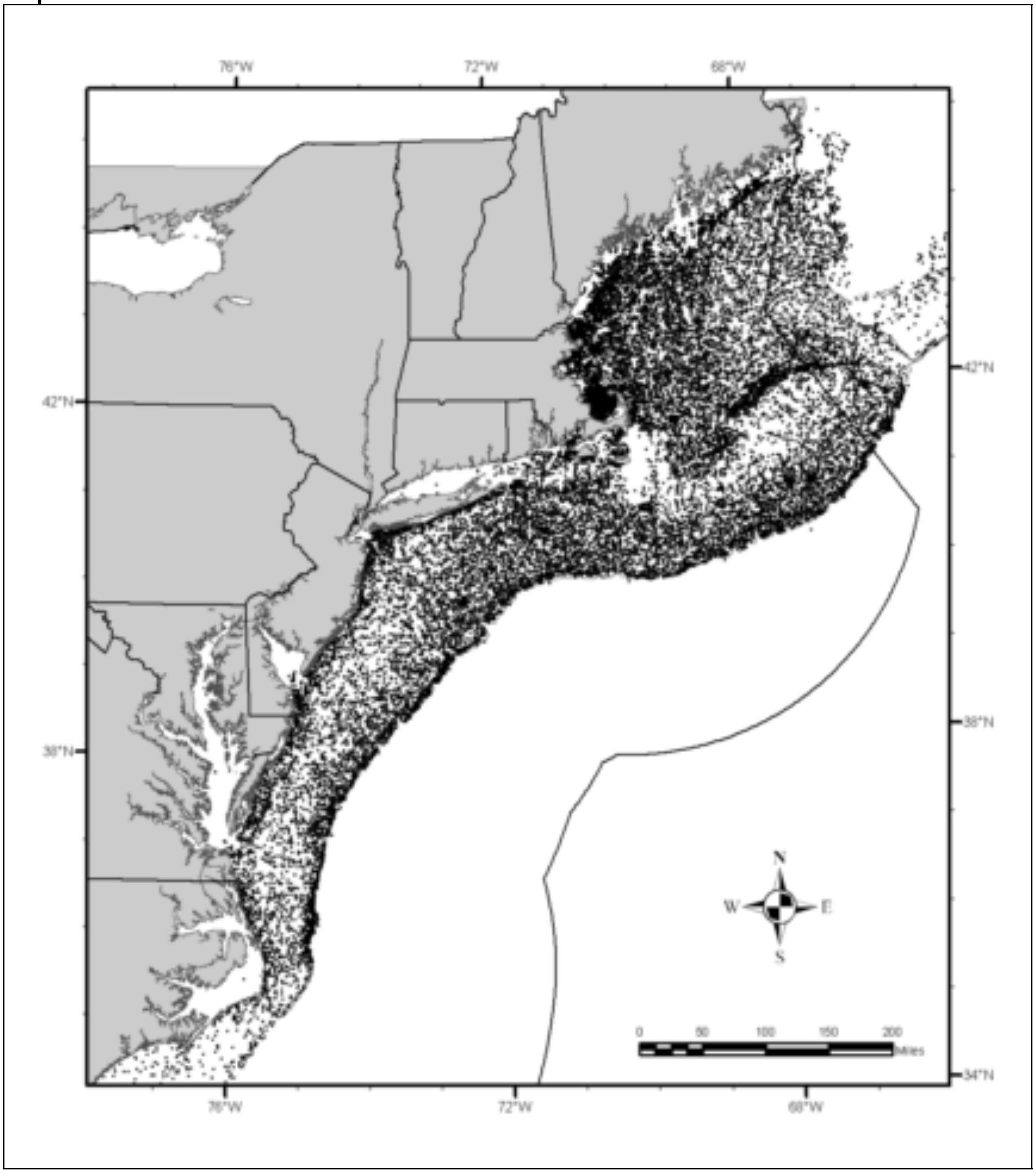
Map 21. Menhaden

Map 22. Mysids Shrimp

Map 23. Ophiuroids



Map 24. Other Hakes



Map 25. Pandalid Shrimp

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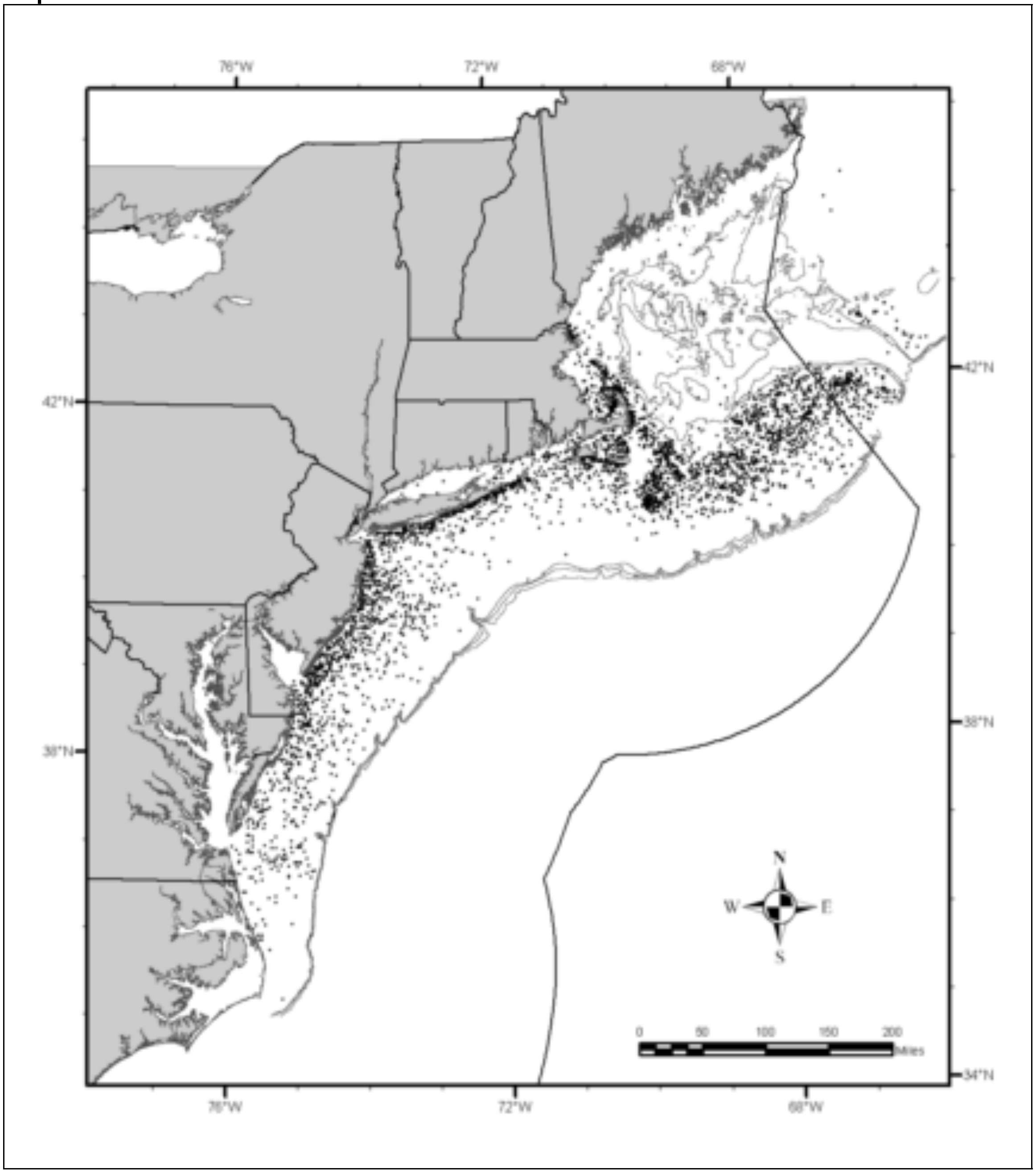
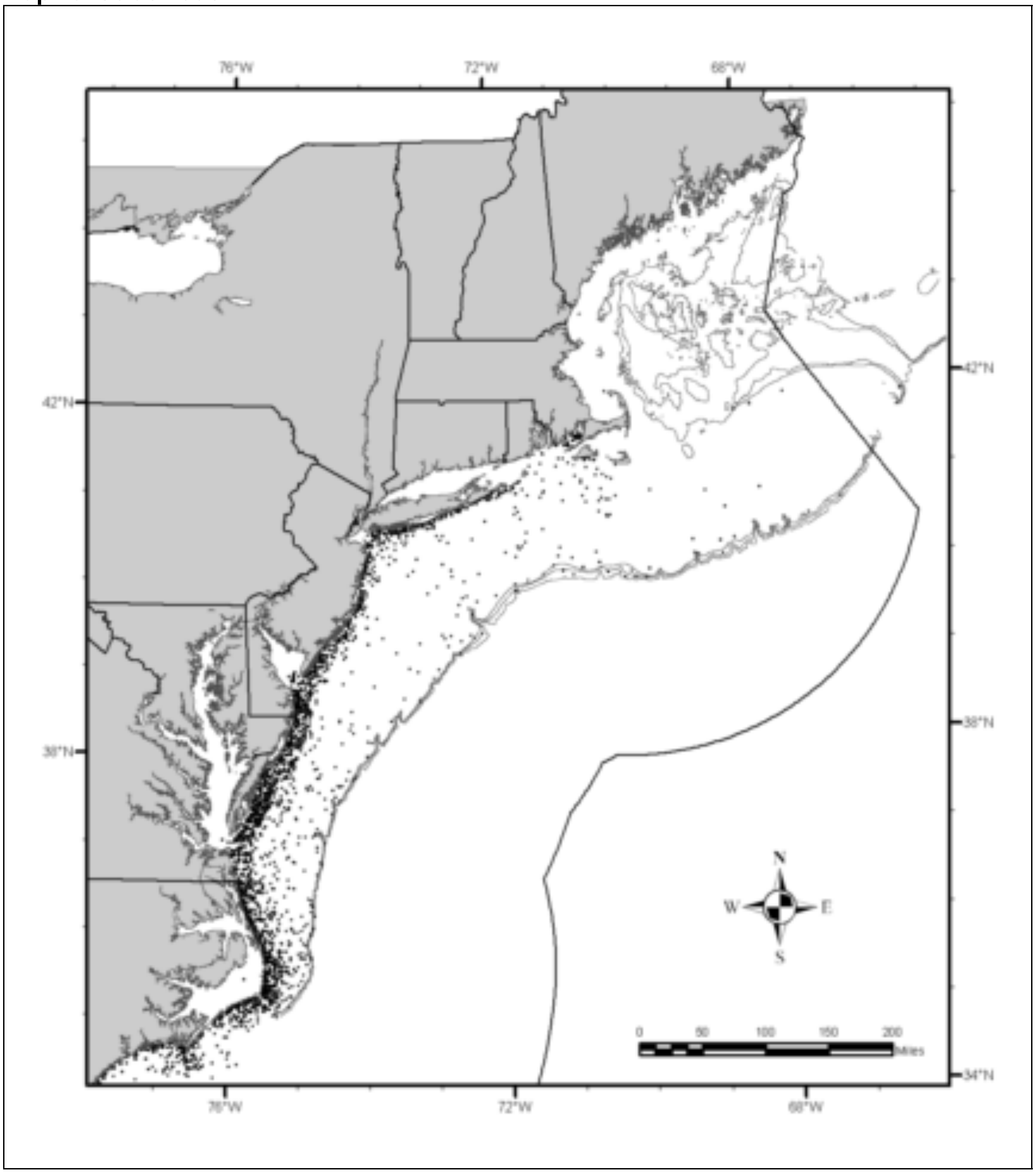
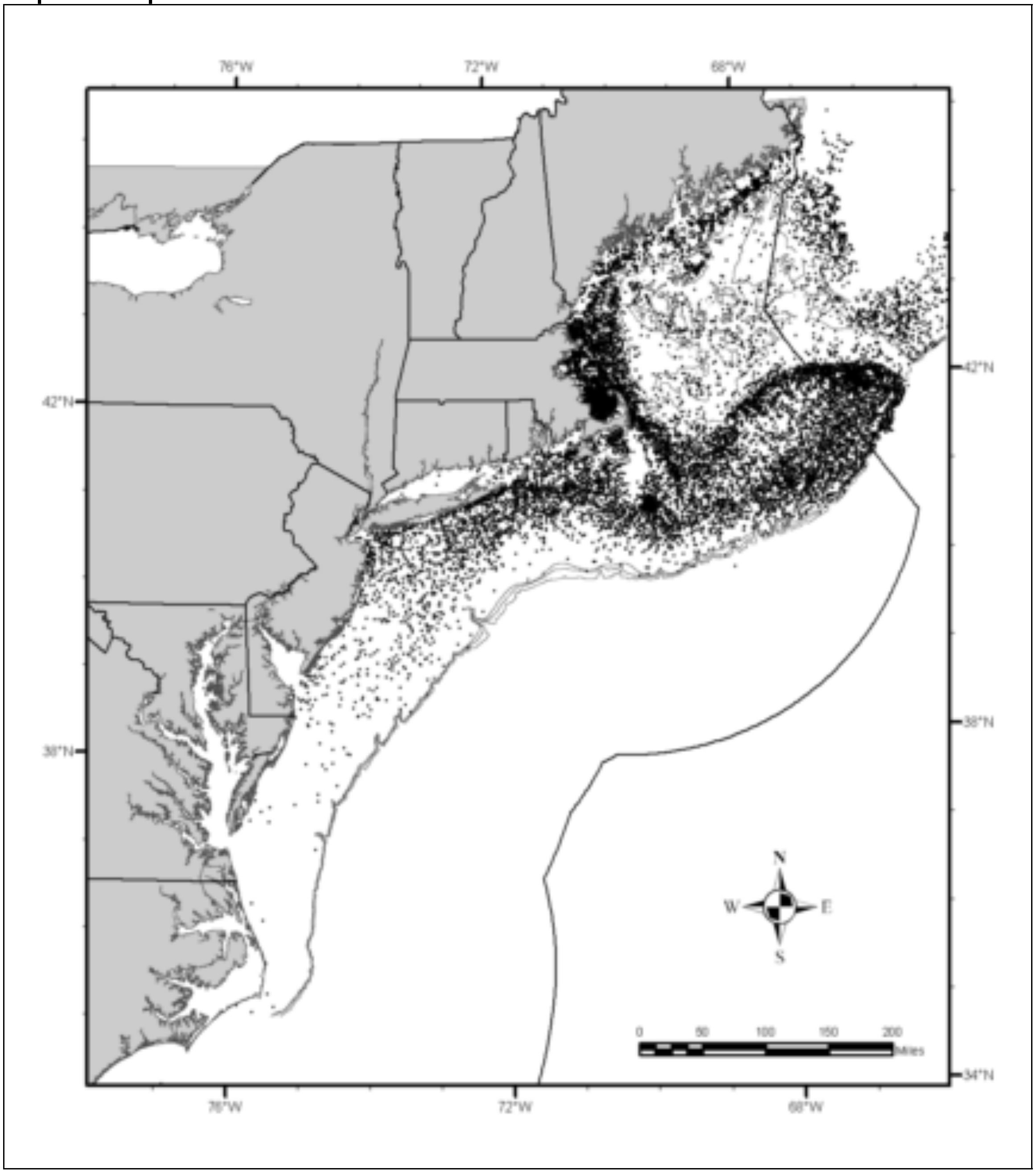


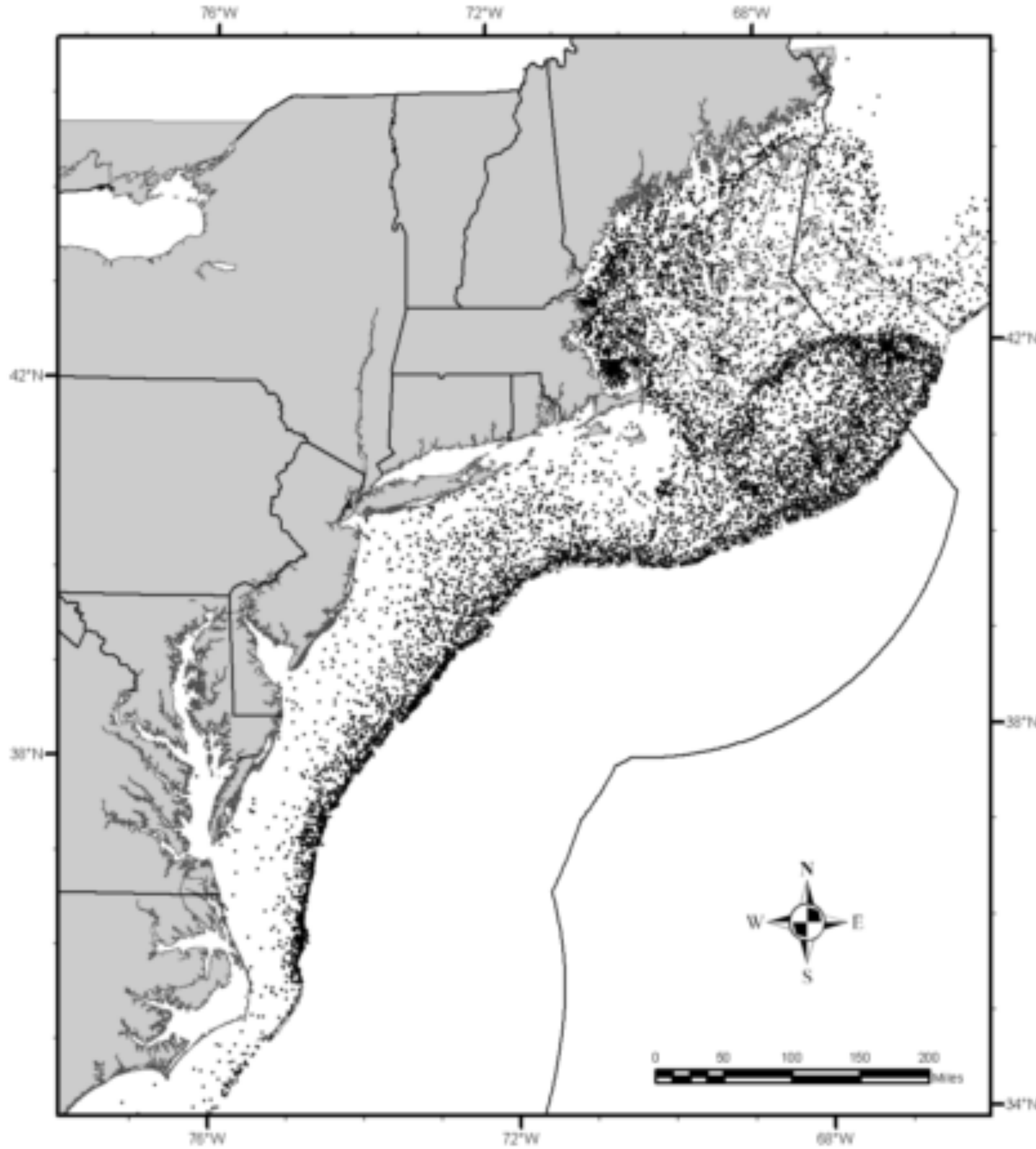
Map 29. Sciaenidae



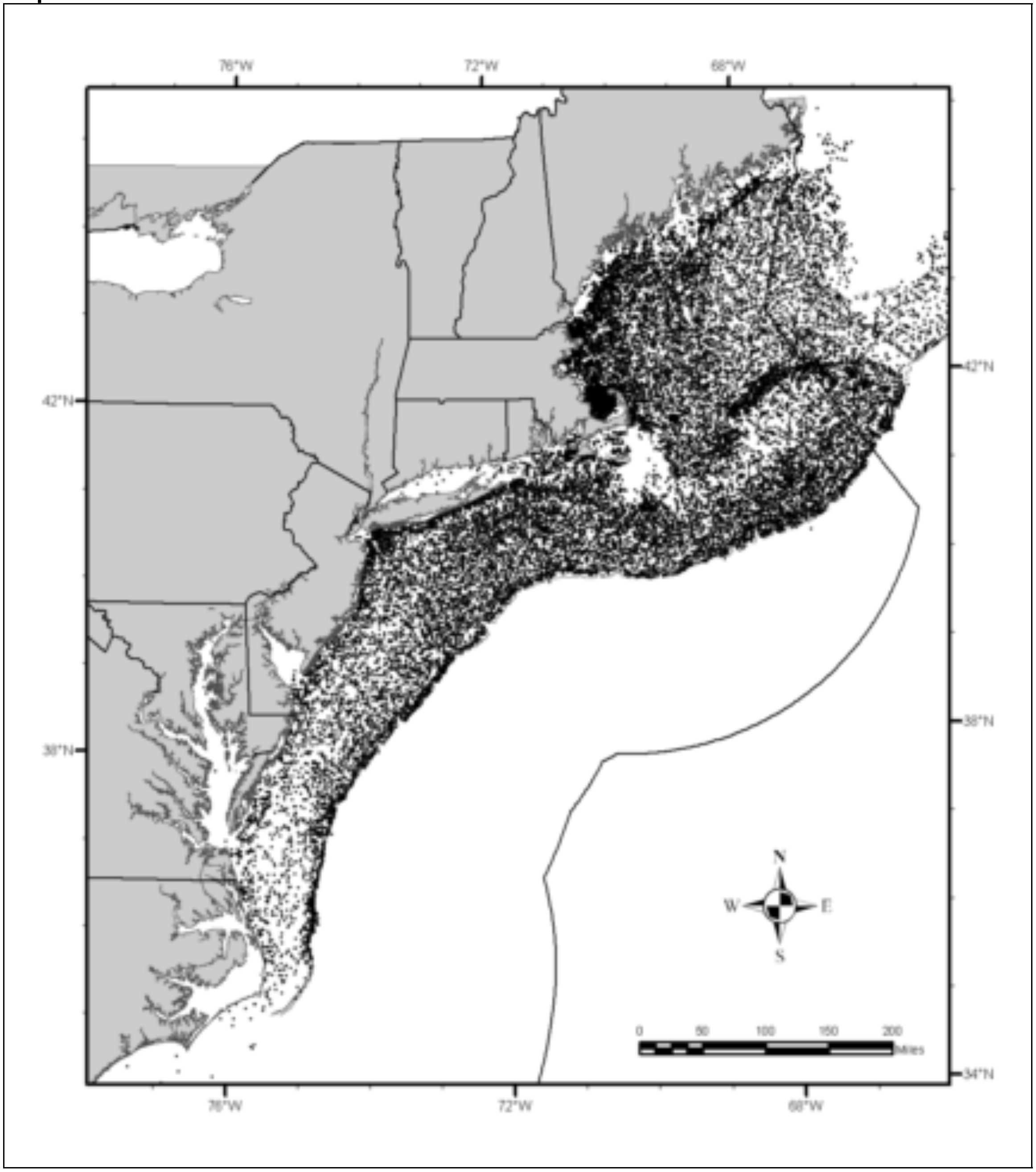
Map 30. Sculpins



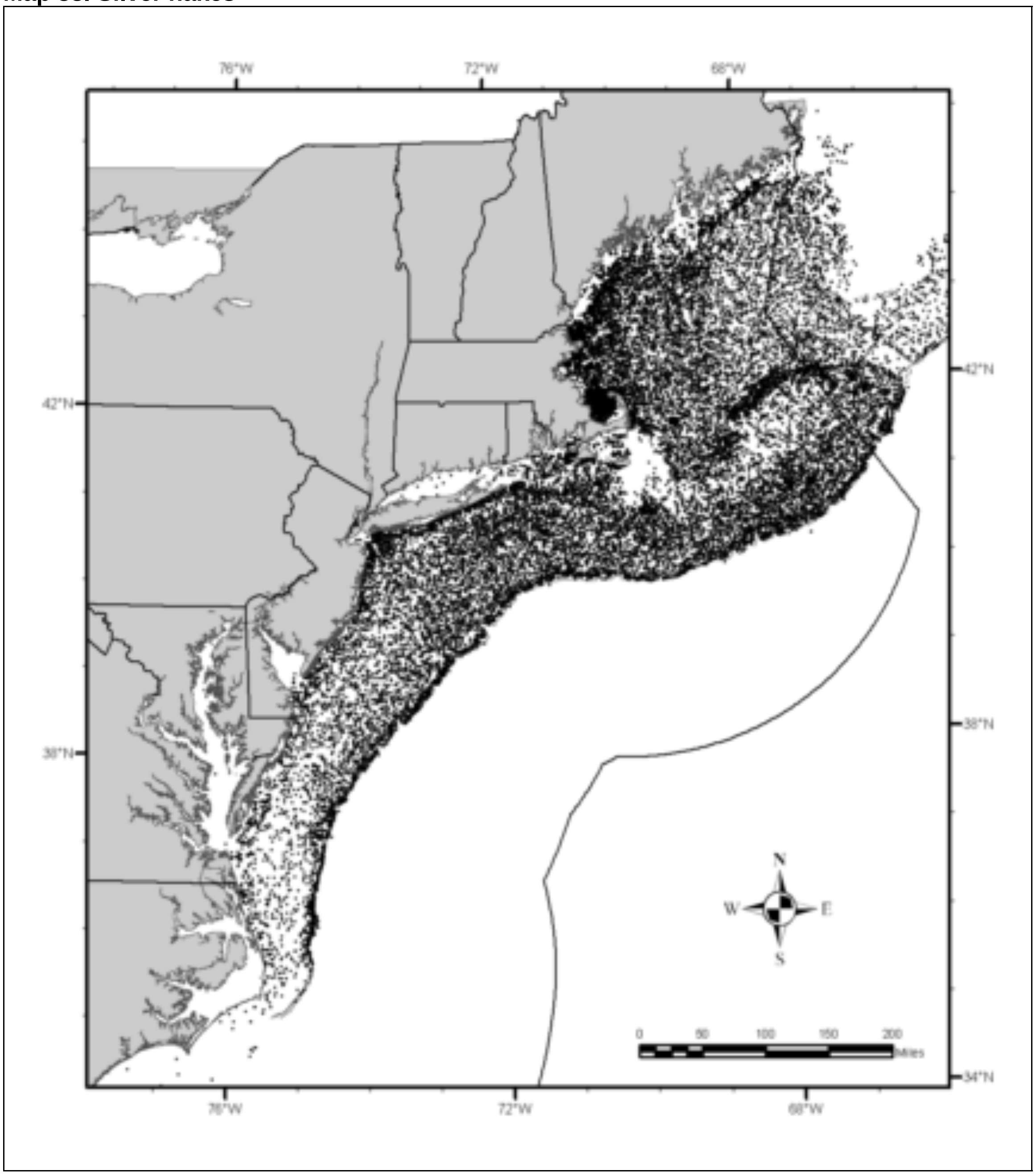
Map 31. Shortfin Squid



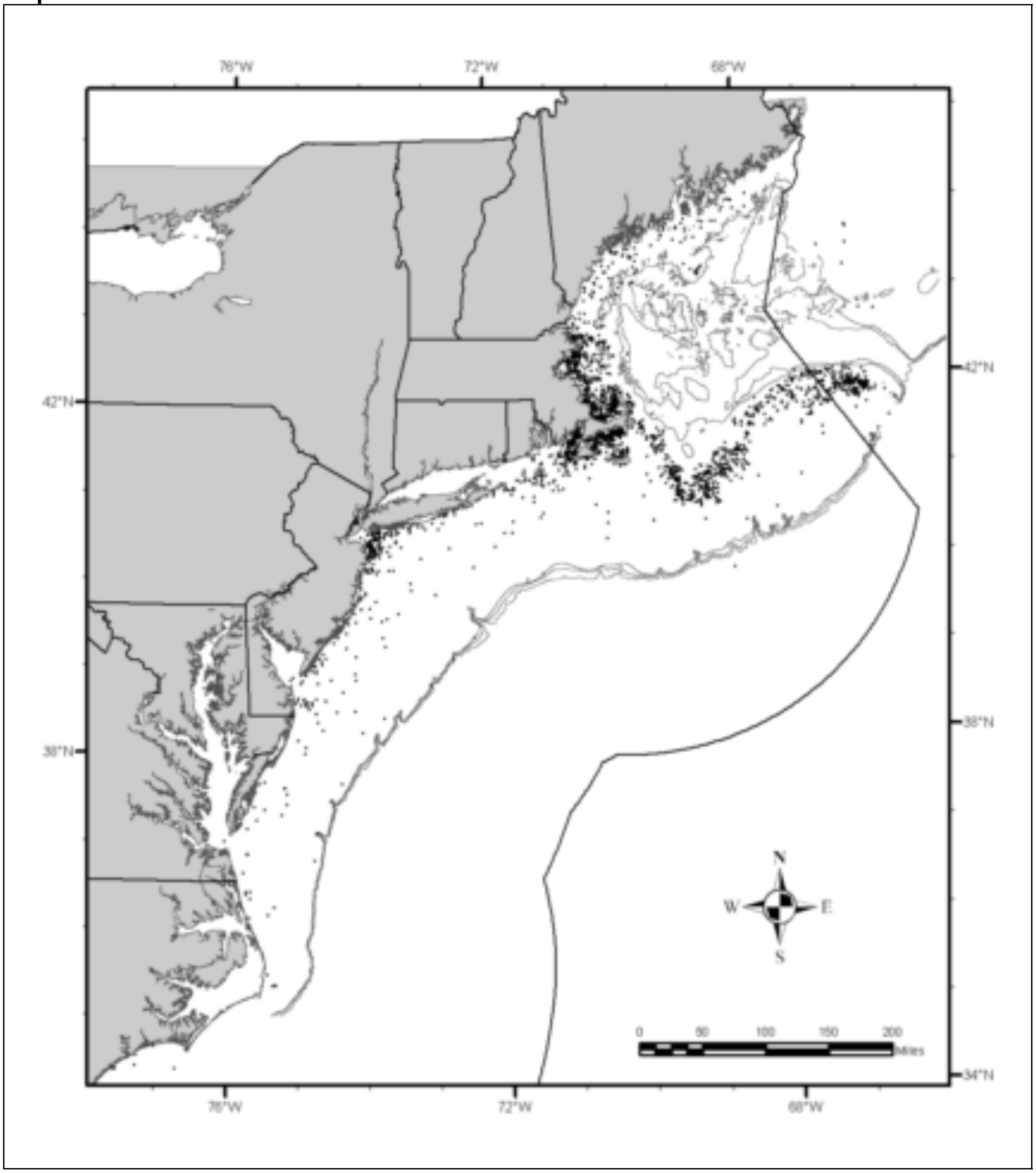
Map 32. Silver hake



Map 33. Silver hakes



Map 34. Wrasses



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John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

PHASE 1

APPENDIX D
IMPACTS TO MARINE FISHERIES HABITAT FROM NON-FISHING ACTIVITIES IN THE NORTHEAST U.S.

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DRAFT
Impacts to Marine Fisheries Habitat from Non-Fishing Activities in the Northeast U.S.

by
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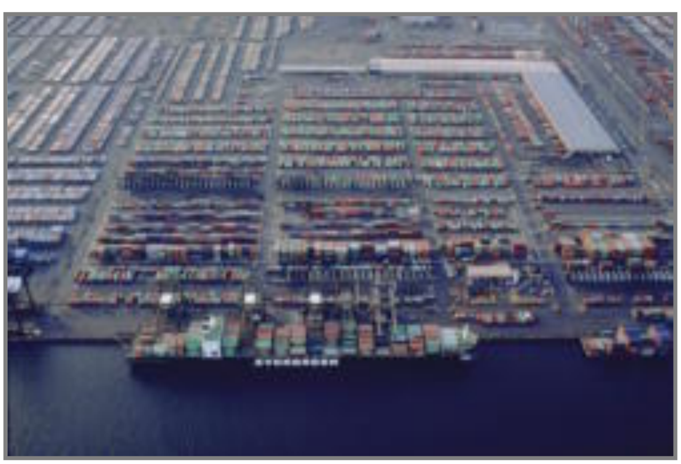

February 2007

DRAFT
Impacts to Marine Fisheries Habitat from Non-Fishing Activities in the Northeast U.S.

by

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U.S DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Regional Office
Habitat Conservation Division
Gloucester, MA 01930

February 2007

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PREFACE

This is the final report resulting, in part, from a technical workshop held in Mystic, Connecticut on January 10-12, 2005 entitled "Workshop on Impacts to Coastal Fishery Habitat from Non-Fishing Activities. The workshop and report was conceived by the Northeast Region Essential Fish Habitat Steering Committee which is comprised of representatives from NOAA Fisheries Northeast Regional Office (NERO), NOAA Fisheries Northeast Fisheries Science Center (NEFSC), New England Fisheries Management Council (NEFMC), Mid-Atlantic Fisheries Management Council (MAFMC), and the Atlantic States Marine Fisheries Commission (ASMFC). The workshop was jointly sponsored by NOAA Fisheries, NEFMC and ASMFC.

The original intent of the workshop was to provide the necessary information to the NEFMC and MAFMC to assist them in updating the non-fishing impact analyses within their Fishery Management Plans as required by the Essential Fish Habitat (EFH) regulations. As work progressed, we realized that this information would be extremely useful to a much larger audience of agencies, consultants and components of the public involved in marine and aquatic habitat assessment activities - and so this comprehensive report was developed. Our goal has been to insure that the best scientific information is available for use in making sound decisions with respect to the various environmental reviews and permitting processes conducted within the marine environment.

The large comprehensive nature of this report required extensive collaboration among the 12 listed authors. The authors are comprised of Marine Habitat Resource Specialists and Fishery Biologists within the NERO Habitat Conservation Division and NOAA Fisheries Headquarters Office of Habitat Conservation (OHC).

We would like to thank the participants of the technical workshop who graciously provided their time and expertise towards identifying and assessing the range of impacts that threaten coastal resources in the Northeast Region of the U.S (see appendix for list of participants). We would particularly like to thank the following individuals for their advice, time and valuable assistance in the preparation and review of this report: Claire Steimle, New England Fishery Science Center – Library Assistance; Numerous staff of the NOAA Library; Dr. David Stevenson, NOAA Fisheries, Northeast Regional Office – Reviewer; Kathi Rodrigues, Office of Habitat Conservation – Reviewer; Jeanne Hanson – NOAA Fisheries, Alaska Regional Office – Reviewer and Workshop Participant; Joanne Delaney, National Marine Sanctuaries Program – Reviewer

Louis A. Chiarella
Chair, Northeast Region Essential
Fish Habitat Committee

ACRONYMS AND ABBREVIATIONS

ACZA	ammoniacal copper zinc arsenate
ANS	aquatic nuisance species
ATOC	Acoustic Thermography of Ocean Climates
BMP	best management practice
BOD	biological oxygen demand
C	Celsius
CCA	chromated copper arsenate
cm	centimeters
CSO	combined sewer overflow
CWA	Clean Water Act
dB	decibel
DDE	dichlorodiphenyl dichloroethylene
DDT	dichlorodiphenyl trichloroethane
DNA	deoxyribonucleic acid
EMF	electromagnetic field
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
ESP	electric service facility
F	Fahrenheit
FMP	fishery management plan
ft	feet or foot
GIS	geographic information system
Hz	Hertz
IPCC	Intergovernmental Panel on Climate Change
km	kilometer
L	liter
LFAS	low frequency active sonar
LNG	liquefied natural gas
LWD	large wood debris
m	meter
MARPOL	International Convention for the Prevention of Pollution from Ships
ml	milliliter
mm	millimeter
MMS	Mineral Management Service
MPRSA	Marine Protection, Research and Sanctuaries Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSD	marine sanitation device
NATO	North Atlantic Treaty Organisation
NEFMC	New England Fishery Management Council
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	nonpoint source

NRC	National Research Council
OCS	Outer Continental Shelf
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
pH	the measure of acidity or alkalinity of a solution
PPCP	pharmaceutical and personal care products
ppt	parts per thousand
s	second
SAV	submerged aquatic vegetation
SCUBA	self-contained underwater breathing apparatus
TBT	tributyltin
THC	thermohaline circulation
TOY	time-of-year
μA	microamp
μg	micrograms
USACE	United States Army Corps of Engineers
US EPA	United States Environmental Protection Agency
μV	microvolt

GLOSSARY OF TERMS

alevins	young salmonid fish distinguished by an attached yolk sac
alkalinity	the quantitative capacity of water to neutralize an acid
amnesic shellfish poisoning	caused by the amino acid, domoic acid, as the contaminant of shellfish
anadromous	migrating from the sea to fresh water to spawn
anoxia	complete absence of oxygen in aquatic habitats
aquatic nuisance species	introduced (non-native) organisms that produce harmful impacts on aquatic natural resources
autotrophic	a class of organism that produces organic compounds from carbon dioxide as a carbon source, using either light or reactions of inorganic chemical compounds, as a source of energy; also known as a producer in a food chain
benthic	in or associated with the seafloor
benthos	organisms living on, in, or near the bottom of water bodies
bioaccumulation	the accumulation of substances, such as pesticides, methylmercury, or other organic chemicals in an organism or part of an organism
biocide	a chemical substance capable of killing different forms of living organisms (e.g., pesticide)
borrow pit	an excavation dug to provide material for fill elsewhere; used in aggregate or mineral mining, and in beach nourishment
carcinogenic	cancer causing agent
catadromous	migrating from fresh water to the sea to spawn
climax community	a community of organisms the composition of which is more or less stable and in equilibrium with existing natural environmental conditions
creosote	a brownish oily liquid consisting chiefly of aromatic hydrocarbons obtained by distillation of coal tar and used especially as a wood preservative
cumulative	increasing in amount by one addition after another
cytolysis	the dissolution or destruction of a cell
demersal	dwelling at or near the bottom of a body of water
denitrification	the process of reducing nitrate and nitrite, highly oxidised forms of nitrogen available for consumption by many groups of organisms, into gaseous nitrogen
desalination	any of several processes that remove the excess salt and other minerals from water in order to obtain fresh water suitable for consumption or irrigation
diadromous	migratory between fresh and salt waters
diel	occurring on a daily basis, such as vertical migrations in some copepods and fish
dissolved oxygen	a measure of the amount of gaseous oxygen dissolved in an aqueous solution
echolocation	the biological sonar used by dolphins and whales for navigation and foraging

ecosystem	refers to the entire community of organisms and the environment in which they live
endocrine disruptor	an exogenous (outside the body) agent that interferes with the production, release, transport, metabolism, binding, action or elimination of natural hormones in the body responsible for the maintenance of homeostasis and the regulation of developmental processes
entrainment	the voluntary or involuntary movement of aquatic organisms from the parent water body into a surface diversion or through, under or around screens, and results in the loss of the organisms from the population
epibiota	attached plants and animals that settle and grow on natural or artificial hard surfaces
epipelagic	part of the open ocean comprising the water column from the surface down to around 200 meters
estrogenic	compounds that mimics female steroid hormones or inhibits male steroid hormones
eutrophication	enrichment of nutrients causing excessive plant growth that can reduce oxygen concentration and kill aquatic organisms
extirpate	to eliminate completely certain populations within the range of a given species
gas supersaturation	the overabundance of gases in turbulent water, such as at the base of a dam spillway; can cause a fatal condition in fish similar to the bends
genotype	the genetic constituents in each cell of an organism
glacial till	an unsorted, unstratified mixture of fine and coarse rock debris deposited by a glacier
hardpan	a layer of hard subsoil or clay
headwater	the source of water for a river or stream
heterotrophic	a class of organism that requires organic substrates to get its carbon for growth and development; also known as a consumer in the food chain
hydrophobicity	the property of being water-repellent, or tending to repel and not absorb water
hyperplasia	an increase in the number of the cells causing an organ or tissue to increase in size
hypersaline	salinity well in excess of that of sea water
hypertrophy	an increase in the size of an organ or in a select area of the tissue due to an increase in the size of cells, while the number stays the same
hyporheic zone	saturated zone under a river or stream, comprising of substrates with interstices filled with water
hypoxia	a low oxygen condition in aquatic habitats
ichthyoplankton	eggs and larvae of fish that drift in the water column
impingement	involuntary contact and entrapment of aquatic organisms on the surface of intake screens due to the approach velocity exceeding the swimming capability of the organism
littoral zone	also called the intertidal zone, it lies between the high tide mark and the low tide mark
lotic	pertaining to running water, as opposed to lentic or still waters
macroinvertebrate	an animal lacking a backbone and visible without the aid of magnification

meroplankton	organisms that are planktonic for only a part of their life cycles, usually the larval stage
methylmercury	formed from inorganic mercury by the action of anaerobic organisms that live in aquatic systems and sediments; a bioaccumulative environmental toxin
mutagenic	agent causing genetic mutations
neurotoxic shellfish poisoning	shellfish poisoning caused by exposure to a group of polyethers called brevetoxins
organochlorides	a large, diverse group of organic compounds containing at least one covalently bonded chlorine atom, some of which are considered to be persistent organic pollutants and are harmful to the environment (e.g., PCB, DDT, chlordane, dioxins)
organometallic	A member of a broad class of compounds whose structures contain both carbon and a metal; e.g., methylmercury and tetra-ethyl lead persistent and bioaccumulative environmental toxins
osmoregulatory	any physiological mechanism for the maintenance of an optimal and constant level of osmotic activity of the fluid in and around the cells
paralytic shellfish poisoning	caused by a group of toxins elaborated by planktonic algae (dinoflagellates, in most cases) upon which the shellfish feed;
parr	developmental stage of young salmonid fish that follows the fry and lasting for one to three years in their native stream before becoming smolts
pelagic	ssociated with the water column
phytoplankton	microscopic plants that drift in the water column
planktivorous	feeding on plankton (e.g., most fish larvae and many pelagic fishes)
pycnocline	a layer of rapid change in water density with depth mainly caused by changes in water temperature and salinity
radionuclide	an atom with an unstable nucleus that can occur naturally, but can also be artificially produced; also known as radioisotope
redd	an area in gravel where salmonids bury their eggs; also known as nests or gravel nests
riparian	land directly adjacent to a stream, lake, or estuary
salmonid	belonging to, or characteristic of the family salmonidae, which includes the salmon, trout, and whitefish
sedimentation	the deposition by settling of suspended solids
siltation	sedimentary material consisting of very fine particles intermediate in size between sand and clay
smoltification	a suite of physiological, morphological, biochemical and behavioral changes, including development of the silvery color of adults and a tolerance for seawater, that take place in young salmonid fish they prepare to migrate downstream and enter the sea
soil infiltration	the passage of water through the surface of the soil, via pores or small openings, into the soil profile spermatogenesis- the process by which male gametes are formed in many sexually reproducing organisms
synergistic	combined effects being greater than the sum of individual effect

tailwater	an area immediately below a dam where the river water is cooler than normal and rich in nutrients
tannins	a broad group of astringent, plant polyphenol compounds that bind and precipitate proteins; used in manufacturing inks and dyes
thermocline	a vertical temperature gradient, in some layer of a body of water, that is appreciably greater than the gradients above and below it
time-of-year restrictions	seasonal constraints for dredging to avoid or minimize impacts of sensitive periods in the life-history of organism, such as spawning, egg development and migration
tonne	sometimes referred to as a metric tonne, the measurement of mass equal to 1,000 kilograms
trophic level	the position that an organism occupies in a food chain
turbidity	the cloudiness or haziness of water caused by individual particles, or suspended solids
volitional fish passage	any type of structure that provides fish passage over, through or around an obstruction in a river or stream (e.g., dam) that can be successfully achieved under the fishes own power (as opposed to trap and truck methods)
xenobiotic	a chemical which is found in an organism but which is not normally produced or expected to be present in it; e.g., pollutants, such as dioxins or PCBs

INTRODUCTION

Impacts to Habitat

Habitat alteration and disturbance occurs from natural processes and human activities. Deegan and Buchsbaum (2005) placed human impacts to marine habitats into three categories: 1) permanent loss; 2) degradation; and 3) periodic disturbance. Permanent loss of habitat can result from activities such as wetland filling, coastal development, harbor dredging and offshore mining operations (Robinson and Pederson 2005). These activities lead to a loss of habitat quantity (Deegan and Buchsbaum 2005). Habitat degradation may be caused by physical changes, such as increased suspended sediment loading, overshadowing from new piers and wharves, as well as introduction of chemical contamination from land-based human activities (Robinson and Pederson 2005). Periodic disturbances are created by activities such as trawling and dredging for fish and shellfish, and maintenance dredging of navigation channels. Habitat degradation and periodic disturbances result in a loss of habitat quality.

The general focus of this report pertains to marine, estuarine, and anadromous fishes and their habitats. However, the preparers of the report have attempted to provide a perspective of coastal aquatic habitat and the organisms that depend upon those habitats in a broad ecosystem context. Although the report often refers to "fishery habitat" or "fish", the definitions of these resources should not necessarily be constrained to any particular regulatory or management mandate, such as Essential Fish Habitat (EFH). The authors have attempted to include information on known or potential impacts that may affect the ecological functions and values for habitats for all species of fish and invertebrates. Because the focus of this report is on impacts to fish and fishery habitats, we have not included discussions on habitats specific to marine mammals and sea turtles.

Losses of habitat quantity and quality may reduce the ability of a region to support healthy and productive fish populations. The difference is that permanent loss is irreversible, habitat degradation may or may not be reversible, and periodic disturbance is generally reversible once the source of disturbance is removed (Deegan and Buchsbaum 2005). Deegan and Buchsbaum (2005) state that recovery times for degraded habitat depend on the nature of the agent causing the degradation and the physical characteristics of the habitat. Recovery times for periodic disturbances will vary depending on the intensity and periodicity of the disturbance and the nature of the habitat itself. Superimposed on these human-related alterations are natural fluctuations in habitats, such as storms, and long-term climatic changes.

Habitat quantity is a measure of the total area available, while habitat quality is a measure of the carrying capacity of an existing habitat (Deegan and Buchsbaum 2005). The degradation of habitat quality, such as through siltation and alteration of salinity, food webs and flow patterns, may be just as devastating to the biological community as a loss in quantity (Deegan and Buchsbaum 2005). The physical structure of the habitat does not need to be directly altered for negative consequences to occur (Deegan and Buchsbaum 2005). For example, reductions in water quality can impair and limit the ability of aquatic organisms to grow, feed, and reproduce.

Habitat loss and degradation are interrelated because habitat loss is the ultimate end point of gradual declines in habitat quality (Deegan and Buchsbaum 2005). From the population perspective, the loss of habitat quantity and quality creates stress on that population. Populations stressed by one factor are generally more susceptible to additional stresses caused by other factors (Robinson and Pederson 2005).

The review by Lotze *et al.* (2006) shows that severe depletion (50 percent abundance level) of marine resources first began with the onset of European colonization. Lotze *et al.* (2006) found that 45 percent of species depletions and 42 percent of extinctions involved multiple human impacts, mostly exploitation and habitat loss. Seventy eight percent of resource recoveries are attributed to both habitat protection and restricted exploitation. Only 22 percent of recoveries are attributed to reduced exploitation alone (Lotze *et al*. 2006). Therefore, Lotze *et al.* (2006) concludes that reduced exploitation, increased habitat protection and improved water quality need to be considered together, and the cumulative effects of multiple human interventions must be included in both management and conservation strategies.

Characterization of Habitat in the Northwest Atlantic

Habitats provide living things with the basic life requirements of nourishment and shelter (Stevenson *et al.* 2004). According to Deegan and Buchsbaum (2005), habitat includes the physical environment, the chemical environment, and the many organisms that comprise a food web. Habitats may also provide a broader range of benefits to the ecosystem, such as the way seagrasses physically stabilize the substrate and help recirculate oxygen and nutrients (Stevenson *et al.* 2004). These habitats do not exist in isolation, but are linked through ecological and oceanographic processes that are part of the larger ecosystem (Tyrell 2005). The movement of the water plays a major role in the interconnection of habitat by transporting nutrients, food, larvae, sediments, and pollutants among them (Tyrell 2005).

The northwest Atlantic includes a broad range of habitats with varying physical and biological properties extending from the cold waters of the Gulf of Maine south to the more temperate climate of the Mid-Atlantic Bight. In this region the oceanographic and physical processes interact to form a network of expansively to narrowly distributed habitat types (Stevenson *et al.* 2004). This region, also known as the Northeast U.S. Shelf Ecosystem (Sherman *et al.* 1996), is comprised of four distinct subregions: the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight, and the continental slope (Stevenson *et al*. 2004). This report focuses on three major systems comprising this ecosystem: riverine, estuarine/nearshore, and marine/offshore environments.

Riverine:

Riverine habitats are located along the coast of New England and the Mid-Atlantic and provide essential habitat to anadromous and catadromous fishes, and include freshwater streams, rivers, streamside wetlands and the banks and associated vegetation that may be bordered by other freshwater habitats (NEFMC 1998).

Riverine habitats serve multiple purposes including migration, feeding, spawning, nursery, and rearing functions. An important component of a river system also includes the riparian corridor. The term “riparian” refers to the land directly adjacent to a stream, lake, or estuary. A healthy riparian area has vegetation harboring prey items (e.g., insects), contributes necessary nutrients, provides large woody debris that creates channel structure and cover for fish, and provides shade, which controls stream temperatures (NEFMC 1998) .

Estuarine/Nearshore:
Estuaries are the bays and inlets influenced by both the ocean and rivers, and they serve as the transition zone between fresh and salt water. Estuaries support a community of plants and animals that are adapted to the zone where fresh and salt waters mix. Estuarine habitats fulfill fish and wildlife needs for reproduction, feeding, refuge, and other physiological necessities (NEFMC 1998). Coastal and estuarine features such as salt marshes, mud flats, rocky intertidal zones, sand beaches, and submerged aquatic vegetation are critical to inshore and offshore habitats and fishery resources of the northeast U.S. (Stevenson *et al.* 2004). Healthy estuaries include eelgrass beds that protect young fish from predators, provide habitat for fish and wildlife, improve water quality, and control sediments. In addition, mud flats, high salt marsh, and saltmarsh creeks also provide productive shallow water habitat for epibenthic fishes and decapods (NEFMC 1998). Inshore habitats are dynamic and heterogeneous environments that support the majority of marine and anadromous fishes at some stage of development (NEFMC 1998).

Marine/Offshore:
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 (Stevenson *et al.* 2004).

The offshore benthic habitat features include sand waves, shell aggregates, gravel beds, boulder reefs, and submerged canyons which provide nursery requirements for many species of fishes (NEFMC 1998). Many marine organisms inhabit the stable offshore environment for substantial stages of their life history.

Essential Fish Habitat

In 1996, the U. S. Congress declared that “one of the greatest long-term threats to the viability of the commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats. Habitat considerations should receive increased attention for the conservation and management of fishery resources of the United States.” Along with this declaration, Congress added new habitat conservation provisions to the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the federal law that governs U.S. marine fisheries management. The MSA requires that any fishery management plan (FMP) describe and identify essential fish habitat , minimize adverse effects on habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat. Essential fish habitat (EFH) has been defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.”

The MSA also requires federal agencies to consult with the Secretary of Commerce, acting through the National Oceanic and Atmospheric Administration – National Marine Fisheries Service (NMFS), on all actions authorized, funded, or undertaken, or proposed to be authorized, or undertaken, by the agency, that may adversely affect EFH. The process developed for conducting these EFH consultations is described in the EFH regulations (50 CFR 600.905 – 920). In summary, Federal agencies initiate consultation by preparing and submitting an EFH Assessment to NMFS that describes the action, analyzes the potential adverse effects of the action on EFH, and provides the agency's conclusions regarding the effects of the action on EFH. In response, NMFS provides the agencies conservation recommendations to conserve EFH by avoiding, minimizing, mitigating, or otherwise offsetting the adverse effects to EFH. Adverse effect is defined as any impact which reduces the quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to benthic organisms, prey species, and their habitat, and other ecosystem components. Adverse effects may be site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions [50 CFR 600.910(a)].

Once NMFS provides conservation recommendations, the federal action agencies must provide a detailed response in writing to NMFS. The response must include measures proposed for avoiding, mitigating, or offsetting the impact of a proposed activity on EFH. If the federal action agency chooses not to adopt NMFS' conservation recommendations it must explain its reasons for not following the recommendations.

Report Purpose

This report stems from a workshop entitled "Technical Workshop on Impacts to Coastal Fishery Habitat from Non-Fishing Activities", which was held January 10 – 12, 2005 in Mystic, CT. The workshop convened a group of experts in the field of environmental, marine habitat and fisheries impact assessment from federal and state government agencies. The goals of the workshop were to: 1) describe known and potential adverse effects of human induced, non-fishing, activities on fisheries habitats; 2) create a matrix on the degree of impacts associated with various activities in riverine, estuarine, and marine habitats; and 3) develop a suite of best management practices and conservation recommendations that could be used to avoid or minimize adverse impacts to fisheries habitats. Refer to Chapter 1 Workshop Summary for a detailed summary of the technical workshop.

The general purpose and goals of this report is to:

1. Identify human activities that may adversely impact essential fish habitat (EFH). Since Stevenson *et al.* (2004) characterized the impacts to EFH from fishing activities in the Northeast Region the focus of this report is on non-fishing activities.
2. Review and characterize existing scientific information regarding human induced impacts to EFH.
3. Provide Best Management Practices (BMPs) and conservation measures that can be implemented for specific types of activities that avoid or minimize adverse impacts to EFH.
4. Provide a comprehensive reference document for use by federal and state marine resource managers, permitting agencies, professionals engaged in marine habitat assessment activities, the regulated community, and the public.

5. Insure that the best scientific information is available for use in making sound decisions with respect to project planning, environmental assessment, and permitting.

It is anticipated that the information in this report will be used to assist federal agencies and their consultants in the preparation of EFH Assessments. In addition, this report will assist NMFS habitat specialists in: 1) reviewing proposed projects; 2) considering potential impacts that may adversely affect EFH; and 3) providing consistent and scientifically supported EFH conservation recommendations. This report will also provide insight for the public and the regulated community on the issues of concern to NMFS along with approaches to design and implementation of projects that avoid and minimize adverse effects to fish habitat.

The BMPs and conservation measures provided in this report are designed to minimize or avoid the adverse effects of human activities on EFH. These measures are provided as a means to avoid or minimize adverse impacts and promote the conservation and enhancement of EFH. The BMPs and conservation measures follow conservation principals recommended by Hanson *et al.* (2003): 1) non-water-dependent actions should not be located in EFH if such actions may have adverse impacts on EFH; 2) activities that may result in significant adverse affects on EFH should be avoided where less environmentally harmful alternatives are available; 3) if alternatives do not exist, the impacts of these actions should be minimized; and 4) environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH.

<u>Organization of the Report</u>

The document is organized by activities that may potentially impact EFH occurring in riverine, estuarine/coastal, and marine/offshore areas. The initial chapter describes the technical workshop that was conducted, and presents the results of those discussions and habitat impact evaluations. The major activities that were identified as impacting these three habitat areas include:

- coastal development
- energy-related activities
- alterations of freshwater systems
- marine transportation
- offshore dredging and disposal
- physical and chemical effects of water intake and discharge facilities
- agriculture and silviculture
- introduced/nuisance species and aquaculture
- global affects and other impacts

Each subsequent chapter is dedicated to the characterization of impacts associated with the major activities listed above. Each chapter describes the adverse effects on EFH and the species associated with those habitats caused by an activity, provides the scientific references to support those findings, and concludes with best management measures or conservation recommendations that could be implemented to avoid or minimize those particular adverse effects. Although the activities and affects identified in the technical workshop are generally reflected in the appropriate report chapter, the reader may notice some minor variation if the chapter author(s) failed to find specific information in the literature or believed additional discussion of affects were warranted. The preparers of this report have attempted to characterize the current knowledge of impacts and affects from existing and potential activities in the coastal areas of the Northeast Region of the U.S.; however, the reader should not consider the information in the report as comprehensive for all activities and impacts on fishery habitats. For more detailed analyses and understanding, the readers should refer to the cited references and most current literature regarding specific activities and impacts.

The conservation measures and BMPs included with each activity present a series of practices or steps that can be undertaken to avoid or minimize impacts to fishery habitats. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect habitat. More specific or different measures based on the best and most current scientific information may be developed as part of the project planning or regulatory process. The conservation recommendations and BMPs provided represent a generalized menu of the types of measures that can contribute to the conservation of EFH and other coastal aquatic habitats.

The final chapter contains a brief discussion of the purpose and application of compensatory mitigation used to offset adverse effects on fishery habitat. We have chosen to include a discussion on compensatory mitigation in its own chapter because its application is generally not considered a best management practice or a recommendation to conserve fishery habitat. Instead, compensatory mitigation is a method of offsetting adverse effects after they have occurred. For that reason, compensatory mitigation should only be considered after all measures to avoid and then minimize impacts have been exhausted. Compensatory mitigation should never be used as a first-line conservation measure.

Each chapter has been developed as a potential stand-alone document so many of the impact types described in one chapter may be found in other chapters containing similar impacts. This format was chosen so that the reader could remain focused on one category of activities without having to search other chapters for applicable discussions. Therefore, the reader will find some redundancy in the various chapters.

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TECHNICAL WORKSHOP ON IMPACTS TO COASTAL FISHERIES HABITAT FROM NON-FISHING ACTIVITIES

Introduction

A technical workshop was hosted by NOAA Fisheries, Northeast Region Habitat Conservation Division on January 10-12, 2005 at Mystic, Connecticut, to seek the views and recommendations of approximately 40 scientists, resource managers, and other marine resource professionals on threats to fishery habitat from non-fishing activities in the northeast coastal region. Generally, the participants of the workshop were federal and state environmental managers and regulators, but also included individuals from academic institutions and other organizations that have expertise and knowledge of various human-induced impacts on coastal environmental resources. A list of the participants of the workshop and their affiliation is provided in Appendix A of this report. The primary purpose of the workshop was to provide a forum for marine resource professionals to review and evaluate existing information on non-fishing impacts for the purpose of updating, as necessary, fishery management plans under the New England and Mid-Atlantic fishery management councils. In addition, NOAA Fisheries sought to broaden the overall scope of this activity to develop a non-fishing impacts reference document for use by professionals engaged in marine habitat assessment, permitting agencies, and state and federal marine resource managers. This report represents the product of information gathered during the technical workshop and the combined efforts of staff from the Northeast Region's Habitat Conservation Division who authored selected chapters in the report. In general, the activities and effects contained within the various chapters of his report reflect the categories of activities and effects evaluated and discussed during the Technical Workshop on Impacts to Coastal Fishery Habitat from Non-fishing Activities.

The specific goals/tasks of the technical workshop included:

1) Identify all known and potential adverse effects for each category of non-fishing activity by life history strategies or stages (i.e., benthic/demersal and pelagic) and ecosystem strata (i.e., riverine, estuarine, and marine). This list of activities may also include adverse impacts to identified prey species or other specific life history requirements for species.
2) Create a matrix of non-fishing impacts for life history strategies/stages and ecosystem strata and ask the participants of the workshop to score the intensity of each impact using a relative scoring method.
3) Develop a suite of conservation measures and best management practices (BMPs) intended to avoid and minimize the adverse effects on fishery habitat and resources.
4) Identify possible information and data limitations and research needs in assessing impacts on fishery habitat or measures necessary to avoid and minimize those impacts.

Conservation measures were, to the extent possible, based on methods and technologies that have been evaluated through a scientific, peer-reviewed process. The intent was to develop recommendations that provide resource managers and regulators with specific methods and technologies, yet have flexibility in their applications for various locations or project types. Ideally, providing a suite of conservation measures appropriate for various activities would give the end user several options of recommendations to consider.

Based upon the results of the workshop and effects scoring, some recommended research needs have been developed. These include biological research needed in basic life history requirements for some species and habitat types, physiological or biochemical responses of organisms in response to various physical and chemical perturbations and stressors, or technological advances in understanding or solutions to impact assessment and mitigation.

The format of the two-day workshop consisted of a series of breakout sessions, attended by the workshop participants, which represented the primary categories of non-fishing activities believed to threaten fishery resources and habitats in the northeast coast. There were ten separate breakout sessions conducted during the workshop, which are reflected in the chapters of this report. For each of the breakout sessions, a matrix of activities and known or potential adverse effects to fishery habitat, prepared by the workshop organizers, was reviewed by the workshop participants. The participants were encouraged to openly discuss and evaluate the relevance and significance for each of the activities and effects, and to provide any additional activities and effects not included in the matrix. A large number of non-fishing activities occur within the coastal region, and those activities have a wide range of effects and intensities on fishery habitat. In order to identify the importance of life history requirements of species and the physical and chemical differences of the coastal environments for which fishery resources occur, each impact type and effect was evaluated in the context of life history strategies or stages (i.e., benthic and demersal) and ecosystem type or strata (i.e., riverine, estuarine/nearshore, and marine/offshore). Following an open discussion, the participants were asked to score, by life history strategies/stages and ecosystem strata, the various activities and adverse effects on the impact matrix. An example of the session matrix is provided in Appendix B. In addition, participants were asked to include specific and relevant "conservation recommendations" or BMPs to avoid and minimize adverse effects to fishery habitat and resources.

On the last day of the workshop, the participants engaged in an informal discussion on the significance of cumulative effects and how multiple and additive effects can influence impacts to fishery habitat and resources. While the discussions were general in nature and few specifics of cumulative effects were discussed, a number of participants commented that cumulative effects are important and should play a larger role in assessment of habitat impacts. During the workshop some participants voiced their concerns that not enough time was made available during the two-day workshop to discuss and explore the topics, particularly the time available for the participants to score the matrices. There were some concerns that, given the breadth of material covered in the workshop, some of the impacts and effects were not thoroughly covered. Nonetheless, we found that the scores provided by the participants in the impact matrices for most breakout sessions to be relatively consistent throughout. While the variability in scores for some impact categories was high, we believe that the mean and median values for most effects scores provide an accurate reflection of professional judgment by the participants. The relatively high variability in the scores of some impact types and effects may be due to different interpretations by the participants. For example, the Offshore Dredging and Disposal Activities session included dredged material disposal and offshore aggregate mining impacts. We believe that there may have been different interpretations by the participants of the term "offshore", leading to a high standard deviation in the effects for the estuarine/nearshore ecosystem in this session.

Effects Scoring System

Because one of the goals of the workshop was to assess the intensity or degree of threat for known and potential impacts to fishery habitats, the workshop organizers strived to develop a scoring system that could be used to accurately quantify the impacts for each activity and effect based upon the professional judgment of the participants. Assigning an absolute value to measure the significance of adverse effects for any specific activity is difficult and can depend upon the type of habitat being affected, the type, intensity and duration of the activity and disturbance, and a number of natural physical, chemical and biological processes that may be occurring in the area and at the time of the activity. For this and other reasons, the workshop organizers chose a relative scoring system with a range from 0 to 5, with a 1 being the lowest impact and a 5 being the highest impact. A "0" was used if an impact is not expected to occur or is not applicable, and a "UN" (unknown) was used if the participant does not know the degree of impact for a particular activity.

During and after the workshop, some participants indicated that they believed the relative scoring method used to quantify threats was arbitrary and imprecise, and would lead to over or under estimating the effects to fishery habitat and resources. We believe that a relative scoring method that allows flexibility and professional judgment in assigning a value for an effect is better than an absolute scoring system that has discreet and pre-defined values. Using a relative scoring range of 0 through 5 provided the participants a choice from a continuum of intensity values for each effect, and avoids the difficulty in finding consensus for the definition of pre-defined values. We recommend that for future workshops of this type, the organizers provide an explanation, prior to the workshop, of the scoring system to be used in order to avoid lengthy discussions at the beginning of the workshop.

We used an index to qualitatively measure the intensity of each effect by calculating the mean and median values for the scores of each impact type and effect for the breakout sessions. The mean and median values for each impact type and effect were converted to a Habitat Impact Category (HIC), which was established using the following criteria:

If either the mean or median value was greater than or equal to 4.0, a HIC score of "high" was assigned; if the mean value was between 2.1 and 3.9, a HIC score of "medium" was assigned; and if the mean value was less than or equal to 2.0, a HIC score of "low" was assigned.

Note: We defined the "high" HIC to include either mean or median values in order to be risk averse in identifying activities that are known to be or may be a potential high threat. Only mean values were used to determine "medium" and "low" HIC.

Results of Workshop Scores

Coastal Development

The results of the scoring in the Coastal Development session are listed in Table 1a, and the effects that were scored as high for all impact types are presented in Table 1b. The activities and threats identified in this session were greater than other sessions due to the cross cutting nature of activities associated with human coastal development. Because of this, some of impact types and activities assessed in this session were discussed in other sessions.

Non-point Source Pollution and Urban Runoff
For this impact type, several effects were scored as high for both riverine and estuarine/nearshore ecosystems in the benthic/demersal strategy (i.e., nutrient loading/eutrophication; loss/alteration of aquatic vegetation; release of heavy metals; release of pesticides; and sedimentation/turbidity). The scores for riverine and estuarine/nearshore ecosystems in the pelagic strategy were highly similar to those of the benthic/demersal strategy. The high scores for the pelagic strategy included nutrient loading/eutrophication; loss/alteration of aquatic vegetation; release of pesticides; release of pharmaceuticals; and sedimentation/turbidity. The nutrient loading/eutrophication effect had a median value of 5.0 for all strategies and ecosystem types, except for the marine/offshore ecosystem. There were no effects in the marine/offshore ecosystem that had high scores, which suggests that, in general, the participants viewed non-point source pollution to be a low to moderate threat to offshore fishery habitat.

Road Construction and Operation
For this impact type, there were strong similarities between the benthic/demersal and pelagic strategies for the riverine ecosystem. The effects having high scores for these two strategies included: increased sedimentation/turbidity; impaired fish passage; altered hydrological regimes; altered temperature regimes; altered stream morphology; altered stream bed characteristics; reduced dissolved oxygen; loss/alteration of aquatic vegetation; altered tidal regimes; and fragmentation of habitat. The benthic/demersal and pelagic strategies for the estuarine/nearshore ecosystems had fewer common effects with high scores, which included: increased sedimentation/turbidity; altered hydrological regimes; reduced dissolved oxygen; and loss/alteration of aquatic vegetation. All of the effects for the marine/offshore ecosystem had low scores. These results suggest that participants considered riverine habitats to be most threatened by road construction and operations, followed by estuarine and nearshore habitats; and that marine/offshore habitats were the least threatened by these activities.

Flood Control/Shoreline Protection
For this impact type, the benthic/demersal strategy in the riverine ecosystem had far more effects scored as high. The high scoring effects included: altered hydrological regimes; altered stream morphology; altered sediment transport; loss/alteration of benthic habitat; impaired fish passage; alteration in natural communities; impacts to riparian habitat; loss of interidal habitat; reduced ability to counter sea level rise; and increased erosion/accretion. While the estuarine/nearshore ecosystem scores had much fewer high scoring effects, there were some similarities with the riverine ecosystem, including altered hydrological regimes; altered sediment transport; loss/alteration of benthic habitat; loss of interidal habitat; reduced ability to counter sea level rise; and increased erosion/accretion. The riverine ecosystem also had much fewer high scoring effects for the pelagic strategy compared to the benthic/demersal strategy, with similarities in altered sediment transport; loss of interidal habitat; reduced ability to counter sea level rise; and increased erosion/accretion. It is noteworthy that scores for four of the effects in the riverine ecosystem for benthic/demersal strategy (altered sediment transport; impacts to riparian habitat; reduced ability to counter sea level rise; and increased erosion/accretion) had median values of 5.0. In addition, the score of the estuarine/nearshore ecosystem for pelagic strategy had a median value of 5.0 for reduced ability to counter sea level rise. These results, combined with the effects for both life history strategies/stages in the marine/offshore ecosystem being scored as low,

suggests that there were strong views by the participants that *Flood Control/Shoreline Protection* has a high potential to primarily adversely affect riverine and estuarine/nearshore habitats.

Beach Nourishment
None of the effects in this impact type had high mean scores. Even the effects in the riverine and estuarine/nearshore ecosystems were low compared to some other impact types in the Coastal Development session. The highest mean values, found in the estuarine/nearshore ecosystem and benthic/demersal strategy, were in altered benthic habitat, alteration/loss of benthic habitat and alteration in natural communities (means = 3.2, 3.3, 3.3; standard deviation (SD) = ±1.5, 1.3 and 1.4, respectively). For the other effects in this impact type the means were less than 3.0 and the SDs were high, indicating large variations by the participants in the perceptions of threat. This high variation in perceived threat may be a reflection of regional perspectives: while the majority of the participants involved in this workshop were from the New England region, about one-quarter of the participants were from the mid-Atlantic region where beach nourishment projects are much more common. The associated impacts to benthic habitats from beach nourishment are also generally thought to be greater in the mid-Atlantic and south Atlantic regions than in New England. However, because the responses of the participants were anonymous it isn't possible to test this hypothesis.

Wetland Dredging and Filling
This impact type had similarly high scoring effects associated with the riverine and estuarine/nearshore ecosystems for both the benthic/demersal and pelagic strategies. The high scoring effects for these ecosystems and strategies included: alteration/loss of habitat; loss of submerged aquatic vegetation; altered hydrological regimes; loss of wetlands; loss of fishery productivity; and loss of flood storage capacity. In the riverine ecosystem and benthic/demersal strategy, three effects had median values of 5.0 (i.e., alteration/loss of habitat; loss of wetlands; and loss of fishery productivity). In addition, the alteration/loss of habitat had a median value of 5.0 for riverine and estuarine/nearshore ecosystems for both benthic/demersal and pelagic strategies. These results likely reflect the areas where the effects of dredging and filling would have the most profound affect and where fishery resource impacts could be the greatest. There were no effects in the marine/offshore ecosystem for this impact type that had high mean or median values, suggesting that most participants do not view dredging and filling activities to impact offshore habitats to any significant degree. The dredging and filling activities assessed in this session are related to projects associated with coastal development and did not include dredging of navigational channels, offshore disposal of dredged material, or offshore mineral mining. These activities and effects were considered in other sessions at the workshop (i.e., Marine Transportation and Offshore Dredging and Disposal sessions).

Overwater Structures
Scores in this impact type were generally low compared to most in this session. The only impact in the riverine and estuarine/nearshore ecosystems that had a consistent median value of 4.0 in both benthic/demersal and pelagic strategy was changes in predator/prey interactions. Only one other impact (i.e., shellfish closures due to bird roosting) had a median value of 4.0 in this impact type. There appeared to be varying opinions by participants on the importance of the other impacts commonly associated with overwater structures, such as shading impacts to vegetation, altered hydrological regimes, benthic habitat impacts and increased erosion/accretion. The mean

and median values for these effects ranged from 3.0 to 3.5, suggesting that they were viewed by most participants as moderately threatening effects, but not high. There were no effects in the marine/offshore ecosystem for this impact type that had high mean or median values, suggesting that the participants considered riverine and nearshore/estuarine ecosystems to be primarily effected.

Pile Driving and Removal
The results of this impact type and the *Marine Debris and Illegal Dumping* (see below) were similar in that none of the effects had high mean and/or median values. The mean and median values for effects in the riverine and estuarine/nearshore ecosystems were low compared to the effects of other impact types in this session. While at least one participant had scored each effect in the riverine and estuarine/nearshore ecosystems as either 4 or 5 for both impact types, the mean values were in the range of 2 to 3 and with relatively low SDs. This suggests that most participants feel the various effects to habitat from pile driving and removal and marine debris and illegal dumping may be moderate, but not high. And since the effects in the marine/offshore ecosystem for both benthic/demersal and pelagic strategies had low mean and median values, the participants appeared to view the impacts from *Pile Driving and Removal* primarily affecting riverine and estuarine/nearshore areas.

Marine Debris and Illegal Dumping
Some of the effects scores for this impact type were distinctly different from the *Pile Driving and Removal* impact type, primarily in the riverine ecosystem and pelagic strategy. This impact type was the only one that had low values in the riverine ecosystem (i.e., ingestion; contaminant releases; introduction of pathogens; and conversion of habitat). In addition, there were several effects for the marine/offshore ecosystems and pelagic strategy that had medium scores (i.e., ingestion; contaminant releases; introduction of invasive species; and conversion of habitat). These results likely reflect the participant's views on the geographic areas and life history stages/strategies most affected by marine debris and illegal dumping.

Energy-Related Activities
The results of the scoring for Energy-Related Activities session are listed in Table 2a, and the effects that were scored as high for all impact types are presented in Table 2b.

Petroleum Exploration and Transportation
The high scoring effects associated with this impact type had strong similarities in both the benthic/demersal and pelagic strategies. The greatest number of effects that had high scores was in the estuarine/nearshore ecosystem, including: habitat conversion; contaminant discharge; oil spills; and impacts from clean-up activities. Oil spills had median values of 5.0 and means above 4.0 for all ecosystems and life history strategies, and the very low SDs for the means suggests that most participants felt strongly about the concern for impacts to fishery habitats from oil spills. Habitat conversion had high median values for both life history stages and ecosystems, except for the marine/offshore ecosystem and pelagic strategy. These results likely reflect the participant's views on the geographic areas where the effects of petroleum exploration and transportation would have the most profound affect and where fishery resource impacts to be the greatest.

Liquified Natural Gas
The high scoring effects associated with this impact type were similar for the riverine and estuarine/nearshore ecosystems for the benthic/demersal stategy. Effects that had high scores in the riverine and estuarine/nearshore ecosystems of the benthic/demersal strategy were: habitat conversion; loss of benthic habitat; discharge of contaminants; release of contaminants; introduction of invasive species; vessel impacts; and benthic impacts from pipelines. The scores for loss of benthic habitat effect for the benthic/demersal strategy and estuarine/nearshore ecosystem had a median value of 5.0, suggesting a high degree of agreement among the participants for this effect. The discharge of contaminants effect was the only impact that had a high score across all ecosystems and life history strategies. Underwater noise was unique in having a high median value only in the pelagic strategy for the riverine and estuarine/nearshore ecosystems. This result likely indicates a perception by the participants on the geographic areas and life history strategy/stages that would be most vulnerable to underwater noise associated with LNG facilities.

Offshore Wind Energy Facilities
There were few high scoring effects associated with this impact type. The majority of the high mean and/or median values were in the estuarine/nearshore ecosystem and the benthic/demersal strategy, including: loss of benthic habitat; habitat conversion; alteration of community structure; and spills associated with service structure. One effect, loss of benthic habitat, had a median value of 5.0, suggesting a high degree of concern by the participants regarding loss of benthic habitat in the estuarine/nearshore ecosystem. The loss of benthic habitat and habitat conversion were also the only two effects that had median values of 4.0 in the marine/offshore ecosystem for benthic/demersal strategy. The underwater noise effect was unique in having a high value only in the pelagic strategy for marine/offshore ecosystems. These impacts likely reflect the participant's views on the geographic areas and life history strategies that offshore wind energy facilities could have on fishery resources. Considering that no offshore wind energy facilities have been constructed in the U.S. at the time of the workshop, participants may have had little or no experience with which to judge offshore wind energy projects and impacts to fishery resources.

Wave/Tidal Energy Facilities
This impact type also had few effects scored as high. Only two effects in the benthic/demersal strategy had high mean and/or mean values for both the riverine and estuarine/nearshore ecosystems (i.e., habitat conversion and loss of benthic habitat). One effect, siltation/sedimentation/turbidity, had a high score only in the benthic/demersal strategy of the estuarine/nearshore ecosystem. The entrainment/impingement effect had high scores in the riverine and estuarine/nearshore ecosystems of only the pelagic strategy. For the riverine ecosystem, impacts to migration was scored as high in the pelagic strategy only. Two other effects, alteration of hydrological regimes and altered current patterns only had high median values for the estuarine/nearshore ecosystem in the pelagic strategy. There were no high scoring effects in the marine/offshore ecosystem of either life history strategy. These results likely reflect the habitats and life history strategies/stages that the participants viewed the effects of wave/tidal energy facilities would have the most profound effect on fishery resources. Similar to offshore wind energy facilities, no wave or tidal energy facilities have been constructed in the northeast U.S. at the time of this workshop with which to assess impacts to habitats.

Cable and Pipeline
Due to the nature of this impact type, the majority of effects with high values were associated with benthic/demersal strategies. Effects with mean and/or median values of 4.0 or higher that were common to benthic/demersal strategy and both riverine and estuarine/nearshore ecosystems were: loss of benthic habitat; habitat conversion; resuspension of contaminants; spills associated with service structure; physical barriers to habitat; and impacts to migration. Three effects that were scored high for benthic/demersal strategies and estuarine/nearshore ecosystem, but not in the riverine ecosystem, were: siltation/sedimentation/turbidity; impacts to submerged aquatic vegetation; and impacts from construction activities. In the pelagic strategy for this impact type, only water withdrawal had a median value of 4.0 or greater.

<u>Alteration of Freshwater Systems</u>
The results of the scoring for Alteration of Freshwater Systems session are listed in Table 3a, and the effects that were scored as high for all impact types are presented in Table 3b. Due to the nature of this session, the majority of high scores were in the riverine ecosystem for all impact types and there was a high degree of similarity for both benthic/demersal and pelagic life history strategies. The effects for all impact types in the marine/offshore ecosystem were scored as low in this session.

Dam Construction/Operation
For this impact type, the effects scored as high for the riverine ecosystem for both benthic/demersal and pelagic strategies included: impaired fish passage; altered hydrological regimes; altered temperature regimes; altered sediment/LWD (large wood debris) transport; altered stream morphology; altered stream bed characteristics; reduced dissolved oxygen; alteration of wetlands; changes in species communities; riparian zone development; and acute temperature shock from water releases. Eight of these twelve effects had median values of 5.0, suggesting a high degree of agreement amongst the participants that these effects represented significant threats to fishery resources. The effects that scored high in the estuarine/nearshore ecosystem and both the benthic/demersal and the pelagic strategies included: impaired fish passage; alteration of extent of tide; and alteration of wetlands. Two other effects, altered hydrological regimes and altered temperature regimes, were scored as high in the estuarine/nearshore ecosystem for the benthic/demersal life history strategy only. These results suggest that, while dam construction and operations primarily affect riverine ecosystems, participants considered several indirect effects be important in estuarine/nearshore ecosystems.

Dam Removal
For the two effects listed in this impact type, both the benthic/demersal and pelagic strategies had high scores in the riverine ecosystem. As expected, these reflect the areas that would be most affected by dam removal projects in freshwater systems. The effects scoring high for the benthic/demersal strategy and riverine ecosystem included: release of contaminated sediments and alteration of wetlands. The release of contaminated sediments also scored high in the estuarine/nearshore ecosystem, as well. Similar to the results of the *Dam Construction/Operation* impact type described above, the participants viewed indirect effects to estuarine/nearshore ecosystems to be important for at least one effect.

Stream Crossing
All but one of the effects for this impact type had mean and/or median values of 4.0 or greater in the riverine ecosystem for both benthic/demersal and pelagic strategies. The high scoring effects for this impact type included: impacts to fish passage; alteration of hydrological regimes; bank erosion and habitat conversion. The estuarine/nearshore ecosystem had no effects that were scored as high, and all of the effects in the marine/offshore ecosystem were scored as low. As in other impact types for this session, this reflects the regions that would be most impacted by stream crossing projects.

Water Withdrawal/Diversion
For this impact type, a large numbers of effects were scored as high and had strong similarities within the riverine ecosystem for both benthic/demersal and pelagic strategies. The effects scoring high for riverine in both the benthic/demersal and pelagic life history strategies included: impaired fish passage; altered hydrological regimes; reduced dissolved oxygen; altered temperature regimes; release of nutrients/eutrophication; release of contaminants; altered stream morphology; altered stream bed characteristics; siltation/sedimentation/turbidity; change in species communities; alteration in groundwater levels; loss of forested/palustrine wetlands; and impacts to water quality. Five of these effects had median values of 5.0, indicating a strong agreement in the participants on the nature of those threats. Only the pelagic strategy and riverine ecosystem had a high score for entrainment and impingement. For the estuarine/nearshore ecosystem, impaired fish passage was the only effect with high scores in both the benthic/demersal and pelagic strategy. This impact type also had a high score for change in species communities for the pelagic strategy in the estuarine/nearshore ecosystem. This reflects the general results for this session that estuarine/nearshore ecosystems are only indirectly affected by these activities.

Dredging and Filling/Mining
As with the other impact types for this session, this impact type had a large number of effects that were scored as high in the riverine ecosystem. There also was strong similarity in high scoring effects for riverine ecosystem for both the benthic/demersal and pelagic strategy, including: reduced flood water retention; altered hydrological regimes; increased storm water runoff; loss of riparian and riverine habitat; altered stream morphology; altered stream bed characteristics; siltation/sedimentation/turbidity; reduced dissolved oxygen; altered temperature regimes; release of nutrients/eutrophication; release of contaminants; loss of submerged aquatic vegetation; and change in species communities. In the estuarine/nearshore ecosystem, both benthic/demersal and pelagic life history strategies were scored high for loss of submerged aquatic vegetation. Only two other effects for the estuarine/nearshore ecosystem had high scores: change in species communities and release of nutrients/eutrophication. These results are consistent with those of the other impact types in this session.

Marine Transportation
The results of the scoring for the Marine Transportation session are listed in Table 4a, and the effects that were scored as high for all impact types are presented in Table 4b. All but one high scoring effect in this session were in the riverine and estuarine/nearshore ecosystems, and there were nearly twice as many in the benthic/demersal strategy compared to the pelagic strategy.

Construction and Expansion of Ports and Marinas
The high scoring impacts associated with this impact type were similar for the riverine and estuarine/nearshore for both benthic/demersal and pelagic life history strategies. However, the participants generally scored the effects for the benthic/demersal strategy as being higher than the pelagic strategy. Impacts that had high scores for both riverine and estuarine/nearshore ecosystems in the benthic/demersal strategies were: loss of benthic habitat; siltation/sedimentation/turbidity; contaminant releases; altered hydrological regimes; loss of wetlands; loss of submerged aquatic vegetation; conversion of substrate/habitat; and loss of intertidal flats. Several effects had median values of 5.0 across both ecosystems (i.e., loss of benthic habitat, loss of wetlands, and loss of intertidal flats) and the estuarine/nearshore ecosystem had one effect that uniquely had a median value of 5.0 (i.e., loss of submerged aquatic vegetation). The low standard deviation for the means in the effects suggests that most participants felt strongly about the concern for impacts to fishery habitats from these activities. For the pelagic strategy, effects that had high mean and/or median values for both riverine and estuarine/nearshore ecosystems were: altered hydrological regimes; loss of wetlands; loss of submerged aquatic vegetation; and loss of water column. Several of the effects in the pelagic strategy had median values of 5.0, including: loss of wetlands (for riverine and estuarine/nearshore ecosystems) and loss of submerged aquatic vegetation (for the estuarine/nearshore ecosystem). The only effect that was scored as high in the marine/offshore ecosystem for the *Construction and Expansion of Ports and Marinas* impact type was loss of benthic habitat, suggesting most participants viewed the impacts occurring at or near a port and marina facility.

Operations and Maintenance of Ports and Marinas
There were few high scoring effects associated with this impact type. Only two effects, contaminant releases and storm water runoff, had high scores in the benthic/demersal strategy and both were in the riverine and estuarine/nearshore ecosystems. This follows the general tendency of scores for this session.

Vessel Operation and Maintenance
Similar to the previous impact type, there were few high scoring effects associated with this impact type. The only high mean or median value common to both the riverine and estuarine/nearshore ecosystems in the benthic/demersal strategy was the impacts to benthic habitat effect. Contaminant spills and discharges was the only other high scoring effect for this impact type, and was seen in both the estuarine/nearshore and pelagic strategy. This suggests that participants perceived the impacts associated with vessel operations to primarily affect benthic habitats and to be low to moderate in the marine/offshore ecosystems of both life history strategies.

Navigation Dredging
There was a high degree of similarity in the highest scoring effects associated with this impact type, primarily between the riverine and estuarine/nearshore ecosystems in the benthic/demersal strategy. Effects that had high mean and/or median values in the both the riverine and estuarine/nearshore ecosystems of the benthic/demersal strategy were: conversion of substrate/habitat; loss of submerged aquatic vegetation; siltation/sedimentation/turbidity;

contaminant releases; altered hydrological regimes; altered temperature regimes; loss of intertidal flats; and loss of wetlands. Several of these effects had median values of 5.0 (i.e., loss of intertidal flats, loss of submerged aquatic vegetation, and loss of wetlands), which suggests that there was a high degree of agreement with the participants on the significance of these threats to benthic and demersal habitats. Effects that had high mean and/or median values in the riverine and estuarine/nearshore ecosystems for the pelagic strategy included: loss of submerged aquatic vegetation; loss of intertidal flats; and loss of wetlands. There were two other effects that were scored as high in the riverine ecosystem of the pelagic strategy: siltation/sedimentation/turbidity and altered hydrological regimes. The loss of wetlands effect also had median values of 5.0 for the riverine and estuarine/nearshore ecosystems for the pelagic strategy. There were no effects in the offshore/marine ecosystem of either life history strategy/stage that had high mean or median values, indicating the general view of participants that marine transportation impacts are primarily limited to areas within or nearby ports and marinas.

Offshore Dredging and Disposal

The results of the scoring for the Offshore Dredging and Disposal session are listed in Table 5a, and the effects that were scored as high for all impact types are presented in Table 5b. Due to the nature of this session topic, all effects in this session with high mean and/or median values were in marine/offshore ecosystem. One interesting result in the scores for all impact types in this session is the relatively low mean values and high standard deviations for effects in the estuarine/nearshore ecosystem. About half of the participants in this session either did not provide a score for impacts in the riverine or estuarine/nearshore ecosystems, or they marked them as "not-applicable". The remaining participants who did provide a score for these two ecosystems generally scored them relatively high. This suggests a difference in participant's interpretation of where "offshore" activities are located. Specifically, some individuals may consider the "offshore" area to be within close enough proximity of the nearshore and estuarine environments to adversely affect these areas, while others may perceive the "offshore" area to be too far removed to have a noticeable effect. It may be prudent for organizers of future workshops of this type to define the geographic range for ecosystems.

Offshore Mineral Mining

For this impact type, all of the effects with high values were in the benthic/demersal strategy and marine/offshore ecosystem. The four high scores were in: loss of benthic habitat types; conversion of substrate/habitat; changes in sediment composition; and change in community structure. The loss of benthic habitat types and conversion of substrate/habitat had median values of 5.0 and 4.5, respectively, suggesting a strong agreement on the threat of these two effects. Although most of the effects in the pelagic strategy in the marine/offshore ecosystem were scored as medium, both riverine and estuarine ecosystems for both life history strategies had low scores. These results likely reflect the participant's views on where the effects of offshore mineral mining would have the most profound effect on fishery resources. However, as with all of the impact types in this session there was a high degree of variability in the participant's responses in the estuarine/nearshore ecosystem. Although the mean values for the effects in this ecosystem were less than 2.0, the SDs were greater than ±2.0 for most effects.

Petroleum Extraction

The highest scoring effects for this impact type were in the marine/offshore ecosystem. The high scores for both the benthic/demersal and pelagic strategies were contaminant releases and drilling mud impacts. All of the remaining effects in the marine/offshore ecosystem and the benthic/demersal strategy had medium scores, and all but two of the remaining effects in the pelagic strategy had medium scores. All of the riverine and estuarine/nearshore ecosystems effects had low scores. However, the mean values for the effects in the estuarine/nearshore ecosystem were generally less than 1.5, with SDs greater than ±1.5.

Dredge Material Disposal
In this impact type, all high scores were in the benthic/demersal strategy and marine/offshore ecosystem. The high values were: burial/disturbance of benthic habitat; conversion of substrate/habitat; and changes in sediment composition. The means for all of these effects were greater than 4.0 with SDs ±1.0 or less, and median values were 5.0, suggesting a high degree of agreement among the participants that these were considerable threats to fishery habitat and resources. Except for one effect in the estuarine/nearshore ecosystem (i.e., burial/disturbance of benthic habitat, mean=2.1, SD±2.5), all of the riverine and estuarine/nearshore ecosystems had low scores. However, as with other impact types in this session, the mean values for the effects in the estuarine/nearshore ecosystem were generally less than 1.5, with SDs greater than ±1.5.

Disposal of Fish Wastes
For this impact type, all high scores were in the marine/offshore ecosystem. The four high scores for the benthic/demersal strategy were: introduction of fish wastes; release of nutrients/eutrotrophication; release of biosolids; and loss of benthic habitat types. Two effects had high scores in the pelagic strategy: introduction of fish wastes and release of nutrients/eutrotrophication. As with the other impact types in this session, the effects in the riverine and estuarine/nearshore ecosystems had low scores. Although the mean values for the effects in the estuarine/nearshore ecosystem were generally less than 2.0, the SDs were greater than ±2.0.

Vessel Disposal
The effects in this impact type had effects with high scores in the marine/offshore ecosystem and the benthic/demersal life history strategy. The two effects with high values were conversion of substrate/habitat and changes in community structure. Most of the effects in the pelagic strategy for the marine/offshore ecosystem were scored as medium. Similar to the other impact types in this session, all of the riverine and estuarine/nearshore ecosystems effects had low scores. However, the mean values for scores in the estuarine/nearshore ecosystem were generally less than 1.5, with SDs greater than ±1.5.

<u>Chemical Effects: Water Discharge Facilities</u>
The results of the scoring for the Chemical Effects: Water Discharge Facilities session are listed in Table 6a, and the effects that were scored as high for all impact types are presented in Table 6b. This proportion of high scores in this session was the largest of any session in the workshop. Approximately 87 percent of the 23 effects identified for this session were scored as high.

Sewage Discharge

For this impact type, the riverine and estuarine/nearshore ecosystems for both benthic/demersal and pelagic strategy had a greatest number of effects with high mean and/or median values. This likely reflects the participant's views where the effects of sewage discharges may have the greatest impact on fishery habitat. Out of the thirteen effects listed in the benthic/demersal strategy for this impact type, the riverine and estuarine/nearshore ecosystems had eleven and twelve effects, respectively, with mean and/or median values of 4.0 or greater. In the benthic/demersal strategy, the effects that were scored high for both the riverine and estuarine/demersal ecosystems were: release of nutrients/eutrophication; release of contaminants; impacts to submerged aquatic vegetation; reduced dissolved oxygen; siltation/sedimentation/turbidity; impacts to benthic habitat; changes in species composition; trophic level alterations; introduction of pathogens; introduction of harmful algal blooms and contaminant bioaccumulation/biomagnification. For the riverine and estuarine/nearshore ecosystem, five and seven effects, respectively, had median values of 5.0. For the pelagic strategy, the riverine and estuarine/nearshore ecosystems had nine and eleven effects, respectively, with mean and/or median values of 4.0 or greater. The effects that were scored as high in both the riverine and estuarine/nearshore ecosystem included: release of nutrients/eutrophication; release of contaminants; impacts to submerged aquatic vegetation; reduced dissolved oxygen; siltation/sedimentation/turbidity; changes in species composition; trophic level alterations; introduction of harmful algal blooms and contaminant bioaccumulation/biomagnification. In the riverine and estuarine/nearshore ecosystem for the pelagic strategy, three and five effects, respectively, had median values of 5.0. Although the marine/offshore ecosystem had fewer effects scored as high compared to the other two ecosystems, four scored high in the benthic/demersal strategy (i.e., release of nutrients/eutrophication; release of contaminants; introduction of harmful algal blooms; and contaminant bioaccumulation/biomagnification) and two were scored high in the pelagic strategy (i.e., release of nutrients/eutrophication; release of contaminants). Release of nutrients/eutrophication and release of contaminants were scored high in both life history strategies/stages and all three ecosystems in this impact type, suggesting that the participants viewed these two effects to particularly threaten fishery habitats.

Industrial Outfalls

In this impact type, the riverine and estuarine/nearshore ecosystems for benthic/demersal strategy had the highest scoring effects. As with the *Sewage Discharge* impact type discussed above, the participants likely view these ecosystems to be at greater risk to industrial outfall impacts. For the benthic/demersal strategy, there were seven and six effects in the riverine and estuarine/nearshore ecosystems, respectively, that had median values of 4.0. In the benthic/demersal life history strategy, the effects that were scored high in the riverine ecosystem were: alteration of water alkalinity; release of heavy metals; release of chlorine compounds; release of pesticides; release of organic compounds; release of petroleum products; and release of inorganic compounds. The estuarine/nearshore effects were similar to the riverine ecosystem, except that alteration of water alkalinity was scored as medium. Comparatively, only one effect in the marine/offshore ecosystem had a median value of 4.0 (i.e., release of organic compounds). Interestingly, for the pelagic strategy, the riverine ecosystem effects had less than half the number of high scores compared to the benthic/demersal strategy (i.e., release of chlorine compounds; release of pesticides; and release of inorganic compounds). The effects scored high for the estuarine/nearshore ecosystem in the pelagic strategy were very similar to the benthic/demersal strategy (i.e., release of chlorine compounds; release of pesticides; release of organic compounds; release of petroleum products; and release of inorganic compounds). There were no effects in the marine/offshore ecosystem for the pelagic strategy that had high mean or median values, suggesting that most participants view industrial outfall impacts to be localized in riverine and nearshore habitats.

Combined Sewer Overflows (CSO)
All of the effects in this impact type were combined into a single line, which included all of the effects listed in the *Industrial Outfalls* impact type. The participant's scores in this combined impact type resulted in high scores for all ecosystems and both life history strategies/stages. The median values for the riverine and estuarine/nearshore ecosystems for both benthic/demersal and pelagic ecosystems were 5.0, suggesting an agreement among the participants that the effects from CSO's represent a significant threat to fishery habitat and resources in these areas.

Physical Effects: Water Intake and Discharge Facilities
The results of the scoring for the Physical Effects: Water Intake and Discharge Facilities session are listed in Table 7a, and the effects that were scored as high for all impact are presented in Table 7b. The effects with high scores in the riverine and estuarine/nearshore ecosystems were very similar for both benthic/demersal and pelagic strategies. Likewise, the marine/offshore ecosystem effects were scored similarly for the two strategies.

Discharge Facilities
For this impact type, high scoring effects common to the riverine and estuarine/nearshore ecosystems included: turbidity/sedimentation; altered sediment composition; reduced dissolved oxygen; alteration of salinity regimes; alteration of temperature regimes; habitat exclusion/avoidance; restrictions to migration; attraction to flow; alteration of community structure; increased need for dredging; ballast water discharge; and release of radioactive wastes. These results likely reflect the participant's views where the effects of discharge facilities would have the most profound physical effects on fishery resources. One effect, alteration of temperatures regimes, had a median value of 5.0 for the riverine and estuarine/nearshore ecosystems for both benthic/demersal and pelagic strategies, indicating a high degree of agreement among the participants on the significance of this threat. For the pelagic strategy, the effects that had high scores for both riverine and estuarine/nearshore ecosystems were: reduced dissolved oxygen; alteration of salinity regimes; alteration of temperature regimes; habitat exclusion/avoidance; restrictions to migration; acute toxicity; attraction to flow; alteration of community structure; increased need for dredging; and release of radioactive wastes. None of the effects in the marine/offshore ecosystem for either benthic/demersal or pelagic ecosystems had high mean and/or median values, suggesting that most participants do not view discharge facilities to affect habitats in those areas.

Water Intake Facilities
In this impact type, there were strong similarities in the high scoring effects in the riverine and estuarine/nearshore ecosystems. Nearly all of the effects with high scores were in the riverine and estuarine/nearshore ecosystems, suggesting that the participant's considered the fishery resources in these areas to be most affected by water uptake facilities. The benthic/demersal and pelagic strategies had effects with high scores common to both in the riverine and

estuarine/nearshore ecosystems, including: entrainment/impingement; alteration of hydrological regimes; flow restrictions; conversion/loss of habitat; alteration of community structure; increase need for dredging; and ballast water uptake. The only effect that had high scores for the marine/Offshore ecosystem was entrainment/impingment, which had a median value of 5.0 for both benthic/demersal and pelagic strategies. All other effects in the marine/offshore ecosystem for this impact type had low to moderate mean or median values, suggesting that most participants view these effects from uptake facilities to be of lesser threat to offshore habitats. The entrainment/impingement effect had a median score of 5.0 for both life history strategies/stages and all three ecosystem types, indicating a strong agreement among the participants regarding the significance of this threat.

Agriculture and Silviculture

The results of the scoring for Agriculture and Silviculture session are listed in Table 8a, and the effects that were scored as high for all impact types are presented in Table 8b. All of the high scoring effects for this session were in the riverine and estuarine/nearshore ecosystem. The riverine ecosystem had the highest scoring effects for all impact types, scoring either high or medium for all impact types and effects in both benthic/demersal and pelagic life history strategies. This likely reflects the areas where most agricultural activities take place and where impacts to fishery resources are the greatest.

Cropland, Rangelands, Livestock and Nursery Operations

For the benthic/demersal life history strategy in the riverine ecosystem, ten of the twelve effects in this impact type were scored high, and four of these effects (i.e., release of nutrients/eutrophication; bank/soil erosion; and release of pesticides, herbicides, fungicides) had median values of 5 suggesting agreement amongst the participants on the significance of the level of threat these effects may have on fishery habitat. For the benthic/demersal strategy, six effects had high scores for both riverine and estuarine/nearshore ecosystems (i.e., release of nutrients/eutrophication; bank/soil erosion; siltation, sedimentation/turbidity; release of pesticides, herbicides, fungicides; loss/alteration of wetlands/riparian zone; and endocrine disruptors). The pelagic strategy for the riverine ecosystem had eight effects with high scores, but only three of these scored high in the estuarine/nearshore ecosystem. These results reflected the general tendency of this session for higher scores in the riverine and estuarine/nearshore ecosystems.

Silviculture and Timber Harvest Activities

Seven of the eight effects listed in this impact type had high scores, but only two of these were also scored high in the estuarine/nearshore ecosystem. All of the effects in the riverine ecosystem for the pelagic strategy were scored high (i.e., siltation, sedimentation/turbidity; impaired fish passage; bank/soil erosion; altered temperature regimes; release of pesticides, herbicides, fungicides; release of nutrients/eutrophication; reduced dissolved oxygen; and loss/alteration of wetlands/riparian zone). The same two effects that were scored as high in the benthic/demersal strategy were also scored high in the pelagic strategy (i.e., release of pesticides, herbicides, and fungicides and release of nutrients/eutrophication). With noted in the above impact type discussion, the results reflected here reflect the general tendency of this session for higher scores in the riverine and estuarine/nearshore ecosystems.

Timber and Paper Mill Processing Activities
The scores in this impact type followed a pattern similar to the other two impact types in this session, with the highest impacts associated with the riverine ecosystem. The effects that were scored as high for the riverine ecosystem were: chemical contaminant release; thermal discharge; reduced dissolved oxygen; and conversion of benthic substrate. Only one effect was scored high in the estuarine/nearshore ecosystem for both benthic/demersal and pelagic strategies (i.e., chemical contaminant release). Entrainment and impingement and impaired fish passage effects were scored as high for only the pelagic life history strategies for all impact types in this session. All of the effects scored low for the marine/offshore ecosystem in both benthic/demersal and pelagic life history strategies, suggesting that the participants did not consider agricultural activities to affect offshore habitats.

<u>Introduced/Nuisance Species and Aquaculture</u>
The results of the scoring for Introduced/Nuisance Species and Aquaculture session are listed in Table 9a, and the effects that were scored as high for all impact types are presented in Table 9b. The majority of the effects scored high in this session were in the estuarine/nearshore ecosystem, followed by the riverine ecosystem. This may reflect the areas where the introduction of exotic, nuisance species could have the greatest potential impact on fishery resources.

Introduced /Nuisance Species
In this impact type, the benthic/demersal strategy had slightly more effects that were scored high in the estuarine/nearshore ecosystem, compared to the riverine ecosystem. For the benthic/demersal strategy, the riverine ecosystem had four effects with median values of 4.0 or greater, while the estuarine/nearshore ecosystem had six. The effects that were scored high in both riverine and estuarine/nearshore ecosystem were: habitat alterations; gene pool alterations; alterations to communities /competition w/ native species and changes in species diversity. Four of the six effects in the estuarine/nearshore ecosystem for the benthic/demersal strategy had median values of 5.0. Only one effect, changes in species diversity, had a high score in the marine/offshore ecosystem for the benthic/demersal strategy. For the pelagic strategy, the riverine ecosystem had two impacts with median values of 4.0 and greater, while the estuarine/nearshore ecosystem had four. The two effects in the pelagic strategy with common, high-scoring effects were: gene pool alterations and changes in species diversity. The introduced diseases effect was scored as high for the estuarine/nearshore ecosystem for both benthic/demersal and pelagic strategies. Changes in species diversity was the only effect that had a high mean score in the marine/offshore ecosystem (i.e., benthic/demersal strategy) and this effect scored the highest among the workshop participants in all three ecosystems and in both life history strategies/stages.

Aquaculture
For this impact type, a pattern similar to the scores in the *Introduced/Nuisance Species* impact type was observed. However, the participants scored more effects higher in the benthic/demersal strategy/stage than the pelagic strategy/stage. For the benthic/demersal strategy, five effects were scored high in the riverine ecosystem, while the estuarine/nearshore ecosystem contained eleven. The high scoring effects in the estuarine/nearshore ecosystem for this strategy were: discharge of organic waste/contaminants; seafloor impacts; introduction of exotic invasive species; food web impacts; gene pool alterations; impacts to water quality; changes in species

diversity; sediment deposition; introduction of diseases; habitat replacement/exclusion and habitat conversion. Two of the high scoring effects (i.e., food web impacts and gene pool alterations) had median scores of 5.0. Although the number of effects scored as high was less for the pelagic strategy, there were also more in the estuarine/nearshore compared to the riverine ecosystem. The effects scored as high in the estuarine/nearshore ecosystem were: introduction of exotic invasive species; food web impacts; impacts to water column; impacts to water quality; changes in species diversity and habitat conversion. As observed in the benthic/demersal strategy, the high scoring effects in the riverine ecosystem of the pelagic strategy were: food web impacts and gene pool alterations. Neither the benthic/demersal or pelagic strategies had high scores in the marine/offshore ecosystem.

<u>Global Effects and Other Impacts</u>

The results of the scoring for the Global Effects and Other Impacts session are listed in Table 10a, and the effects that were scored as high for all impact types are presented in Table 10b. The effects scored high in this session did not show a strong tendency for specific ecosystems or life history strategies/stages compared to other sessions, suggesting a view by the workshop participants that threats are generally more wide-spread across all the region and species.

Climate Change

For this impact type, there were high similarities between each of the three ecosystems for both benthic/demersal and pelagic strategies. There were also common, high scoring effects between the riverine and estuarine/nearshore ecosystems, including: alteration of hydrological regimes; alteration of temperature regimes; changes in dissolved oxygen concentrations; release of contaminants; alteration of weather patterns; changes in community structure; and loss of wetlands. Only two effects were scored as high in the marine/offshore ecosystem of the benthic/demersal strategy (i.e., alteration of temperature regimes and changes in community structure). In the pelagic strategy/stages, there were also strong similarities of high scoring effects between the riverine and estuarine/nearshore ecosystems, including: alteration of hydrological regimes; alteration of temperature regimes; changes in dissolved oxygen concentrations; alteration of weather patterns; changes in community structure; and loss of wetlands. Four effects had high scores in the marine/offshore ecosystem of the pelagic strategy (i.e., alteration of hydrological regimes; alteration of temperature regimes; alteration of weather patterns and changes in community structure). Two effects, alteration of temperature regimes and changes in community structure, were scored as high in all ecosystem types and life history strategies/stages. This suggests that there was agreement amongst the participants that effects relating to climate change, such as changes in temperature regimes, community structure, and loss of wetland could have the most profound effect on fishery habitats and resources.

Ocean Noise

For this impact type, there were no high scoring effects in either the riverine or estuarine/nearshore ecosystems. The only effect that had a high score was mechanical injury to marine organisms in the marine/offshore ecosystem for both the benthic/demersal and pelagic strategies. The scores suggest that for all other effects in this impact type, participants generally perceived the impacts on fishery habitat and resources associated with ocean noise as moderate. It should be noted that although many of the effects listed for the *Ocean Noise* impact type are affects on organisms and not habitat in the strictest sense, we have included these effects because of their potential to affect the quality of the aquatic environment. For the purposes of this report, these effects could alter the quality of the water column to a degree that may be considered an adverse effect on coastal and marine habitats.

Atmospheric Deposition
The effects in this impact type that were scored as high were: nutrient loading/eutrophication; mercury loading/bioaccumulation; and PCB's and other contaminants. Except for one high scoring effect in the marine/offshore ecosystem of the pelagic strategy (i.e., mercury loading/bioaccumulation), all of these effects were in the riverine and estuarine/nearshore ecosystem. All other effects in the impact type were scored as medium, suggesting that participants generally perceived these effects associated with atmospheric sources as being moderate.

Military/Security Activities
For this impact type, there were no high scoring effects for the riverine ecosystem. The only two effects that had high scores were chemical releases in the estuarine/nearshore ecosystem of the benthic/demersal strategy and noise impacts in the marine/offshore ecosystem of the pelagic strategy. The scores suggest that for all other effects in this impact type, participants generally perceived the impacts on fishery habitats associated with military and security activities as low to moderate. As noted in the results for the *Ocean Noise* impact type, noise and blasting impacts are generally effects to organisms and not to habitat in the strictest sense; however, we have considered these impacts as occurring in the water column and, therefore have the effect of altering the environment of the water column and adversely impacting coastal and marine habitats.

Natural Disasters/Events
All of the effects associated with this impact type had high scores in the riverine and estuarine/nearshore ecosystem. The loss/alteration of habitat effect scored high in the riverine and estuarine/nearshore ecosystems for both benthic/demersal and pelagic strategies/stages. One other effect, impacts to water quality, was scored high for the riverine ecosystem and pelagic strategy and the estuarine/nearshore ecosystem for both benthic/demersal and pelagic strategies. However, most of the mean and/or median values were low to moderate for this impact type, suggesting that participants do not consider most effects from natural disasters to be of high concern.

Electromagnetic fields (Natural & Manmade)
None of the impacts in this impact type had high mean and/or median values. The results of the scores indicate that, while at least one participant had scored most effects in this impact type as high, the mean and median values were in the 2.0-3.0 range with relatively low SDs. This suggests that most participants feel the various impacts associated with electromagnetic fields to be low to moderate.

Workshop Summary
As might be expected, there were positive correlations between the highest scoring effects and the ecosystem types that those activities occur. For example, the high scoring effects in the Alteration of Freshwater Systems and Agriculture and Silviculture sessions were generally all in

the riverine ecosystem. Except for the Offshore Dredging and Disposal session, there were fewer effects that were scored high in the marine/offshore ecosystem compared to the riverine and estuarine/nearshore ecosystems. This suggests the workshop participants viewed the intensity of effects from non-fishing impacts to decrease as the distance from the activity increases. As one might expect, many of the far field effects scored high were those activities that effect the water column (e.g., ocean noise, impacts to water quality, nutrient release) or effects that are capable of being transported by currents (oil spills or drilling mud releases). In addition, the Global Effects and Other Impacts session had high scores more evenly distributed across all ecosystems due to the nature of the impacts discussed in this session (e.g., climate change, atmospheric deposition, ocean noise).

Many of the effects that were scored as high in the workshop session were those that are well documented in the literature as having adverse effects on coastal resources. For example, nutrient enrichment and siltation/sedimentation effects were scored as high in nearly all workshop sessions, demonstrating the widely accepted views that these impacts translate to general reductions in the quality and quantity of fishery resources and habitats. Some of the more unexpected results of the workshop session scores are those effects that had high mean and/or median values, but may be a topic that does not have a wealth of research documenting those impacts. Some of these results may be based upon a collective judgment by the participants that these activities or effects require additional scientific investigations to resolve the perceived risks and concerns. In several of these effects or activities, the authors of the associated report chapters were unable to locate information in the scientific literature regarding those threats. For example, release of pharmaceuticals and endocrine disruptors were two effects that were scored high in the workshop session, and yet the potential scope and intensity of adverse effects that these chemicals have on fishery resources has not been thoroughly investigated.

The impact types and effects that were scored as high in the workshop sessions are listed separately in Tables 1b-10b. These effects were considered to be those that are or have the greatest potential to impact fisheries habitat by the workshop participants. Further investigation may be warranted for these activities and affects, including research in characterizing and quantifying the impacts on fishery resources, as well as investigating methods of avoiding and/or minimizing the impacts.

Table 1. Habitat Impact Categories in Coastal Development Workshop Session (n=14)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Nonpoint Source Pollution and Urban Runoff	Nutrient loading/eutrophication	H	H	M	H	H	M
	Loss/alteration of aquatic vegetation	H	H	L	H	H	L
	Release of petroleum products	M	M	M	M	M	M
	Alteration to water alkalinity	M	M	L	M	M	L
	Release of heavy metals	H	H	M	M	H	M
	Release of radioactive wastes	M	M	L	M	M	L
	Release of pesticides	H	H	M	H	H	M
	Release of pharmaceuticals	H	M	L	H	H	L
	Alteration to temperature regimes	H	M	L	H	M	L
	Sedimentation/turbidity	H	H	L	H	H	L
	Altered hydrological regimes	M	M	L	M	M	L
	Introduction of pathogens	M	M	L	M	M	L
Road Construction and Operation	Release of sediments in aquatic habitat	H	M	L	M	M	L
	Increased sedimentation/turbidity	H	H	L	H	H	L
	Impaired fish passage	H	M	L	H	H	L
	Altered hydrological regimes	H	H	L	H	H	L
	Altered temperature regimes	H	M	L	H	M	L
	Altered stream morphology	H	M	L	H	M	L
	Altered stream bed characteristics	H	M	L	H	M	L
	Reduced dissolved oxygen	H	H	L	H	H	L
	Introduction of exotic invasive species	M	M	L	M	M	L
	Loss/alteration of aquatic vegetation	H	H	L	H	H	L
	Altered tidal regimes	H	H	L	H	M	L
	Contaminant releases	M	M	L	M	M	L
	Fragmentation of habitat	H	M	L	H	H	L
	Altered salinity regimes	M	M	L	M	M	L
Flood Control/ Shoreline Protection	Altered hydrological regimes	H	H	L	H	M	L
	Altered temperature regimes	M	M	L	M	M	L
	Altered stream morphology	H	M	L	H	M	L
	Altered sediment transport	H	H	L	H	H	L
	Alteration/loss of benthic habitat	H	H	L	M	M	L
	Reduction of dissolved oxygen	M	M	L	M	M	L
	Impaired fish passage	H	M	L	H	M	L
	Alteration in natural communities	H	M	L	M	M	L
	Impacts to riparian habitat	H	M	L	H	M	L
	Loss of intertidal habitat	H	H	L	M	H	L
	Reduced ability to counter sea level rise	H	H	L	M	H	L
	Increased erosion/accretion	H	H	L	H	H	L
Beach Nourishment	Altered hydrological regimes	M	M	L	M	M	L
	Altered temperature regimes	L	L	L	L	L	L
	Altered sediment transport	M	M	L	M	M	L
	Alteration/loss of benthic habitat	M	M	L	L	M	L
	Alteration in natural communities	M	M	M	L	M	L
	Increased sedimentation/turbidity	M	M	L	M	M	L

Table 1 (Continued). Habitat Impact Categories in Coastal Development Workshop Session (n=14)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Wetland Dredging and Filling	Alteration/loss of habitat	H	H	L	H	H	L
	Loss of submerged aquatic vegetation	H	H	L	M	H	L
	Altered hydrological regimes	H	H	L	H	H	L
	Reduction of dissolved oxygen	M	M	L	M	M	L
	Release of nutrients/eutrophication	M	M	L	M	M	L
	Release of contaminants	M	M	L	M	M	L
	Altered tidal prism	M	M	L	M	M	L
	Altered current patterns	M	M	L	M	M	L
	Altered temperature regimes	M	M	L	M	M	L
	Loss of wetlands	H	H	L	H	H	L
	Loss of fishery productivity	H	H	L	H	H	L
	Introduction of invasive species	M	M	L	M	M	L
	Loss of flood storage capacity	H	H	L	H	H	L
	Increased sedimentation/turbidity	M	M	L	M	M	L
Overwater Structures	Shading impacts to vegetation	M	M	L	M	M	L
	Altered hydrological regimes	M	M	L	M	M	L
	Contaminant releases	M	M	L	M	M	L
	Benthic habitat impacts	M	M	L	M	M	L
	Increase erosion/accretion	M	M	L	M	M	L
	Eutrophication due to bird roosting	M	M	L	M	M	L
	Shellfish closures due to bird roosting	H	M	L	M	M	L
	Changes in predator/prey interactions	H	H	L	H	H	L
Pile Driving and Removal	Energy Impacts	M	M	L	M	M	L
	Benthic habitat impacts	M	M	L	M	M	L
	Increased sedimentation/turbidity	M	M	L	M	M	L
	Contaminant releases	M	M	L	M	M	L
	Shading impacts to vegetation	M	M	L	M	M	L
	Changes in hydrological regimes	M	M	L	M	M	L
	Changes in species composition	M	M	L	M	M	L
Marine Debris	Entanglement	M	M	L	M	M	L
	Ingestion	L	M	L	M	M	M
	Contaminant releases	L	M	L	L	M	M
	Introduction of invasive species	M	M	L	M	M	M
	Introduction of pathogens	L	M	L	L	M	M
	Conversion of habitat	L	M	L	L	M	L

Table 2. Habitat Impact Categories in Energy-Related Activities Workshop Session (n=13)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Petroleum Exploration, Production and Transportation	Underwater noise	M	M	M	M	M	M
	Habitat conversion	H	H	H	H	H	M
	Loss of benthic habitat	M	H	M	M	M	M
	Contaminant discharge	M	H	M	M	H	M
	Discharge of debris	M	M	M	M	M	L
	Oil spills	H	H	H	H	H	H
	Siltation/sedimentation/turbidity	M	M	M	M	M	M
	Resuspension of contaminants	M	H	M	M	M	L
	Impacts from clean-up activities	H	H	M	M	H	M
Liquified Natural Gas	Habitat conversion	H	H	M	M	M	M
	Loss of benthic habitat	H	H	M	M	M	L
	Discharge of contaminants	H	H	H	H	H	H
	Discharge of debris	M	M	M	M	M	L
	Siltation/sedimentation/turbidity	M	H	M	M	M	M
	Resuspension of contaminants	M	H	M	M	H	L
	Entrainment/Impingement	M	M	M	M	H	M
	Alteration in temperature regimes	M	M	L	M	M	L
	Alteration of hydrological regimes	M	M	L	M	M	L
	Underwater noise	M	M	M	H	H	M
	Release of contaminants	H	H	M	H	H	M
	Exclusion zone impacts	M	M	L	M	M	L
	Physical barriers to habitat	M	M	M	M	M	L
	Introduction of invasive species	H	H	M	H	M	M
	Vessel impacts	H	H	L	M	M	L
	Benthic impacts from pipelines	H	H	M	M	M	M
Offshore Wind Energy Facilities	Loss of benthic habitat	M	H	H	L	M	M
	Habitat conversion	M	H	H	L	M	M
	Siltation/sedimentation/turbidity	L	M	M	L	M	M
	Resuspension of contaminants	L	M	L	L	M	L
	Alteration of hydrological regimes	L	M	M	L	M	M
	Altered current patterns	L	M	M	L	M	M
	Alteration of electromagnetic fields	L	L	L	L	L	L
	Underwater noise	L	L	M	L	M	H
	Alteration of community structure	M	H	M	L	H	M
	Erosion around structure	L	M	M	L	L	L
	Spills associated w/ service structure	M	H	M	L	M	M

Table 2 (Continued). Habitat Impact Categories in Energy-Related Activities Workshop Session (n=13)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Wave/Tidal Energy Facilities	Habitat conversion	H	H	M	M	M	M
	Loss of benthic habitat	H	H	M	M	M	L
	Siltation/sedimentation/turbidity	M	H	M	M	M	L
	Resuspension of contaminants	M	M	L	M	M	L
	Alteration of hydrological regimes	M	M	M	M	H	L
	Altered current patterns	M	M	M	M	H	M
	Entrainment/Impingement	M	M	L	H	H	M
	Impacts to migration	M	M	L	H	M	L
	Electromagnetic fields	L	L	L	L	L	L
Cables and Pipelines	Loss of benthic habitat	H	H	M	L	M	L
	Habitat conversion	H	H	M	M	M	M
	Siltation/sedimentation/turbidity	M	H	M	M	M	M
	Resuspension of contaminants	H	H	M	M	M	M
	Altered current patterns	M	M	M	L	M	L
	Alteration of electromagnetic fields	L	L	L	L	L	L
	Underwater noise	L	L	L	L	M	M
	Alteration of community structure	M	M	M	M	M	M
	Erosion around structure	L	M	M	L	M	M
	Biocides from hydrostatic testing	M	M	M	M	M	M
	Spills associated w/ service structure	H	H	M	M	M	M
	Physical barriers to habitat	H	H	H	L	L	L
	Impacts to SAV	M	H	M	M	M	L
	Water withdrawal	M	M	L	H	H	L
	Impacts from construction activities	M	H	H	M	M	M
	Impact from maintenance activities	M	M	M	L	M	M
	Thermal impacts associated with cables	L	L	L	L	L	L
	Impacts associated with armoring of pipe	M	M	M	L	L	L
	Impacts to migration	H	H	H	L	L	L

Table 3. Habitat Impact Categories in Alteration of Freshwater Systems Workshop Session (n=13)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Dam Construction /Operation	Impaired fish passage	H	H	L	H	H	L
	Altered hydrological regimes	H	H	L	H	M	L
	Altered temperature regimes	H	H	L	H	M	L
	Altered sediment/LWD transport	H	M	L	H	M	L
	Altered stream morphology	H	M	L	H	M	L
	Altered stream bed characteristics	H	M	L	H	M	L
	Reduced dissolved oxygen	H	M	L	H	M	L
	Alteration of extent of tide	H	H	L	H	H	L
	Alteration of wetlands	H	H	L	H	H	L
	Change in species communities	H	M	L	H	M	L
	Bank erosion due to drawdown	M	L	L	M	L	L
	Riparian zone development	H	M	L	H	M	L
	Acute temperature shock	H	M	L	H	M	L
Dam Removal	Release of contaminated sediments	H	H	L	H	M	L
	Alteration of wetlands	H	M	L	H	M	L
Stream Crossings	Impacts to fish passage	H	M	L	H	M	L
	Alteration of hydrological regimes	H	M	L	H	M	L
	Bank erosion	H	L	L	M	L	L
	Habitat conversion	H	M	L	H	M	L
Water Withdrawal/ Diversion	Entrainment & Impingement	M	M	L	H	M	L
	Impaired fish passage	H	H	L	H	H	L
	Altered hydrological regimes	H	M	L	H	M	L
	Reduced dissolved oxygen	H	M	L	H	M	L
	Altered temperature regimes	H	H	L	H	M	L
	Release of nutrients/eutrophication	H	M	L	H	M	L
	Release of contaminants	H	M	L	H	M	L
	Altered stream morphology	H	L	L	H	M	L
	Altered stream bed characteristics	H	M	L	H	M	L
	Siltation/sedimentation/turbidity	H	M	L	H	M	L
	Change in species communities	H	M	L	H	H	L
	Alteration in groundwater levels	H	L	L	H	L	L
	Loss of forested/palustrine wetlands	H	L	L	H	L	L
	Impacts to water quality	H	M	L	H	M	L
	Loss of flood storage	M	L	L	M	L	L

Table 3 (Continued). Habitat Impact Categories in Alteration of Freshwater Systems Workshop Session (n=13)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Dredging and Filling, Mining	Reduced flood water retention	H	M	L	H	M	L
	Reduced nutrient uptake and release	M	M	L	M	M	L
	Reduced detrital food source	H	M	L	M	M	L
	Altered hydrological regimes	H	M	L	H	M	L
	Increased storm water runoff	H	M	L	H	M	L
	Loss of riparian and riverine habitat	H	M	L	H	M	L
	Altered stream morphology	H	M	L	H	L	L
	Altered stream bed characteristics	H	M	L	H	M	L
	Siltation/sedimentation/turbidity	H	M	L	H	M	L
	Reduced dissolved oxygen	H	M	L	H	M	L
	Altered temperature regimes	H	M	L	H	M	L
	Release of nutrients/eutrophication	H	M	L	H	H	L
	Release of contaminants	H	M	L	H	M	L
	Loss of SAV	H	H	L	H	H	L
	Change in species communities	H	H	L	H	M	L

Table 4. Habitat Impact Categories in Marine Transportation Workshop Session (n=18)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Construction and Expansion of Ports and Marinas	Loss of benthic habitat	H	H	H	M	M	M
	Siltation/sedimentation/turbidity	H	H	M	M	M	M
	Contaminant releases	H	H	M	M	H	M
	Altered hydrological regimes	H	H	L	H	H	L
	Altered tidal prism	M	H	L	M	H	L
	Altered current patterns	M	M	L	M	M	L
	Altered temperature regimes	H	M	L	H	M	L
	Loss of wetlands	H	H	L	H	H	L
	Underwater blasting/noise	M	M	L	M	M	M
	Loss of submerged aquatic vegetation	H	H	M	H	H	M
	Conversion of substrate/habitat	H	H	M	M	M	M
	Loss of intertidal flats	H	H	L	L	M	L
	Loss of water column	M	M	L	H	H	L
	Altered light regime	M	M	L	M	M	L
	Derelict structures	M	M	L	M	M	L
Operations and Maintenance of Ports and Marinas	Contaminant releases	H	H	M	M	M	M
	Storm water runoff	H	H	M	M	M	L
	Underwater noise	M	M	L	M	M	L
	Alteration of light regimes	M	M	L	M	M	L
	Derelict structures	M	M	L	L	L	L
	Mooring impacts	M	M	L	L	L	L
	Release of debris	M	M	L	M	L	L
Operation and Maintenance of Vessels	Impacts to benthic habitat	H	H	L	M	M	L
	Resuspension of bottom sediments	M	M	L	M	M	L
	Erosion of shorelines	M	M	L	M	M	L
	Contaminant spills and discharges	M	H	M	M	H	M
	Underwater noise	M	M	M	M	M	M
	Derelict structures	M	M	L	L	L	L
	Increased air emissions	L	L	L	L	L	L
	Release of debris	M	M	L	L	L	L
Navigation Dredging	Conversion of substrate/habitat	H	H	M	M	M	L
	Loss of submerged aquatic vegetation	H	H	M	H	H	L
	Siltation/sedimentation/turbidity	H	H	M	H	M	L
	Contaminant releases	H	H	M	M	M	M
	Release of nutrients/eutrophication	M	M	M	M	M	L
	Entrainment and impingement	M	M	M	M	M	L
	Underwater blasting/noise	M	M	L	M	M	L
	Altered hydrological regimes	H	H	L	H	M	L
	Altered tidal prism	M	M	L	M	M	L
	Altered current patterns	M	M	L	M	M	L
	Altered temperature regimes	H	H	L	M	M	L
	Loss of intertidal flats	H	H	L	H	H	L
	Loss of wetlands	H	H	L	H	H	L
	Contaminant source exposure	M	M	M	M	M	L

Table 5. Habitat Impact Categories in Offshore Dredging and Disposal Workshop Session (n=22)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Offshore Mineral Mining	Loss of benthic habitat types	L	L	H	L	L	M
	Conversion of substrate/habitat	L	L	H	L	L	L
	Siltation/sedimentation/turbidity	L	L	M	L	L	M
	Changes in bottom topography	L	L	M	L	L	L
	Changes in sediment composition	L	L	H	L	L	L
	Sediment transport from site (erosion)	L	L	M	L	L	L
	Impacts to water quality	L	L	M	L	L	M
	Release of contaminants	L	L	M	L	L	M
	Change in community structure	L	L	H	L	L	M
	Changes in water flow	L	L	M	L	L	M
	Noise impacts	L	L	L	L	L	M
Petroleum Extraction	Contaminant releases	L	L	H	L	L	H
	Drilling mud impacts	L	L	H	L	L	H
	Siltation/sedimentation/turbidity	L	L	M	L	L	M
	Release of debris	L	L	M	L	L	L
	Noise impacts	L	L	M	L	L	M
	Changes in light regimes	L	L	M	L	L	M
	Habitat conversion	L	L	M	L	L	M
	Pipeline installation	L	L	M	L	L	L
Offshore Dredge Material Disposal	Burial/disturbance of benthic habitat	L	M	H	L	L	M
	Conversion of substrate/habitat	L	L	H	L	L	M
	Siltation/sedimentation/turbidity	L	L	M	L	L	M
	Release of contaminants	L	L	M	L	L	M
	Release of nutrients/eutrophication	L	L	M	L	L	M
	Altered hydrological regimes	L	L	M	L	L	M
	Altered current patterns	L	L	M	L	L	M
	Changes in bottom topography	L	L	M	L	L	L
	Changes in sediment composition	L	L	H	L	L	L
	Changes in water bathymetry	L	L	M	L	L	L
Fish Waste Disposal	Introduction of pathogens	L	L	H	L	L	H
	Release of nutrients/eutrophication	L	L	H	L	L	H
	Release of biosolids	L	L	H	L	L	M
	Loss of benthic habitat types	L	L	H	L	L	L
	Behavioral affects	L	L	M	L	L	M
Vessel Disposal	Release of contaminants	L	L	M	L	L	M
	Conversion of substrate/habitat	L	L	H	L	L	M
	Changes in bathymetry	L	L	M	L	L	L
	Changes in hydrodynamics	L	L	M	L	L	M
	Changes in community structure	L	L	H	L	L	M
	Impacts during deployment	L	L	M	L	L	M
	Release of debris	L	L	M	L	L	L

Table 6. Habitat Impact Categories in Chemical Effects: Water Discharge Facilities Workshop Session (n=19)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Sewage Discharge Facilities	Release of nutrients/eutrophication	H	H	H	H	H	H
	Release of contaminants	H	H	H	H	H	H
	Impacts to SAV	H	H	M	H	H	M
	Reduced dissolved oxygen	H	H	M	H	H	M
	Siltation/sedimentation/turbidity	H	H	M	H	H	M
	Impacts to benthic habitat	H	H	M	M	M	M
	Changes in species composition	H	H	M	H	H	M
	Trophic level alterations	H	H	M	H	H	M
	Introduction of pathogens	H	H	M	M	H	M
	Introduction of harmful algal blooms	H	H	H	H	H	M
	Bioaccumulation/biomagnification	H	H	H	H	H	M
	Behavioral avoidance	M	H	M	M	H	M
	Release of pharmaceuticals	M	M	M	M	M	M
Industrial Discharge Facilities	Alteration in water alkalinity	H	M	M	M	M	L
	Release of heavy metals	H	H	M	M	M	M
	Release of chlorine compounds	H	H	M	H	H	M
	Release of pesticides	H	H	M	H	H	M
	Release of organic compounds	H	H	H	M	H	M
	Release of petroleum products	H	H	M	M	H	M
	Release of inorganic compounds	H	H	M	H	H	M
	Release of organic wastes	M	M	M	M	M	M
	Introduction of pathogens	M	M	M	M	M	M
Combined Sewer Overflows	Potential for all of the above effects	H	H	H	H	H	H

Table 7. Habitat Impact Categories in Physical Effects: Water Intake and Discharge Facilities Workshop Session (n=11)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Discharge Facilities	Scouring of substrate	M	M	L	L	L	L
	Turbidity/sedimentation	H	H	M	M	M	L
	Alteration of sediment composition	H	H	M	L	L	L
	Reduced dissolved oxygen	H	H	M	H	H	L
	Alteration of salinity regimes	H	H	L	H	H	M
	Alteration of temperature regimes	H	H	M	H	H	M
	Conversion/loss of habitat	M	M	M	M	M	M
	Habitat exclusion/avoidance	H	H	L	H	H	L
	Restrictions to migration	H	H	L	H	H	L
	Acute toxicity	M	H	M	H	H	M
	Behavioral changes	M	M	L	M	M	L
	Cold shock	M	M	M	H	M	L
	Stunting of growth in fishes	M	M	L	M	M	L
	Attraction to flow	H	H	M	H	H	M
	Alteration of community structure	H	H	M	H	H	M
	Changes in local current patterns	M	M	L	M	M	L
	Physical/chemical synergies	M	H	M	M	M	M
	Increased need for dredging	H	H	L	H	H	L
	Ballast water discharge	H	H	M	M	M	M
	Gas-bubble disease/mortality	M	M	L	M	H	L
	Release of radioactive wastes	H	H	M	H	H	M
Intake Facilities	Entrainment/impingement	H	H	H	H	H	H
	Alteration of hydrological regimes	H	H	M	H	H	L
	Flow restrictions	H	H	L	H	H	L
	Construction related impacts	H	M	M	M	M	M
	Conversion/loss of habitat	H	H	M	H	H	M
	Seasonal loss of habitat	M	M	L	M	M	M
	Backwash (cleaning of system)	M	M	L	M	M	L
	Alteration of community structure	H	H	L	H	H	L
	Increased need for dredging	H	H	M	H	H	L
	Ballast water uptake	H	H	M	H	H	M

Table 8. Habitat Impact Categories in Agriculture and Silviculture Workshop Session (n=11)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC) LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Cropland, Rangelands, Livestock and Nursery Operations	Release of nutrients/eutrophication	H	H	L	H	H	L
	Bank/soil erosion	H	H	L	M	M	L
	Altered temperature regimes	M	M	L	M	M	L
	Siltation/sedimentation/turbidity	H	H	L	H	H	L
	Altered hydrological regimes	M	M	L	M	M	L
	Entrainment & Impingement	M	L	L	H	L	L
	Impaired fish passage	M	L	L	H	M	L
	Reduced soil infiltration	M	L	L	M	L	L
	Release of pesticides	H	H	L	H	M	L
	Reduced dissolved oxygen	H	M	L	H	M	L
	Soil compaction	M	M	L	M	L	L
	Loss/alteration of wetlands	H	H	L	M	M	L
	Land-use change (post agriculture)	H	M	L	H	M	L
	Introduction of invasive species	M	M	L	M	L	L
	Introduction of pathogens	H	M	L	M	M	L
	Endocrine disruptors	H	H	L	H	H	L
	Change of community structure	M	M	L	M	M	L
	Change in species composition	H	M	L	M	M	L
Silviculture and Timber Harvest Activities	Reduced soil infiltration	M	M	L	M	L	L
	Siltation/sedimentation/turbidity	H	M	L	H	M	L
	Altered hydrological regimes	M	M	L	M	M	L
	Impaired fish passage	M	L	L	H	M	L
	Bank/soil erosion	H	M	L	H	M	L
	Altered temperature regimes	H	M	L	H	M	L
	Release of pesticides	H	H	L	H	H	L
	Release of nutrients/eutrophication	H	H	L	H	H	L
	Reduced dissolved oxygen	H	M	L	H	M	L
	Loss/alteration of wetlands	H	M	L	H	M	L
	Soil compaction	M	L	L	M	L	L
Timber and Paper Mill Processing Activities	Chemical contamination release	H	H	L	H	H	L
	Entrainment & Impingement	M	L	L	H	M	L
	Thermal discharge	H	L	L	M	L	L
	Reduced dissolved oxygen	H	M	L	H	M	L
	Conversion of benthic substrate	H	M	L	M	L	L
	Loss/alteration of wetlands	M	M	L	M	M	L
	Alteration of light regimes	M	L	L	M	L	L

Table 9. Habitat Impact Categories in Introduced/Nuisance Species and Aquaculture Workshop Session (n=14)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Introduced/ Nuisance Species	Habitat alterations	H	H	M	M	M	M
	Trophic alterations	M	H	M	M	M	M
	Gene pool alterations	H	H	M	H	H	M
	Alterations to communities	H	H	M	M	H	M
	Introduced diseases	M	H	M	M	H	M
	Changes in species diversity	H	H	H	H	H	M
	Alteration in health of native species	M	M	M	M	M	M
	Impacts to water quality	M	M	M	M	M	M
Aquaculture	Discharge of organic waste	M	H	M	M	M	M
	Seafloor impacts	M	H	M	M	M	M
	Introduction exotic invasive species	H	H	M	M	H	M
	Food web impacts	H	H	M	H	H	M
	Gene pool alterations	H	H	M	H	M	M
	Impacts to water column	M	M	M	M	H	M
	Impacts to water quality	M	H	L	M	H	M
	Changes in species diversity	M	H	M	M	H	M
	Sediment deposition	H	H	M	L	L	L
	Introduction of diseases	M	H	M	M	M	M
	Habitat replacement/exclusion	H	H	M	M	M	L
	Habitat conversion	H	H	M	M	H	M

Table 10. Habitat Impact Categories in Global Effects and Other Impacts Workshop Session (n=17)

IMPACT TYPE	POTENTIAL EFFECTS	HABITAT IMPACT CATEGORIES (HIC)					
		LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Climate Change	Alteration of hydrological regimes	H	H	M	H	H	H
	Alteration of temperature regimes	H	H	H	H	H	H
	Changes in dissolved oxygen	H	H	M	H	H	M
	Nutrient loading/eutrophication	M	H	M	M	M	M
	Release of contaminants	H	H	M	M	M	M
	Bank/soil erosion	H	M	L	M	M	L
	Alteration in salinity	M	H	M	M	H	M
	Alteration of weather patterns	H	H	M	H	H	H
	Alteration in alkalinity	M	M	M	M	M	M
	Changes in community structure	H	H	H	H	H	H
	Changes in ocean/coastal use	M	M	M	M	M	M
	Changes in ecosystem structure	M	H	L	M	H	L
	Loss of wetlands	H	H	L	H	H	L
Ocean Noise	Mechanical injury to organisms	M	M	H	M	M	H
	Impacts to feeding behavior	M	M	M	M	M	M
	Impacts to spawning behavior	M	M	M	M	M	M
	Impacts to migration	M	M	M	M	M	M
	Exclusion of organisms to habitat	M	M	M	M	M	M
	Changes in community structure	M	M	M	M	M	M
Atmospheric Deposition	Nutrient loading/eutrophication	H	H	M	H	H	M
	Mercury loading/bioaccumulation	H	H	M	H	H	H
	PCB's and other contaminants	H	H	M	H	H	M
	Alteration to ocean alkalinity	M	M	M	M	M	M
	Alteration of climatic cycle	M	M	M	M	M	M
Military/ Security Activities	Exclusion of organisms to habitat	L	L	M	L	M	M
	Noise impacts	M	M	M	M	M	H
	Chemical releases	M	H	M	M	M	M
	Impacts to tidal/intertidal habitats	M	M	L	L	M	L
	Blasting injuries from ordinances	M	M	M	M	M	M
Natural Disasters and Events	Loss/alteration of habitat	H	H	M	H	H	M
	Impacts to habitat from debris	M	M	M	M	M	L
	Impacts to water quality	M	H	M	H	H	M
	Impacts from emergency response	M	M	L	M	M	L
	Alteration of hydrological regimes	M	M	M	M	M	L
	Changes in community composition	M	H	M	M	M	M
	Underwater landslides	L	L	M	L	L	M
EMFs	Changes to migration of organisms	M	M	M	M	M	M
	Behavioral changes	M	M	M	M	M	M
	Changes in predator/prey relationships	L	M	M	M	M	M

Table 11. High Scoring Effects in Coastal Development Workshop Session (n=14)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Nonpoint Source Pollution and Urban Runoff	Nutrient loading/eutrophication	●	●		●	●	
	Loss/alteration of aquatic vegetation	●	●		●	●	
	Release of heavy metals	●	●			●	
	Release of pesticides	●	●		●	●	
	Release of pharmaceuticals	●			●	●	
	Alteration to temperature regimes	●			●		
	Sedimentation/turbidity	●	●		●	●	
Road Construction and Operation	Release of sediments in aquatic habitat	●					
	Increased sedimentation/turbidity	●	●		●	●	
	Impaired fish passage	●			●	●	
	Altered hydrological regimes	●	●		●	●	
	Altered temperature regimes	●			●		
	Altered stream morphology	●			●		
	Altered stream bed characteristics	●			●		
	Reduced dissolved oxygen	●	●		●	●	
	Loss/alteration of aquatic vegetation	●	●		●	●	
	Altered tidal regimes	●	●		●		
	Fragmentation of habitat	●			●	●	
Flood Control/ Shoreline Protection	Altered hydrological regimes	●	●		●		
	Altered stream morphology	●			●		
	Altered sediment transport	●	●		●	●	
	Alteration/loss of benthic habitat	●	●				
	Impaired fish passage	●			●		
	Alteration in natural communities	●					
	Impacts to riparian habitat	●			●		
	Loss of intertidal habitat	●	●			●	
	Reduced ability to counter sea level rise	●	●			●	
	Increased erosion/accretion	●	●		●	●	
Wetland Dredging and Filling	Alteration/loss of habitat	●	●		●	●	
	Loss of SAV	●	●			●	
	Altered hydrological regimes	●	●		●	●	
	Loss of wetlands	●	●		●	●	
	Loss of fishery productivity	●	●		●	●	
	Loss of flood storage capacity	●	●		●	●	
Overwater Structures	Shellfish closures due to bird roosting	●					
	Changes in predator/prey interactions	●	●		●	●	

Table 12. High Scoring Effects in Energy-Related Activities Workshop Session (n=13)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Petroleum Exploration, Production and Transportation	Habitat conversion	●	●	●	●	●	
	Loss of benthic habitat		●				
	Contaminant discharge		●			●	
	Oil spills	●	●	●	●	●	●
	Resuspension of contaminants		●				
	Impacts from clean-up activities	●	●			●	
Liquified Natural Gas	Habitat conversion	●	●				
	Loss of benthic habitat	●	●				
	Discharge of contaminants	●	●	●	●	●	●
	Siltation/sedimentation/turbidity		●				
	Resuspension of contaminants		●			●	
	Entrainment/Impingement					●	
	Alteration of hydrological regimes						
	Underwater noise				●	●	
	Release of contaminants	●	●		●	●	
	Physical barriers to habitat						
	Introduction of invasive species	●	●		●		
	Vessel impacts	●	●				
	Benthic impacts from pipelines	●	●				
Offshore Wind Energy Facilities	Loss of benthic habitat		●	●			
	Habitat conversion		●	●			
	Underwater noise						●
	Alteration of community structure		●			●	
	Spills associated w/ service structure		●				
Wave/Tidal Energy Facilities	Habitat conversion	●	●				
	Loss of benthic habitat	●	●				
	Siltation/sedimentation/turbidity		●				
	Alteration of hydrological regimes					●	
	Altered current patterns					●	
	Entrainment/Impingement				●	●	
	Impacts to migration				●		
Cables and Pipelines	Loss of benthic habitat	●	●				
	Habitat conversion	●	●				
	Siltation/sedimentation/turbidity		●				
	Resuspension of contaminants	●	●				
	Spills associated w/ service structure	●	●				
	Physical barriers to habitat	●	●	●			
	Impacts to SAV		●				
	Water withdrawal				●	●	
	Impacts from construction activities		●	●			
	Impacts to migration	●	●	●			

Table 13. High Scoring Effects in Alteration of Freshwater Systems Workshop Session (n=13)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Dam Construction /Operation	Impaired fish passage	●	●		●	●	
	Altered hydrological regimes	●	●		●		
	Altered temperature regimes	●	●		●		
	Altered sediment/LWD transport	●			●		
	Altered stream morphology	●			●		
	Altered stream bed characteristics	●			●		
	Reduced dissolved oxygen	●			●		
	Alteration of extent of tide	●	●		●	●	
	Alteration of wetlands	●	●		●	●	
	Change in species communities	●			●		
	Riparian zone development	●			●		
	Acute temperature shock	●			●		
Dam Removal	Release of contaminated sediments	●	●		●		
	Alteration of wetlands	●			●		
Stream Crossings	Impacts to fish passage	●			●		
	Alteration of hydrological regimes	●			●		
	Bank erosion	●					
	Habitat conversion	●			●		
Water Withdrawal/ Diversion	Entrainment & Impingement				●		
	Impaired fish passage	●	●		●	●	
	Altered hydrological regimes	●			●		
	Reduced dissolved oxygen	●			●		
	Altered temperature regimes	●	●		●		
	Release of nutrients/eutrophication	●			●		
	Release of contaminants	●			●		
	Altered stream morphology	●			●		
	Altered stream bed characteristics	●			●		
	Siltation/sedimentation/turbidity	●			●		
	Change in species communities	●			●	●	
	Alteration in groundwater levels	●			●		
	Loss of forested/palustrine wetlands	●			●		
	Impacts to water quality	●			●		

Table 13 (Continued). High Scoring Effects in Alteration of Freshwater Systems Workshop Session (n=13)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Dredging and Filling, Mining	Reduced flood water retention	●			●		
	Reduced detrital food source	●					
	Altered hydrological regimes	●			●		
	Increased storm water runoff	●			●		
	Loss of riparian and riverine habitat	●			●		
	Altered stream morphology	●			●		
	Altered stream bed characteristics	●			●		
	Siltation/sedimentation/turbidity	●			●		
	Reduced dissolved oxygen	●			●		
	Altered temperature regimes	●			●		
	Release of nutrients/eutrophication	●			●	●	
	Release of contaminants	●			●		
	Loss of SAV	●	●		●	●	
	Change in species communities	●	●		●		

Table 14. High Scoring Effects in Marine Transportation Workshop Session (n=18)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Construction and Expansion of Ports and Marinas	Loss of benthic habitat	●	●	●			
	Siltation/sedimentation/turbidity	●	●				
	Contaminant releases	●	●			●	
	Altered hydrological regimes	●	●		●	●	
	Altered tidal prism		●			●	
	Altered temperature regimes	●			●		
	Loss of wetlands	●	●		●	●	
	Loss of SAV	●	●		●	●	
	Conversion of substrate/habitat	●	●				
	Loss of intertidal flats	●	●				
	Loss of water column				●	●	
Operations and Maintenance of Ports and Marinas	Contaminant releases	●	●				
	Storm water runoff	●	●				
Operation and Maintenance of Vessels	Impacts to benthic habitat	●	●				
	Contaminant spills and discharges		●			●	
Navigation Dredging	Conversion of substrate/habitat	●	●				
	Loss of SAV	●	●		●	●	
	Siltation/sedimentation/turbidity	●	●		●		
	Contaminant releases	●	●				
	Altered hydrological regimes	●	●		●		
	Altered temperature regimes	●	●				
	Loss of intertidal flats	●	●		●	●	
	Loss of wetlands	●	●		●	●	

Table 15. High Scoring Effects in Offshore Dredging and Disposal Workshop Session (n=22)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Offshore Mineral Mining	Loss of benthic habitat types			●			
	Conversion of substrate/habitat			●			
	Changes in sediment composition			●			
	Change in community structure			●			
Petroleum Extraction	Contaminant releases			●			●
	Drilling mud impacts			●			●
Offshore Dredge Material Disposal	Burial/disturbance of benthic habitat			●			
	Conversion of substrate/habitat			●			
	Changes in sediment composition			●			
Fish Waste Disposal	Introduction of pathogens			●			●
	Release of nutrients/eutrophication			●			●
	Release of biosolids			●			
	Loss of benthic habitat types			●			
Vessel Disposal	Conversion of substrate/habitat			●			
	Changes in community structure			●			

Table 16. High Scoring Effects in Chemical Effects: Water Discharge Facilities Workshop Session (n=19)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Sewage Discharge Facilities	Release of nutrients/eutrophication	●	●	●	●	●	●
	Release of contaminants	●	●	●	●	●	●
	Impacts to SAV	●	●		●	●	
	Reduced dissolved oxygen	●	●		●	●	
	Siltation/sedimentation/turbidity	●	●		●	●	
	Impacts to benthic habitat	●	●				
	Changes in species composition	●	●		●	●	
	Trophic level alterations	●	●		●	●	
	Introduction of pathogens	●	●			●	
	Introduction of harmful algal blooms	●	●	●	●	●	
	Bioaccumulation/biomagnification	●	●	●	●	●	
	Behavioral avoidance		●			●	
Industrial Discharge Facilities	Alteration in water alkalinity	●					
	Release of heavy metals	●	●				
	Release of chlorine compounds	●	●		●	●	
	Release of pesticides	●	●		●	●	
	Release of organic compounds	●	●	●		●	
	Release of petroleum products	●	●			●	
	Release of inorganic compounds	●	●		●	●	
Combined Sewer Overflows	Potential for all of the above effects	●	●	●	●	●	●

Table 17. High Scoring Effects in Physical Effects: Water Intake and Discharge Facilities Workshop Session (n=11)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Discharge Facilities	Turbidity/sedimentation	●	●				
	Alteration of sediment composition	●	●				
	Reduced dissolved oxygen	●	●		●	●	
	Alteration of salinity regimes	●	●		●	●	
	Alteration of temperature regimes	●	●		●	●	
	Habitat exclusion/avoidance	●	●		●	●	
	Restrictions to migration	●	●		●	●	
	Acute toxicity		●		●	●	
	Cold shock				●		
	Attraction to flow	●	●		●	●	
	Alteration of community structure	●	●		●	●	
	Physical/chemical synergies		●				
	Increased need for dredging	●	●		●	●	
	Ballast water discharge	●	●				
	Gas-bubble disease/mortality					●	
	Release of radioactive wastes	●	●		●	●	
Intake Facilities	Entrainment/impingement	●	●	●	●	●	●
	Alteration of hydrological regimes	●	●		●	●	
	Flow restrictions	●	●		●	●	
	Construction related impacts	●					
	Conversion/loss of habitat	●	●		●	●	
	Alteration of community structure	●	●		●	●	
	Increased need for dredging	●	●		●	●	
	Ballast water uptake	●	●		●	●	

Table 18. High Scoring Effects in Agriculture and Silviculture Workshop Session (n=11)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Cropland, Rangelands, Livestock and Nursery Operations	Release of nutrients/eutrophication	●	●		●	●	
	Bank/soil erosion	●	●				
	Siltation/sedimentation/turbidity	●	●		●	●	
	Entrainment & Impingement				●		
	Impaired fish passage				●		
	Release of pesticides	●	●		●		
	Reduced dissolved oxygen	●			●		
	Loss/alteration of wetlands	●	●				
	Land-use change (post agriculture)	●			●		
	Introduction of pathogens	●					
	Endocrine disruptors	●	●		●	●	
	Change in species composition	●					
Silviculture and Timber Harvest Activities	Siltation/sedimentation/turbidity	●			●		
	Impaired fish passage				●		
	Bank/soil erosion	●			●		
	Altered temperature regimes	●			●		
	Release of pesticides	●	●		●	●	
	Release of nutrients/eutrophication	●	●		●	●	
	Reduced dissolved oxygen	●			●		
	Loss/alteration of wetlands	●			●		
Timber and Paper Mill Processing Activities	Chemical contamination release	●	●		●	●	
	Entrainment & Impingement				●		
	Thermal discharge	●					
	Reduced dissolved oxygen	●			●		
	Conversion of benthic substrate	●					

Table 19. High Scoring Effects in Introduced/Nuisance Species and Aquaculture Workshop Session (n=14)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Introduced/ Nuisance Species	Habitat alterations	●	●				
	Trophic alterations		●				
	Gene pool alterations	●	●		●	●	
	Alterations to communities	●	●			●	
	Introduced diseases		●			●	
	Changes in species diversity	●	●	●	●	●	
Aquaculture	Discharge of organic waste		●				
	Seafloor impacts		●				
	Introduction exotic invasive species	●	●			●	
	Food web impacts	●	●		●	●	
	Gene pool alterations	●	●		●		
	Impacts to water column					●	
	Impacts to water quality		●			●	
	Changes in species diversity		●			●	
	Sediment deposition	●	●				
	Introduction of diseases		●				
	Habitat replacement/exclusion	●	●				
	Habitat conversion	●	●			●	

Table 20. High Scoring Effects in Global Effects and Other Impacts Workshop Session (n=17)

IMPACT TYPE	POTENTIAL EFFECTS	LIFE HISTORY/ECOSYSTEM TYPE					
		Benthic/Demersal Stages			Pelagic Stages		
		Riverine	Estuarine/ Nearshore	Marine/ Offshore	Riverine	Estuarine/ Nearshore	Marine/ Offshore
Climate Change	Alteration of hydrological regimes	●	●		●	●	●
	Alteration of temperature regimes	●	●	●	●	●	●
	Changes in dissolved oxygen	●	●		●	●	
	Nutrient loading/eutrophication		●				
	Release of contaminants	●	●				
	Bank/soil erosion	●					
	Alteration in salinity		●			●	
	Alteration of weather patterns	●	●		●	●	●
	Changes in community structure	●	●	●	●	●	●
	Changes in ecosystem structure		●			●	
	Loss of wetlands	●	●		●	●	
Ocean Noise	Mechanical injury to organisms			●			●
Atmospheric Deposition	Nutrient loading/eutrophication	●	●		●	●	
	Mercury loading/bioaccumulation	●	●		●	●	●
	PCB's and other contaminants	●	●		●	●	
Military/ Security Activities	Noise impacts						●
	Chemical releases		●				
Natural Disasters and Events	Loss/alteration of habitat	●	●		●	●	
	Impacts to water quality		●		●	●	
	Changes in community composition		●				

COASTAL DEVELOPMENT

Introduction

Urban growth and development in the United States continues to expand in coastal areas at a rate approximately four times greater than in other areas of the country (Hanson *et al.* 2003). Although losses of coastal wetlands to development have decreased in the last several decades, the percentual rate of loss has remained similar to that of the 1920-1950 periods (Valiela *et al.* 2004). Losses of coastal wetlands were estimated to be at a rate of 0.2 percent per year from 1922-1954, while loss rates from 1982-1987 were approximately 0.18 percent per year (Valiela *et al.* 2004). The construction of urban, suburban, commercial, and industrial centers and corresponding infrastructure results in land use conversions typically resulting in vegetation removal and the creation of additional impervious surfaces. At least one study has correlated ecosystem-level changes with the addition of impervious surfaces in coastal, urbanized areas. Holland *et al.* (2004) found reduced abundance of stress-sensitive macroinvertebrates and altered food webs in headwater tidal creeks when impervious cover exceeded 20-30 percent land cover. However, measurable adverse changes in the physical and chemical environment were observed when the impervious cover exceeded 10-20 percent land cover (Holland *et al.* 2004). Runoff from impervious surfaces and storm sewers is the most widespread source of pollution into the Nation's waterways (USEPA 1995).

This chapter discusses the various sources of pollution, as well as other impacts to fishery habitat associated with coastal development. There are a number of impacts discussed in this chapter that overlap to some degree with other chapters of this report. We have attempted to minimize redundant information, and have provided the referenced to those chapters where the topic has been treated in more detail.

Nonpoint Source Pollution and Urban Runoff

The major threats to marine and aquatic habitats are a result of increasing human population and coastal development, which is contributing to an increase of human generated pollutant loads. These pollutants are being discharged directly into estuarine and coastal habitats by way of point and non-point sources of pollution (for point source pollution, see the chapters on Chemical and Physical Effects from Water Uptake and Discharge Facilities).

The U.S. Environmental Protection Agency (U.S. EPA) defines "nonpoint source" as anything that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act, which refers to "discernable, confined and discrete conveyance" from which pollutants are or may be discharged. Nonpoint source (NPS) pollution comes from many diffuse sources. Land runoff, precipitation, atmospheric deposition, seepage, and hydrologic modification are the major contributors of NPS pollution. The general categories of NPS pollution are: sediments, nutrients, acids and salts, heavy metals, toxic chemicals and pathogens. While all pollutants can become toxic at high enough levels, there are a number of compounds that can be toxic at relatively low levels. The U.S. EPA has identified and designated these compounds as "priority pollutants." Some of these "priority pollutants" include: 1) metals, such as cadmium, copper, chromium, lead, mercury, nickel, and zinc that arise from industrial operations, mining, transportation, and agriculture use; 2) organic compounds, such as pesticides, PCBs, solvents, petroleum hydrocarbons, organometallic compounds, phenols, formaldehyde, and biochemical methylation of metals in aquatic sediments; 3) dissolved gases, such as chlorine and ammonium; 4) Anions, such as cyanides, fluorides, sulfides, and sulphates; and 5) acids and alkalis (USEPA 2003a).

While the individual, cumulative and synergistic effects of all contaminants on the coastal ecosystem are relatively unknown, pollution may make these resources more susceptible to disease or impair reproductive success. While NPS is usually lower in intensity than an acute point source event, it may be more damaging to fish habitat in the long term. NPS may affect sensitive life stages and processes, is often difficult to detect, and the impacts may go unnoticed for a long time. When population impacts are finally detected, they may not be tied to any one event or source, and may be difficult to correct, clean up, or mediate. Increasing human populations and development within coastal regions generally leads to an increase in impervious surfaces, including but not limited to roads, residential and commercial development and parking lots. Impervious surfaces cause greater volumes of run-off and associated contaminants into aquatic and marine waters.

Urban runoff is generally difficult to control due to the intermittent nature of rainfall and runoff, the large variety of pollutant source types, and the variable nature of source loadings (Safavi 1996). The 2000 National Water Quality Inventory (USEPA 2002) reported that runoff from urban areas is the leading source of impairment in surveyed estuaries and the third largest source of impairment in surveyed lakes. Urban areas can have a chronic and insidious pollution potential that one-time events such as oil spills do not.

It's important to note that coastal pollution on fishery resources may not necessarily represent a serious, widespread threat to all species and life history stages. For example, species that spawn in areas that are relatively deep with strong bottom currents and well-mixed water may not be as susceptible to pollution as species that inhabit shallow, inshore areas near or within enclosed bays and estuaries. Similarly, species whose juvenile life history stages utilize shallow, inshore waters and rivers may be more prone to coastal pollution than species whose early life history stages develop in offshore, pelagic waters.

<u>Nutrient Loading and Eutrophication</u>

In the northeastern U.S., highly eutrophic conditions have been reported in a number of estuarine and coastal systems, including Boston Harbor, Long Island Sound, and Chesapeake Bay (Bricker *et al.* 1999). While much of the excess nutrients within coastal waters originate from sewage treatment plants, non-point sources of nutrients include municipal and agricultural run-off, contaminated groundwater and sediments, atmospheric deposition, septic systems, and wildlife feces (Hanson *et al.* 2003). Failing septic systems contribute to NPS pollution and are a negative consequence of urban development. The U.S. EPA estimates that 10 to 25 percent of all individual septic systems are failing at any one time, introducing feces, detergents, endocrine disruptors, and chlorine into the environment (Hanson *et al.* 2003). Sewage wastes contain significant amounts of organic matter that exert a biochemical oxygen demand, leading to eutrophication of coastal waters (Kennish 1998) (see also the chapter on Chemical Effects: Water Uptake and Discharge Facilities). O'Reilly (1994) found that extensive hypoxia has been more chronic in river-estuarine systems in the southern portions of the northeast U.S. coast (i.e., Narragansett Bay to Chesapeake Bay) than in the northern portion (except for episodic low dissolved oxygen in Boston Harbor/Charles River and the freshwater portion of the Merrimack River). The U.S. EPA's National Coastal Condition Report II (USEPA 2004) reported similar trends in northeast coast estuaries, except that it noted signs of degraded water quality in estuaries north of Cape Cod, MA. Although the U.S. EPA report found much of the Acadian Provinces (Maine and New Hampshire) to have good water quality conditions, it identified the Great Bay, New Hampshire as only having fair to poor conditions (USEPA 2004).

Organic contamination contained within urban runoff, particularly chlorinated and aromatic compounds, has been implicated in causing immuno-suppression in juvenile chinook salmon (Arkoosh *et al.* 2001). There is evidence that nutrient overenrichment has led to increased incidence, extent, and persistence of blooms and noxious or toxic species of phytoplankton; increased frequency, severity, spatial extent, and persistence of hypoxia; alterations in the dominant phytoplankton species and size compositions; and greatly increased turbidity of surface waters from plankton algae (O'Reilly 1994). See also the chapter on Introduced Species, Aquaculture and Other Biological Threats for more information on harmful algae blooms.

Severely eutrophic conditions may reduce submerged aquatic vegetation (SAV) (Goldsborough 1997), cause mass mortality of fish and invertebrates, and alter long-term natural community dynamics. The effect of constant and diurnally fluctuating levels of dissolved oxygen has been shown to reduce the growth of young-of-the-year winter flounder, *Pseudopleuronectes americanus* (Bejda *et al.* 1992). Short and Burdick (1996) correlated eelgrass losses in Waquoit Bay, Massachusetts, with anthropogenic nutrient loading primarily as a result of increased number of septic systems from housing developments in the watershed.

Introduction of Pathogens

Introduction of pathogens to aquatic habitats have become more common and widespread over the last 30 years and various factors may be responsible, including NPS pollution from highly urbanized areas (O'Reilly 1994). Fish diseases and shellfish poisoning (i.e., paralytic, amnesic, and neurotoxic) may be linked to municipal and agricultural runoff. The introduction of coliform bacteria from leaking septic systems, agricultural manure, domestic animals and wildlife can lead to closed beaches and shellfish harvesting area closures.

Sedimentation and Turbidity

Land runoff due to coastal development can result in an unnatural influx of suspended particles from soil erosion having negative effects on riverine, nearshore and estuarine ecosystems. Impacts associated with increased suspended particles in aquatic habitats include high turbidity levels, reduced light transmittance, and sedimentation which may lead to the loss of SAV and other benthic structure. Other effects from elevated suspended particles include disruption in the respiration of fishes and other aquatic organisms, reduction in filtering efficiencies and respiration of invertebrates, reduction of egg buoyancy, disruption of ichthyoplankton development, reduction of growth and survival of filter feeders, and decreased foraging efficiency of sight-feeders (Messieh *et al.* 1991; Wilber and Clarke 2001). For example, Breitburg (1988) found the predation rates of striped bass larvae on copepods to decrease by 40 percent when exposed to high turbidity conditions in the laboratory.

Release of Petroleum Products

Petroleum products consist of thousands of chemical compounds that can be toxic to marine life (Kennish 1998). Polycyclic aromatic hydrocarbons (PAH) can be particularly damaging to marine biota due to their extreme toxicity, rapid uptake, and persistence in the environment (Kennish 1998). PAHs have been found to be significantly higher in urbanized watershed when compared to a non-urbanized watershed (Fulton *et al.* 1993). By far, the largest amount of petroleum released through human activity comes from the use of petroleum products (e.g., cars, boats, paved urban areas, and two-stoke engines) (ASMFC 2004). Most of the petroleum consumption activities are land-based; however, rivers and storm and wastewater streams carry the petroleum to marine environments such as estuaries and bays. Although individual petroleum product releases are small, they are widespread and common and when combined, they contribute nearly 85 percent of the total input from human activities (ASMFC 2004).

Petroleum products can be a major stressor on inshore fish habitats. Short-term impacts include interference with the reproduction, development, growth and behavior (e.g. spawning, feeding) of fishes, especially early life-history stages (Gould *et al.* 1994). PAHs can degrade aquatic habitat, consequently interfering with biotic communities and may be discharged into rivers from non-point sources, including municipal run-off and contaminated sediments. Oil has been shown to disrupt the growth of vegetation in estuarine habitats (Lin and Mendelssohn 1996). Although oil is toxic to all marine organisms at high concentrations, certain species are more sensitive than others and, in general, the early life stages (eggs and larvae) of organisms are most sensitive (Gould et al. 1994; Rice *et al.* 2000).

Oil spills may cover and degrade coastal habitats and associated benthic communities, or may produce a slick on the surface waters which disrupts the pelagic community. The water column may be polluted with oil as a result of wave action and currents dispersing the oil. Benthic habitat and the shoreline can be covered and saturated with oil, leading to the protracted damage of aquatic communities, including the disruption of population dynamics. Oil can persist in sediments for decades after the initial contamination, causing disruption in physiological and metabolic processes of demersal fishes (Vandermeulen and Mossman 1996). These changes may lead to disruption of community organization and dynamics in affected regions, and permanently diminishing fishery habitat. Carcinogenic and mutagenic properties of oil compounds have been identified (Larsen 1992; Gould *et al.* 1994). For more detail on oil spills, see the Chapter on Energy Related Activities.

Alteration of Water Alkalinity

Fishery resources are known to be sensitive to changes in water alkalinity. Freshwater rivers and the brackish waters of estuaries are especially sensitive to acid effluents due to the lower buffering capacity of the higher salinity, oceanic waters. The influx of pH altering flows to aquatic habitats can hinder the survival and sustainability of fisheries. Municipal run-off, contaminated groundwater, and atmospheric deposition are potential non-point sources of acid influx to aquatic habitats. Acidification may disrupt or prevent reproduction, development and growth of fish (USFWS and NMFS 1999). For example, osmoregulatory problems in Atlantic salmon smolts have been demonstrated to be related to habitats with low pH (Staurnes *et al.* 1996). Low pH in estuarine waters has been shown to cause cellular changes in the muscle tissues of Atlantic herring, which may lead to a reduction in swimming ability (Bahgat *et al.* 1989).

Alteration to Temperature Regimes

Alteration of natural temperature regimes can occur in riverine and estuarine ecosystems due to land runoff from urbanized areas. Radiant heating from impervious surfaces, such as concrete and asphalt can increase the water temperature of stream, rivers and bays. The removal of shoreline and riparian vegetation can reduce shading effects and raise the water temperature of creeks and ponds that drain into larger water bodies. Temperature influences biochemical processes, behavior (e.g., migration), and physiology of aquatic organisms (Blaxter 1969), and long-term thermal pollution may change natural community dynamics.

Release of Heavy Metals

Heavy metal contaminants are found in the water column and can persist in the sediments of coastal habitat, including urbanized areas, as well as fairly uninhabited regions, and are a potential environmental threat (Larsen 1992; Readman *et al.* 1993; Buchholtz ten Brink *et al.* 1996). High levels of metals, such as mercury, copper, and arsenic, are found in the sediments of New England estuaries due to past industrial activity (Larsen 1992), and may be released into the water column during navigation channel dredging or made available to organisms as a result of storm events. Some activities associated with shipyards and marinas have been identified as sources of heavy metals in the sediments and surface waters of coastal areas (Milliken and Lee 1990; USEPA 2001; Amaral *et al.* 2005). These include copper, tin and arsenic from boat hull painting and scraping, hull washing and wood preservatives. Treated wood used for pilings and docks releases copper compounds that are applied to preserve the wood (Poston 2001; Weis and Weis 2002). These chemicals can become available to marine organisms through uptake by wetland vegetation, adsorption by adjacent sediments, or directly through the water column (Weis and Weis 2002). Refer to the Overwater Structures section of this chapter for more information on treated wood products and their affects on aquatic organisms. Urban stormwater runoff often contains heavy metals from automobile and industrial facilities, such as mercury, lead (used in batteries), and nickel and cadmium (used in brake linings). Refer to the chapter on Marine Transportation for more information on channel dredging and storm water impacts from marinas and shipyards.

Heavy metals may initially inhibit reproduction and development of marine organisms, but at high concentrations, they can directly contaminate or kill fish and invertebrates. Shifts in phytoplankton species composition may occur due to heavy metal accumulation, which may lead to an alteration of community structure by replacing indigenous producers with species of less value as a food source to the trophic and community structure (NEFMC 1998). Heavy metals are known to produce a number of toxic effects to marine fish species, including skeletal deformities in Atlantic cod from cadmium exposure (Lang and Dethlefsen 1987), larval developmental deformities in haddock from copper exposure (Bodammer 1981) and reduced viable hatch rates in winter flounder embryos and increased larval mortality from silver exposure (Klein-MacPhee *et al.* 1984). Laboratory experiments have shown high mortality of Atlantic herring eggs and larvae at copper concentrations of 30 µg/L and 1,000 µg/L, respectively, and vertical migration of larvae was impaired at copper concentrations of greater than 300 µg/L (Blaxter 1977). Copper may also bioaccumulate in bacteria and phytoplankton (Milliken and Lee 1990). Heavy metals have been implicated in disrupting endocrine secretions of aquatic organisms, potentially disrupting natural physiological processes (Brodeur *et al.* 1997). While long-term impacts do not appear significant in most marine organisms, heavy metals may move upward through trophic levels and accumulate in fish (bioaccumulation) at levels that can eventually cause health problems in human consumers (NEFMC 1998). See also Global Effects and other Impacts chapter for Mercury Loading/Bioaccumulation via the atmosphere.

<u>Release of Radioactive Wastes</u>

Radioactive wastes may be a potential threat to aquatic habitats used by fish and shellfish species. Fishery resources may accumulate radioactive isotopes in tissues that could lead to negative effects on the resource and consumers (ICES 1991). Potential sources of radioactive wastes are urban stormwater runoff, municipal landfills, atmospheric deposition, contaminated groundwater and sediments [e.g., past offshore dumping locations (NEFMC 1998)].

<u>Release of Pesticides and Herbicides</u>

Although agricultural run-off is a major NPS for pesticides, residential areas are also a notable source (See Agriculture and Silviculture chapter for a discussion on agricultural sources of pesticides). Other NPS sources of pesticide discharge into coastal waters include atmospheric deposition and contaminated groundwater (Meyers and Hendricks 1982). Pesticides may bioaccumulate in the ecosystem by retention in sediments and detritus then ingested by macroinvertebrates, which in turn are eaten by larger invertebrates and fish (e.g., Pleuronectiformes) (ASMFC 1992). For example, winter flounder, *Pseudopleuronectes americanus,* livers from Boston and Salem Harbors in Massachusetts contained the highest concentrations of DDT found on the east coast of the U.S. and were ranked first and third, respectively, in the country in terms of total pesticides (Larsen 1992).

There are three basic ways that pesticides can adversely affect the health and productivity of fisheries: 1) a direct toxicological impact on the health or performance of exposed fish; 2) an indirect impairment of the productivity of aquatic ecosystems; and 3) a loss of habitat (e.g., aquatic vegetation) that provides physical shelter for fish and invertebrates (Hanson *et al.* 2003).

For many marine organisms, the majority of effects from pesticide exposures are sublethal, meaning that the exposure does not directly lead to the mortality of individuals. Sublethal effects can be a concern, as they impair the physiological or behavioral performance of individual animals in ways that decrease their growth or survival, alter migratory behavior, or reduce reproductive success (Hanson *et al.* 2003). Early development and growth of organisms involve important physiological processes and include the endocrine, immune, nervous, and reproductive systems. Many pesticides have been shown to impair one or more of these physiological processes in fish (Moore and Waring 2001; Gould *et al.* 1994). For example, evidence has shown that DDT and its chief metabolic by-product, DDE, can act as estrogenic compounds, either by mimicking estrogen or by inhibiting androgen effectiveness (Gilbert 2000). DDT has been shown to cause deformities in winter flounder eggs and embryos and larvae in Atlantic cod (Gould *et al.* 1994). Generally, however, the sublethal impacts of pesticides on fish health are poorly understood.

The direct and indirect effects that pesticides have on fish and other aquatic organisms can be a key factor in determining the impacts on the structure and function of ecosystems (Preston 2002). This includes impacts on primary producers (Hoagland *et al.* 1996) and aquatic microorganisms (DeLorenzo *et al.* 2001), as well as macroinvertebrates that are prey species for fish. Since pesticides are specifically designed to kill insects, it is not surprising that these chemicals are relatively toxic to insects and crustaceans that inhabit river systems and estuaries. The use of pesticides to control mosquitoes has been implicated as a causative agent in the mass mortality of American lobsters in Long Island Sound during 1999 (Balcom and Howell 2006). Recent lab studies have shown that lobsters are considerably more sensitive to the effects of the mosquito adulticide, malathion, than any other species previously tested. Sublethal effects (i.e., impairment of immune response and stress hormone production) occur at concentrations in parts per billion and at concentrations much lower than those observed to cause lethal effects (Balcom and Howell 2006).

Herbicides may alter long-term natural community structure by hindering aquatic plant growth or destroying aquatic plants. Hindering plant growth can have notable effects on fish and invertebrate populations by limiting nursery and forage habitat. Chemicals used in herbicides may also be endocrine disrupters, exogenous chemicals that interfere with the normal function of hormones (NEFMC 1998). Coastal development and water diversion projects contribute substantial levels of herbicides entering fish and shellfish habitat. The major NPS are municipal run-off, contaminated groundwater, and atmospheric deposition (Goldsborough 1997). A variety of human activities such as noxious weed control in residential development and agricultural lands, right-of-way maintenance (e.g., roads, railroads, power lines), algae control in lakes and irrigation canals, and aquatic habitat restoration results in contamination from these substances.

Conservation Measures and Best Management Practices for Nonpoint Source Pollution and Urban Runoff (adapted from Hanson *et al.* 2003)

1. Implement BMPs for sediment control during construction and maintenance operations, including: avoiding ground disturbing activities during the wet season; minimizing the temporal and spatial extent of the disturbance; using erosion prevention and sediment control methods; maintaining natural buffers of vegetation around wetlands, streams, and drainage ways; and avoiding building activities in areas of steep slopes and areas with highly erodable soils. Whenever appropriate, recommend the use of methods such as sediment ponds, sediment traps, bioswales, or other facilities designed to slow runoff and trap sediment and nutrients (USEPA 1993).
2. Whenever possible, remove unnecessary impervious surfaces such as abandoned parking lots and buildings from riparian and shoreline areas, and reestablish wetlands and native vegetation. Construction of new impervious surfaces should be avoided or minimized.
3. Protect, enhance and restore vegetated buffer zones along streams and wetlands that include or influence fishery habitat.
4. Manage stormwater to duplicate the natural hydrologic cycle, maintaining natural infiltration and runoff rates to the maximum extent practicable.
5. Encourage proposed residential developments to utilize municipal wastewater facilities capable of treating sewage to the maximum extent practicable. Any proposed residential developments utilizing septic systems should include modern, state of the art systems that meet or exceed state and local water quality requirements.
6. Encourage communities to implement "smart-growth" development and land-use planning that reduces urban sprawl and minimizes impervious surfaces. Urban planning should emphasize mass transportation such as commuter rail and buses, green spaces and green corridors.
6. Insure that BMPs are implemented and enforced at shipyards and marinas to avoid, minimize, and contain fuel spills and release of other toxic materials. Encourage marinas to participate in NOAA/U.S. EPA's Coastal Nonpoint Program and the Clean Marina Initiative.
7. Whenever practicable, encourage new commercial and residential developments to utilize existing municipal sewage facilities. When septic systems must be utilized, insure that they are properly sited and maintained.
8. Encourage the use of non-treated wood materials in construction near aquatic environments.
9. Incorporate integrated pest management and BMPs as part of the authorization or permitting process to ensure the reduction of pesticide contamination in fishery habitat (Scott *et al.* 1999).
10. Avoid the use of pesticides and herbicides in and near aquatic habitats.
11. Refrain from aerial spraying of pesticides on windy days.

Commercial and Domestic Water Use

Freshwater is withdrawn for human use from riverine environments, which can alter natural current and sedimentation patterns, water quality, water temperature, and associated biotic communities (NEFMC 1998). Natural freshwater flows are subject to human alteration through water diversion for agriculture and industrial uses and modifications to the watershed. An increasing demand for potable water, combined with inefficient use of freshwater resources and natural events (e.g., droughts) have led to serious ecological damage worldwide, as well as in New England (Deegan and Buchsbaum 2005). For example, the flow of the Ipswich River in Massachusetts is reduced by to about one-half historical levels due to water withdrawals for human uses and about one-half of the native fish species on the river have been eliminated or greatly reduced (Bowling and Mackin 2003). Water withdrawal for freshwater drinking supply, power plant coolant systems, and irrigation occurs along urban and suburban areas, causing potential detrimental effects on aquatic habitats. Urbanization leads to increases in the amount of impervious surface (e.g., roads and parking lots), which causes water to flow off the land more quickly than if the land was undeveloped and forested, reducing the natural recharge of groundwater. Alteration of the natural hydroperiod can affect circulation patterns in estuarine systems, leading to both short-term and long-term changes (Deegan and Buchsbaum 2005). In addition, the use of desalinization plants to provide industrial and municipal water needs may further alter chemical and physical environment by discharging hypersaline water into the aquatic ecosystem. Refer to the chapters on Physical Effects: Water Uptake and Discharge Facilities and Alteration of Freshwater Systems for additional information on domestic and commercial freshwater usage.

Conservation Measures and Best Management Practices for Commercial and Domestic Water Use (adapted from Hanson *et al.* 2003)

1. Insure that the design of water diversion projects provide adequate passage, water quality, and proper timing of water flows for all life history stages of anadromous fish, and maintain and restore adequate channel, floodplain, riparian, and estuarine conditions.
2. Incorporate juvenile and adult fish passage facilities on water diversion projects.
3. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Road Construction and Operation

The building and maintenance of roads can affect aquatic habitats by increasing rates of erosion, debris slides or landslides and sedimentation, introduction of exotic species, and degradation of water quality (Furniss *et al.* 1991; Hanson *et al.* 2003). Paved and dirt roads introduce an impervious or semi-pervious surface into the landscape, which intercepts rain and increases runoff, carrying soil, sand and other sediments (Ziegler *et al.* 2001), and oil-based materials more quickly into aquatic habitats. Roads constructed near streams, wetlands and other sensitive areas may cause sedimentation of these habitats and further diminish flood plain storage capacity, especially during road maintenance and use during storms and snowmelt events. Even carefully designed and constructed roads can be a source of sediment and pollutants if they are not properly maintained (Hanson *et al.* 2003).

The effects of roads on aquatic habitat include: 1) contaminant releases; 2) increased release of sediments; 3) reduced dissolved oxygen; 4) changes in water temperature; 5) elimination or introduction of migration barriers; 6) changes in stream flow; 7) introduction of non-native plant species; 8) altered salinity regimes; and 9) changes in channel configuration. These processes can alter the flood plain storage capacity and increase the rate of sedimentation into bays and estuaries, subsequently increasing the need for dredging in those systems.

Contaminant Releases

Roads constructed near or adjacent to aquatic habitats can be a source of chemical contaminants, such as deicing chemicals, road salt, fertilizers and herbicides to control roadside vegetation, and petroleum products from vehicles or from the road asphalt itself (Furniss *et al.* 1991).

Sedimentation, Siltation and Turbidity

The rate of soil erosion around roads is primarily a function of storm intensity, surfacing material, road slope, and traffic levels (Hanson *et al.* 2003). For roads located in steep terrain, mass soil movement triggered by roads can last for decades after roads are built (Furniss *et al.* 1991). Surface erosion results in increased deposition of fine sediments (Bilby *et al.* 1989; MacDonald *et al.* 2001; Ziegler *et al.* 2001), which has been linked to a decrease in salmon fry emergence, decreased juvenile densities, and increased predation in some species of salmon (Koski 1981).

Reduced Dissolved Oxygen

The introduction of stormwater runoff from roads can introduce the organic loads of adjacent streams and rivers, increasing the biological oxygen demand and reducing dissolved oxygen concentrations. Reduced dissolved oxygen concentrations can cause direct mortality of aquatic organisms or result in sub-acute effects such as reduced growth and reproductive success. Bejda *et al.* (1992) found reductions in the growth of juvenile winter flounder exposed to dissolved oxygen levels of 2.2mg/L or varied diurnally between 2.5 and 6.4 mg/L for periods of 11 weeks.

Loss and Alteration of Vegetation and Altered Temperature Regimes

Roads located near streams often involve the removal of riparian vegetation for construction and safety and maintenance. Roads built adjacent to streams result in changes in water temperature and increased sunlight reaching the stream as riparian vegetation is removed and/or altered in composition (Hanson *et al.* 2003). Roads can also alter natural temperature regimes in riverine and estuarine ecosystems due to radiant heating effect from the road surfaces. Riparian vegetation is an important component of rearing habitat for coldwater species such as salmonids, including shade for maintaining cool water temperatures, food supply, channel stability and structure (Furniss *et al.* 1991).

Impaired Fish Passage

Roads can also reduce or eliminate upstream and downstream fish passage through improperly placed culverts at road-stream crossings (Belford and Gould 1989; Clancy and Reichmuth 1990; Evans and Johnston 1980; Furniss *et al.* 1991). Improperly designed stream crossings adversely effect fish and aquatic organisms by blocking access to spawning, rearing and nursery habitat due to: perched culverts constructed with the bottom of the structure above the level of the stream, effectively acting as a dam and physically blocking passage; hydraulic barriers to passage are created by undersized culverts which constrict the flow and create excessive water velocities; smooth-bore (high density plastic) liners help meet the goal of passing water and protecting roadways from flooding, but they greatly increase flow velocities through the passage (Evans and Johnston 1980; Belford and Gould 1989; Furniss *et al.* 1991; Jackson 2003). Culverts can be plugged by debris or overtopped by high flows, road damage, and channel realignment, and extreme sedimentation from roads can cause stream flow to become two shallow for upstream fish movement (Furniss *et al.* 1991). Additional information on impaired fish passage is discussed in the Alteration of Freshwater Systems chapter of this report.

Introduction of Exotic Invasive Species

Roads can be the first point of entry for non-native, opportunistic grass species that are seeded along road cuts or introduced from seeds transported by tires and shoes (Greenberg *et al.* 1997; Lonsdale and Lane 1994). Non-native plants may be able to move away from the roadside and into aquatic sites, where they may out-compete native species and alter the structure and function of the aquatic ecosystem (see also the chapter on Aquaculture and Introduced Species).

Altered Hydrological Regimes

Roads can result in adverse effects to hydrologic processes. They intercept rainfall directly on the road surface, in road cutbanks, and as subsurface water moving down the hillslope; they also concentrate flow, either on the road surfaces or in adjacent ditches or channels (Hanson *et al.* 2003). Roads can divert or reroute water from flow paths that would otherwise be taken if the road were not present (Furniss *et al.* 1991). Lastly, they alter flood plain storage patterns. These hydrological changes may lead to increased erosion and sedimentation impacts in adjacent streams.

Altered Tidal and Salinity Regimes

As discussed above, roads can alter hydrologic processes by rerouting flow paths and concentrate stormwater flow towards salt marsh and tidal creeks. Together with the removal of vegetation adjacent to roads, a large and rapid influx of freshwater can alter the salinity regime and species composition of estuarine habitats. Roads and culverts can also restrict the flow in tidal creeks, lowering the head of tide, altering the estuarine community, and restricting the access of anadromous fish.

Altered Stream Morphology

The geometry of a stream is affected by the amount of water and sediment that the stream carries, and these factors may be altered by roads and stream crossings. Adjustments to stream morphology are usually detrimental to fish habitat (Furniss *et al.* 1991). Alteration of stream morphology can change stream velocity and increase sedimentation of the streambed, which can have adverse affects on spawning and migration of anadromous fish.

Conservation Measures and Best Management Practices for Road Construction and Operation
(adapted from Hanson *et al.* 2003)

1. Roads should be sited to avoid sensitive areas such as streams, wetlands, and steep slopes.
2. Whenever possible, bridges should be built for crossing aquatic environments, rather than utilizing culverts. If culverts must be used, they should be sized, constructed, and maintained to match the gradient, flow characteristics and width of the stream so as to accommodate a 100-year flood event, but equally to provide for seasonal migratory passage of adult and juvenile fishes.
3. Design bridge abutments to minimize disturbances to streambanks and place abutments outside of the floodplain whenever possible.
4. Erosion control measures should be designed into road construction plans.
5. Avoid side casting of road materials into streams.
6. Use only native vegetation in stabilization plantings.
7. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Flood Control/Shoreline Protection

As human populations in coastal areas grow, development pressure increases and structures are often constructed along the coastline to prevent erosion and stabilize shorelines. The protection of coastal development and human communities from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of existing shoreline and riparian habitat. Attempts to protect “soft” shorelines, like beaches, and reduce shoreline erosion are an inevitable consequence of coastal development. Structures placed for coastal shoreline protection include breakwaters, jetties and groins, concrete or wood seawalls, rip-rap revetments (sloping piles of rock placed against the toe of the dune or bluff in danger of erosion from wave action), dynamic cobble revetments (natural cobble placed on an eroding beach to dissipate wave energy and prevent sand loss), and sandbags (Hanson *et al.* 2003). These structures are designed to slow or stop the shoreline from eroding, but in many cases the opposite occurs with erosion rates increasing along the adjacent areas. Many shoreline “hardening” structures, such as seawalls and jetties, tend to reduce the complexity of habitats and the amount of intertidal habitats (Williams and Thom 2001). Generally, “soft” shoreline stabilization approaches (e.g., beach nourishment, vegetative plantings) have less adverse affects to hydrology and habitats.

Flood control measures in low-lying coastal areas include dikes, ditches, tide gates and stream channelization. These measures are generally designed to direct water away from flooding prone areas and, in the case of tide gates, prevent tidal water from entering these areas. Adjacent aquatic habitat can become altered and short- and long-term impacts to local fish and shellfish populations may be associated with the presence of the erosion control structures. Tidal marshes typically have freshwater vegetation on the landward side, saltwater vegetation on the seaward side, and a gradient of species in between. These coastal wetland systems drain freshwater through tidal creeks that empty into the bay or estuary. The use of water control structures can have long-term adverse effects in tidal marsh and estuarine habitats by altering flow of freshwater entering the marsh.

Altered Hydrological Regimes

Water controls structures within marsh habitats intercept and carry away freshwater drainage, block freshwater from flowing across seaward portions of the marsh, increase the speed of runoff of freshwater to the bay or estuary, lower the water table, permit saltwater intrusion into the marsh proper, and create migration barriers for aquatic species (Hanson *et al.* 2003). In deeper channels where anoxic conditions prevail, large quantities of hydrogen sulfide may be produced that are toxic to marsh grasses and other aquatic life. Long-term effects of flood control on tidal marshes include land subsidence (sometimes even submergence), soil compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics (Hanson *et al.* 2003). Alteration of the hydrology of coastal salt marshes can reduce estuarine productivity, restrict suitable habitat for aquatic species, and result in salinity extremes during drought and flood events.

Altered Temperature Regimes

Shoreline modifications, including the construction of seawalls and bulkheads, invariably involve the removal of shoreline vegetation which eliminates shading and can cause increased water temperatures in rivers and the nearshore intertidal zone (Williams and Thom 2001). Conversely, increased shading from seawalls and bulkheads constructed along shorelines may unnaturally reduce local light levels and primary production rates, and reduce water temperatures to the water column adjacent to the structures (Williams and Thom 2001). Tide gates prevent or reduce tidal flushing to an area, causing stagnant water behind the structure and increased water temperature regimes (Williams and Thom 2001). Breakwaters and jetties can also alter hydrological processes which may result in altered fluctuations of nearshore temperature (Williams and Thom 2001).

Reduced Dissolved Oxygen

Breakwaters and jetties affect nearshore hydrological processes, as well as river flow and tidal currents when these structures are placed at the mouth of rivers and estuaries (Williams and Thom 2001). This can reduce the timing and volume of water exchange to rivers, bays and estuaries, and result in reductions in water circulation and dissolved oxygen concentrations for some areas, particularly when combined with eutrophic condition. Flood control structures, such as tide gates, dikes and ditches can restrict the exchange of water within wetlands, which can create stagnant conditions and reduce dissolved oxygen concentrations (Spence 1996; Williams and Thom 2001).

Altered Sediment Transport and Increased Erosion/Accretion

As discussed above, shoreline stabilization structures such as breakwaters, jetties and groins affect nearshore hydrological processes which can alter wave energy and current patterns that, in turn, can affect littoral drift and longshore sediment transport (Williams and Thom 2001). These structures can also impact sediment budgets in estuaries and rivers. Alteration to sediment transport can affect bottom habitats, beach formation, and sand dune size (Williams and Thom 2001). Hardened shorelines, from the construction of seawalls, groins, and revetments, directly affects nearshore sediment transport by impounding natural sediment sources. Shoreline structures can cause beach erosion and accretion impacts to adjacent areas. Long-term, chronic impacts may result in a reduction of intertidal habitat, bottom complexity, and associated soft-bottom plant and animal communities (Williams and Thom 2001). In tidal marshes, flood gate and dike structures restrict sediment transport that are a natural part of marsh accretion process. This can result in subsidence of the marsh and loss of salt marsh vegetation.

Alteration and Loss of Benthic and Intertidal Habitat

As discussed above, breakwaters, jetties and groins can affect nearshore hydrological processes, such as wave energy and current patterns and, in turn, can have impacts on benthic habitats. Increased sedimentation as a result of reflective turbulence and turbidity can reduce or eliminate vegetated shallows (Williams and Thom 2001). In addition, these structures can alter the geomorphology of existing habitats, resulting in a large-scale replacement of soft-bottom, deepwater habitat with shallow and intertidal, hard structure habitats (Williams and Thom 2001). Hydraulic effect alterations to the shoreline as a result of bulkhead and other hard shoreline structures increase wave energy seaward of the armoring causing scouring of bottom sediments and loss of salt marsh vegetation.

Altered Stream Morphology

Flood and erosion control structures such as bulkheads, levees, and dikes built along stream and rivers, as well as the channelization of streams and rivers, result in simplified riverine habitat and a reduction in pools and riffles that provide habitat for fish (Spence *et al.* 1996). In addition, altered stream hydrology and morphology can change sediment grain size and reduce the organic matter available to small organisms that serve as prey for larger species (Williams and Thom 2001).

Impacts to Riparian Habitat

As discussed above, shoreline modifications such as the construction of seawalls and bulkheads, involve the removal of shoreline vegetation which eliminates shading and can cause increased water temperatures in rivers and the nearshore, intertidal zone (Williams and Thom 2001). The loss of riparian vegetation reduces the forage and cover for aquatic organisms and the input of large woody debris and smaller organic detritus including leaves (Spence *et al.* 1996).

Impaired Fish Passage

Tide gates and other flood control structures can eliminate or restrict access of fish to salt marsh wetlands. Tide gates can create physical barriers for estuarine fish species that utilize salt marsh wetlands which provide for feeding and early development habitat. High flow rates at tide gate or culvert openings can prevent small fish from accessing critical marsh and freshwater habitat. In some cases, fishes can become trapped behind tide gates, preventing them from accessing deeper water and potentially stranding them during periods of low water (Williams and Thom 2001).

Alteration of Natural Communities

Armoring of shorelines to prevent erosion and maintain or create shoreline real estate simplifies habitats, reduces the amount of intertidal habitat, and affects nearshore processes and the ecology of coastal species (Williams and Thom 2001). For example, Chapman (2003) found a paucity of mobile species associated with seawalls in a tropical estuary, compared with surrounding areas. In that study, approximately 50 percent of taxa found on natural rocky shorelines were absent on constructed seawall, and seawalls were found to have a diminished proportion of rare taxa. Alterations to the shoreline due to hydraulic action includes increased energy seaward of the armoring from reflected wave energy, narrowing of the dry beach, coarsening of the substrate, steepening of the beach slope, reducing the sediment storage capacity, a loss of organic debris, and a reduction of downdrift sediment (Williams and Thom 2001). Installation of breakwaters and jetties can result in community changes, including burial or removal of resident biota, changes in cover and preferred prey species and predator interaction, as well as the movement of larvae of many species (Williams and Thom 2001).

Reduced Ability to Counter Sea Level Rise

The effect of shoreline erosion and land subsidence will likely be exacerbated by sea level rise due to global climate change. Sea level has risen 10-20 cm (4-8 inches) in the 20th century and may rise another 9-88 cm (4-35 inches) by 2100 (Nedeau 2004). As sea levels continue to rise, salt marshes, mudflats, and coastal shallows must be able to shift horizontally without interruption from natural or manmade barriers (Bigford 1991). Hard structures, such as seawalls, bulkheads, and jetties may inhibit the formation of replacement salt marsh wetlands (Kelly 1992). In addition, global precipitation is likely to increase, with more precipitation and more intense storms in the mid-high latitudes in the northern hemisphere (Nedeau 2004). Along with rising sea levels these factors may exacerbate coastal erosion and increase the apparent need for shoreline protection. See Global Effects and Other Impacts chapter for more information on global climate change.

Conservation Measures and Best Management Practices for Flood Control/Shoreline Protection (adapted from Hanson *et al.* 2003)

1. Avoid or minimize the loss of coastal wetlands as much as possible, including encouraging coastal wetland habitat preservation. Encouraging the preservation of coastal upland buffers from development may allow for the migration of wetlands inland as sea levels rise.
2. Generally, the diking and draining of tidal marshlands and estuaries should not be permitted.
3. Wherever possible, “soft” approaches (such as beach nourishment, vegetative plantings, and placement of large woody debris) should be utilized, in lieu of “hard” shoreline stabilization and modifications (such as concrete bulkheads and seawalls, concrete or rock revetments).

4. Where "hard" shoreline stabilization is necessary, insure the hydrodynamics and sedimentation patterns are properly modeled and the design avoids erosion impacts to adjacent properties.
5. To offset impacts of proposed riparian habitat and stream modifications, include efforts to preserve and enhance fishery habitat (e.g., provide new gravel for spawning or nursery habitats; remove barriers to natural fish passage; and using weirs, grade control structures, and low flow channels to provide the proper depth and velocity for fish).
6. Construct a low-flow channel to facilitate fish passage and help maintain water temperature in reaches where water velocities require armoring of the riverbed.
7. Replace in-stream fish habitat by installing boulders, rock weirs, and woody debris, and by planting shaded riverine aquatic cover vegetation.
8. Avoid installing new water control structures in tidal marshes and freshwater streams. If the installation of new structures cannot be avoided, insure that they are designed to allow optimal fish passage and natural water circulation as much as possible.
9. Insure water control structures are monitored for potential alteration and impacts due to water temperature, dissolved oxygen concentration, and other parameters.
10. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Beach Nourishment

Beach nourishment, the process of mechanically or hydraulically placing sediments (i.e. sand and gravel) directly on an eroding shore to restore or form a protective or desired recreational beach, has been steadily increasing in occurrences along the eastern U.S. coastline since the 1960's (Greene 2002). Beaches and shorelines are dynamic, constantly eroding and accreting due to exposure to waves, currents and wind, and beach nourishment serves as a "soft", sacrificial barrier to protect the beach and property along the coast from storm and flood damage. Between 1923 and 2004, it is estimated that approximately 515 million cubic yards of beach sediment have been deposited on the U.S. east coast barrier island shoreline from Maine to Florida. This includes 966 individual beach nourishment episodes at 343 locations (Valverde *et al.* 1999; PSDS 2005).

Beach nourishment as a protective measure against coastal flooding and storm damage may be considered less impacting to marine organisms and fishery habitat than most "hard" structure solutions discussed in the previous section. However, beach nourishment can have a number of short- and long-term impacts to fishery resources, including displacing benthic organisms during and after nourishment, interference with respiration and feeding in finfish and filter feeding invertebrates, temporary removal of benthic prey, burial of habitat that serve as foraging and shelter sites, potential burial of demersal and benthic species, and mortality of vulnerable life stages, such as eggs, larvae, and juveniles (Greene 2002). Likewise, offshore mining of sand for the beach can result in entrainment, sedimentation and turbidity impacts to fish and invertebrates in and around the borrow site. In addition, the creation of borrow pits may alter the bottom topography and sediment transport processes in offshore habitats, and form depressions with low low-dissolved oxygen conditions. Nourished beaches seldom last as long as natural beaches and natural coastal processes erode the replenished sand, requiring additional nourishment of those beaches (Pilkey and Dixon 1996). The life span of a nourished beach can be highly variable, and primarily dependent upon storm intensity and frequency following the completion of a project. According to Pilkey and Dixon (1996), the life span of most nourished beaches is two to five years. Beach nourishment projects are often conducted at a high cost to taxpayers, and they can represent a long-term and cumulative impact on the marine biological community.

Sea level rise due to global climate change will likely increase the need to nourish beaches for shoreline protection. Global precipitation and more intense storms in the mid-high latitudes in the northern hemisphere will exacerbate erosional forces on beaches (Nedeau 2004). See Global Effects chapter for more on global climate change.

Altered Hydrological Regimes

Sand removed from borrow sites can potentially affect the geomorphology of offshore sand bars and shoals that absorb incoming waves, causing greater wave energy and/or change refraction patterns (Greene 2002). This may increase the erosion rate at the nourished beach and adjacent, non-nourished beaches. In addition, the nourished beach itself may be different following sand placement, including sediment grain size and shape and altered placement of sand grains throughout the area, which can lead to changes in the hydrodynamic patterns in the intertidal zone (Pilkey and Dixon 1996; Greene 2002).

In addition, the conditions in deeply excavated borrow pits can become anaerobic during certain times of the year. The dissolved oxygen concentration within these deep borrow pits can be depressed to a level that adversely affects the ability of fish and invertebrates to utilize the area for spawning, feeding and development (Pacheco 1984). For example, construction grade aggregate removal in Raritan Bay of Long Island Sound and the intercoastal waterway in New Jersey have left borrow pits or large depressions that are more than twice the depth of the surrounding area. The pits have remained chemically, physically and biologically unstable with limited biological diversity for more than five decades. These borrow pits in Raritan Bay were found to possess depressed benthic communities and elevated levels of highly hydrated and organically enriched sediments (Pacheco 1984).

Altered Sediment Transport

Longshore transport of sediments may be affected by the formation of borrow pits, which can be deep depressions taking several years to refill and alter the nearshore sediment budget (Greene 2002). Longshore sediment transport may also be affected in the nearshore environment if material placed on the beach is not compatible with natural or historic material. In addition, nearshore rock groins are often constructed in order to reduce erosion of the nourished beach, which alters the downdrift of sediment and may starve adjacent beaches of sand.

Alteration/Loss of Benthic Habitat

Sand infauna and sessile benthic organisms in the path of dredging equipment at the borrow site are generally removed and killed during mining. In addition, some mobile organisms, such as crustaceans, and larval and juvenile fish, can be entrained by the dredge equipment. Following mining within borrow pits, species diversity of benthic infaunal organisms drops precipitously, but recolonization typically occurs through larval transport and post-settlement life-stages (i.e. juveniles and adults) (Greene 2002).

Benthic fauna at the beach site will be killed by burial following a nourishment event unless an organism is capable of burrowing through the overburden of sand (Greene 2002). Several factors determine survival of beach invertebrate fauna, including the ability for vertical migration through the sand overburden and the recruitment potential of larvae, juveniles, and adult organisms from adjacent areas (Greene 2002). Peterson *et al.* (2000) found an 86-99 percent reduction in the abundance of dominant species of beach macro-invertebrates ten weeks after nourishment on a North Carolina beach. These observations were made between the months of June and July, when the abundances of beach macro-invertebrates are typically at their maximum and providing the important ecosystem service of feeding abundant surf fishes and ghost crabs (Peterson *et al.* 2000).

<u>Alteration in Natural Communities</u>
The recovery of the benthic infauna at a borrow site is dependent upon a number of factors, including the amount of material removed, the fauna present at the site and surrounding area prior to dredging, and the degree of sedimentation that occurs following dredging (Greene 2002). The recovery time of benthic infauna at borrow sites has been reported to be as rapid as less than one year, while other studies have indicated recovery may take greater than five years (Greene 2002). Some differences in recovery time may be attributed to the fact that most benthic infauna recolonization studies look at abundance of individuals, but fail to measure trophic level changes and the life history of individuals in the samples (Greene 2002). The post-dredging benthic community may function very differently than the pre-dredging community. The borrow pits may require several years to refill with sediment and the sediment that accumulates within the depressions may be composed of more silt than the surrounding areas (Greene 2002). Generally, the degree of alteration of the sediment composition appears to be the largest factor in determining long-term impact at a borrow site (Greene 2002).

Similar to the findings on the recovery of benthic infauna at borrow sites, studies assessing the recovery of organisms at nourished beaches is highly variable (Greene 2002). While some studies conclude that beach infauna populations may recover to pre-dredging levels between two to seven months, other studies suggest recovery times are much longer (Greene 2002). Peterson *et al.* (2000) found a large reduction in prey abundance and body size of benthic macro-invertebrates at a nourished intertidal beach that likely translated to trophic level impacts on surf zone fishes and shorebirds.

<u>Increased Sedimentation/Turbidity</u>
High turbidity in the water column and sedimentation on adjacent benthic habitats can result from resuspension of sediment at the discharge pipe and from sediment winnowing from the nourished beach into the surf zone. In addition, turbidity can also occur between the borrow site and the target beach when sand is lost during hopper loading, leaks in the pipelines carrying sand to the beach, and from the dredging activity at the borrow site itself. High turbidity and suspended sediments can be persistent in the nearshore waters long after a beach is nourished if mud balls, silt, and clays are present in the mined sediment (Greene 2002).

Generally, the severity of the effects of suspended sediments on aquatic organisms increases as a function of sediment concentration and the duration of exposure (Newcombe and Jensen 1996). Some of the effects of suspended sediments on marine organisms can include altered foraging patterns and success (Breitburg 1988), gill abrasion and reduced respiratory functions, and death (Wilber and Clark 2001). The sensitivity of species to suspended sediments is highly variable, and dependent upon the nature of the sediment and the life history stage of the species. The eggs and larvae stages of marine and estuarine fish are generally highly sensitive to suspended sediment exposures compared to some freshwater taxa studied (Wilber and Clark 2001). Sedimentation from beach nourishment may also have adverse effects on invertebrates that serve as prey for fish

(Greene 2002). Refer to the Marine Transportation and Offshore Dredging and Disposal chapters for more information regarding turbidity and sedimentation impacts on aquatic organisms.

Conservation Measures and Best Management Practices for Beach Nourishment (adapted from Hanson *et al.* 2003)

1. Avoid sand mining in areas containing sensitive marine benthic habitats (e.g., spawning and feeding sites, hard bottom, cobble/gravel substrate, shellfish beds).
2. Avoid beach nourishment in areas containing sensitive marine benthic habitats adjacent to the beach (e.g., spawning and feeding sites, hard bottom, cobble/gravel substrate).
3. Beach nourishment conducted during the winter and early spring, when productivity for benthic infauna is at a minimum, may minimize the impacts for some beach sites.
3. Source material should be assessed for compatibility with that of material to be placed on beach (e.g., grain size and shape, color). Slope of nourished beach should mimic natural beach profile.
4. Upland beach material sources, if compatible, should be utilized to avoid impacts associated with offshore sand mining.
5. Beach dune and native dune vegetation should be preserved or created/enhanced.
6. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels at the beach and borrow sites.
7. Implementations of seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning season and egg development period). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Wetland Dredging and Filling

The dredging and filling of coastal wetlands for shoreline, commercial and residential development, port, and harbor development directly removes important wetland habitat and alters the habitat surrounding the developed area. Even development projects that appear to have minimal individual wetland impacts can have significant cumulative effects on the aquatic ecosystem. This section discusses the impacts on fishery habitat from dredging and filling freshwater and tidal wetlands for development purposes. Dredging and disposal of dredge material in subtidal habitats (e.g., navigation channel dredging and marine mining) have been addressed in the chapters on Marine Transportation and Offshore Dredging and Disposal. The primary impacts to fishery habitat from the introduction of fill material in or adjacent to wetlands include: 1) physical loss of habitat; 2) loss or impairment of wetland functions; and 3) changes in hydrologic patterns.

The discharge of dredge and fill materials are regulated under Section 404 of the Clean Water Act (CWA) of 1972 for all "waters of the United States", which includes both freshwater and tidal wetlands. The U.S. Army Corps of Engineers (USACE) is responsible for authorizing construction and dredge material discharge activities that affect "waters of the United States" through permits issued by their regulatory program, which must comply with U.S. EPA's 404(b)(1) guidelines. The definition of "waters of the United States" generally include: 1) navigable waters of the United States; 2) wetlands; 3) tributaries of navigable waters, including adjacent wetlands and lakes and ponds; 4) interstate waters and their tributaries, including adjacent wetlands; and 5) isolated wetlands, intermittent streams, and other waters that are not part of a tributary system to interstate waters or navigable waters, where the use, degradation or destruction of these waters could affect interstate or foreign commerce (33 CFR Part 328.3). The USACE regulates both the temporary and permanent discharge of dredge and fill material. Some of the types of discharge of fill material covered under Section 404 of the CWA include: 1) placement of fill that is necessary to the construction of a structure or impoundment; 2) site development fills for recreational, industrial, commercial, or residential; 3) causeway or road fills, dams or dikes; 4) artificial islands; 5) property protection and/or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; 6) beach nourishment; 7) levees; 8) fill for structures such as sewage treatment facilities, intake and outfall pipes associated with power plants and subaqueous utility lines; and 9) artificial reefs.

Loss and Alteration of Wetland Vegetation

Salt marsh wetlands serve as early life history habitat for many fish species, as well as shellfish, crabs, and shrimp, which use the physical structure of the marsh grasses as refuge from predators (Tyrell 2005). Smaller fish, such as mummichog, Atlantic silverside, stickleback, and sheepshead minnow, rely on salt marshes for important parts of their life cycles. These species form the prey base of many larger, commercially important species such as flounder, black sea bass, and bluefish (Collette and Klein-MacPhee 2002).

Filling wetlands removes productive habitat and eliminates the important functions that both aquatic and many terrestrial organisms depend upon. For example, the loss of wetland habitats reduces the production of detritus, an important food source for aquatic invertebrates; alters the uptake and release of nutrients to and from adjacent aquatic and terrestrial systems; reduces wetland vegetation, an important source of food for fish, invertebrates, and water fowl; hinders physiological processes in aquatic organisms (e.g., photosynthesis, respiration) due to degraded water quality and increased turbidity and sedimentation; alters hydrological dynamics, including flood control and groundwater recharge; reduces filtration and absorption of pollutants from uplands; and alters atmospheric functions, such as nitrogen and oxygen cycles (Niering 1988; Mitsch and Gosselink 1993).

Altered Hydrological Regimes

The discharge of dredged or fill material into aquatic habitats can modify current patterns and water circulation by obstructing the flow or changing the direction or velocity of water flow and circulation. As a result, adverse changes can occur in the location, structure, and dynamics of aquatic communities; shoreline and substrate erosion and deposition rates; the deposition of suspended particulates; the rate and extent of mixing of dissolved and suspended components of the water body; and water stratification (Hanson *et al.* 2003). Altering the hydrology of wetlands can affect the water table, ground water discharge, and soil salinity, causing a shift in vegetation patterns and quality of the habitat. Hydrology can be affected by fragmenting the habitat due to the construction of roads and residential development, or by building bulkheads, dikes, levees and other structures designed to prevent or remove floodwater from the land around the wetlands (Niering 1988; Mitsch and Gosselink 1993). These structures also reduce natural tidal flushing and interfere with natural sediment-transport processes, all of which are important functions that maintain the integrity of the marsh habitat (Tyrell 2005). Altered hydrodynamics can affect estuarine circulation, including short-term (diel) and longer term (seasonal or annual) changes (Deegan and Buchsbaum 2005). Alteration of the hydrology and soils of salt marsh wetlands has led to the invasion of an exotic genotype of the common reed, *Phragmites australis*, which has spread dramatically and degraded salt marsh habitats along the Atlantic coast (Posey *et al.* 2003; Tyrell 2005).

Loss of Flood Storage Capacity

Coastal wetlands absorb and store rain and urban runoff, buffering upland development from floods. In addition, coastal marshes provide a physical barrier that protects upland development from storm surge. As a result, the loss and alteration of coastal wetlands can cause upland development to be more prone to flooding from storms and heavy rain events. Furthermore, altering the hydrological regimes of wetlands, through construction of dikes, levees, and tide gates, can redirect floodwater towards rivers and estuaries and bypass the flood storage functions of coastal wetlands.

Altered Current Patterns

Replacing wetlands with roads, buildings and other impervious surfaces increases the volume and intensity of storm water runoff, which can accelerate the rate of coastal erosion. Placing dredge material onto intertidal mud habitats can dramatically alter tidal flow. These effects can change the geomorphology and current patterns of rivers and estuaries. For example, counter current flows set up by freshwater discharges into estuaries are important for larvae and juvenile fish recruitment entering those estuaries. Diurnal behavioral adaptations of marine and estuarine species allow larvae and early juveniles to concentrate in estuaries (Deegan and Buchsbaum 2005).

Altered Temperature Regimes

The loss of riparian and salt marsh vegetation can increase the amount of solar radiation reaching streams and rivers and result in an increase in the water temperatures to those water bodies (Moring 2005). Replacing coastal wetlands with impervious surfaces such as asphalt, which absorb more solar radiation than vegetation, tend to raise the water temperature in adjacent aquatic environments. Altered temperature regimes have the ability to affect the distribution, growth rates, survival, migration patterns, egg maturation and incubation success, competitive ability, and resistance to parasites, diseases, and pollutants of aquatic organisms (USEPA 2003b). In freshwater habitats of the northeastern U.S., the temperature regimes of cold-water fish such as salmon, smelt, and trout, may be exceeded leading to local extirpation of these species (Moring 2005). The removal of riparian vegetation can also have the effect of lowering water temperatures during winter, which can increase the formation of ice and delay the development of incubating fish eggs and alevins in salmonids (Hanson *et al.* 2003).

Release of Nutrients/Eutrophication

When functioning properly, riparian and tidal wetlands support denitrification of nitrate-contaminated ground water. While sediment particles can to bind some nutrients, re-suspension of sediments following a disturbance tends to cause a rapid release of nutrients to the water column (Lohrer and Wetz 2003). By absorbing and converting nutrients in groundwater and storm water, coastal wetlands reduce the risk of eutrophication in estuaries and nearby coastal waters (Tyrell 2005).

Release of Contaminants

The removal of wetlands eliminates an important wetland function: pollution filtration (Niering 1988; Mitsch and Gosselink 1993). Wetlands are capable of absorbing heavy metals, pesticides, excess nutrients, oxygen-consuming substances, and other pollutants that would otherwise be transported directly to aquatic environments. In addition, dredging and filling of wetlands can release contaminants that have accumulated in the sediments into adjacent aquatic habitats.

Increased Sedimentation/Turbidity

When functioning properly, riparian and tidal wetlands filter sediment and runoff from floodplain development. Siltation, sedimentation, and turbidity impacts on riverine and estuarine habitats can be worsened due to the loss and replacement of wetlands with impervious surfaces. Suspended sediments in aquatic environments reduces the availability of sunlight to aquatic plants, covers fish spawning areas and food supply, interferes with filtering capacity of filter feeders, and can clog and harm the gills of fish (USEPA 2003b).

Loss of Fishery Productivity

Hydrological modifications from dredge and fill activities and general coastal development are known to increase the amount of run-off entering the aquatic environment and may contribute to the reduced productivity of fishery resources. Many wetland dependent species, such as mummichog, Atlantic silverside, stickleback, and sheepshead minnow, are important prey for larger, commercially important species such as flounder, black sea bass, and bluefish (Collette and Klein-MacPhee 2002). Although there have been sharp declines or collapses of many estuarine-dependent fisheries in the U.S., attributing reductions in fishery productivity directly to losses of wetland habitat can be complicated (Deegan and Buchsbaum 2005). Recent wetland losses can be quantified for discrete regions and the nation as a whole; however, a number of other factors, such as overfishing, cultural eutrophication, and altered input of freshwater due to flood control structures, probably all contribute to a reduction in the productivity of fisheries. Since the implementation of the Clean Water Act in 1972, the major problems for coastal habitats have changed from outright destruction to more subtle types of degradation, such as cultural eutrophication (Deegan and Buchsbaum 2005).

Introduction of Invasive Species

A non-native genotype of the common reed, *Phragmites australis,* has expanded its range along the entire east coast of the U.S., primarily in wetland habitats disturbed by nutrient loading and hydrological alterations of salt marsh wetlands (Posey *et al.* 2003). *Phragmites* is tolerant of low-salinity conditions in salt marshes, which can occur with tidal restrictions from the construction of tide gates, bulkheads, and dikes. Under these conditions, *Phragmites* can outcompete native salt marsh vegetation such as *Spartina* sp. (Burdick *et al.* 2001; Deegan and Buchsbaum 2005). Salt marshes that are dominated by *Phragmites* may have reduced function and productivity compared to salt marshes consisting of native marsh vegetation (Tyrell 2005).

Conservation Measures and Best Management Practices for Wetland Dredging and Filling (adapted from Hanson *et al.* 2003)

1. The CWA Section 404 assessment criteria and EFH regulations for dredge and fill projects should be applied, including a sequence of measures to avoid, minimize and mitigate for unavoidable impacts in wetlands. Dredging and filling within wetlands should be considered only after all alternatives have been considered.
2. All proposed dredge and fill projects in wetlands should first meet the “water dependency” criteria.
3. Disposal of dredge material should meet or exceed applicable state and/or federal quality standards for such disposal.
4. Identify and characterize fishery habitat functions/services in the project areas.
5. State and federal agencies should identify the direct and indirect affects of wetland fills on fishery habitat during proposed project reviews, including alterations of hydrology and water quality as a result of the proposed project.
6. The cumulative impact from past, current, and all reasonably foreseeable future dredge and fill operations that impact aquatic habitats should be addressed by federal, state, and local resource management and permitting agencies and considered in the permitting process.
7. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Overwater Structures

With increasing coastal development comes a concomitant interest in the construction and operation of waterfront facilities, the use of coastal waterways, and the environmental implications of these activities (Barr 1993). Overwater structures include commercial and residential piers and docks, floating breakwaters, moored barges, rafts, booms, and mooring buoys. These structures are typically located from intertidal areas to areas of water depths approximately 15 m below mean low water (i.e., the shallow subtidal zone). Light, wave energy, substrate type, depth and water quality are the primary factors controlling the plant and animal assemblages found at a particular site. Overwater structures and associated use activities can alter these factors and interfere with key ecological functions such as spawning, rearing, and the use of refugia. Site-specific factors (e.g., water clarity, current, depth, etc.) and the type and use of a given overwater structure determine the occurrence and magnitude of these impacts (Hanson *et al.* 2003).

Shading Impacts to Vegetation

Overwater structures create shade which reduces the light levels below the structure. Shading from overwater structures can reduce prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and phytoplankton abundance (Haas *et al.* 2002). The size, shape and intensity of the shadow cast by a particular structure depends upon its height, width, construction materials, and orientation. In field studies conducted in Massachusetts, the most significant factors affecting shading impacts on eelgrass were the height of the structure above vegetation, orientation of the dock, and dock width (Burdick and Short 1999). High and narrow piers and docks produce narrower and more diffuse shadows than do low and wide structures. Increasing the numbers of pilings used to support a pier increases the shade cast by pilings on the under-pier environment. In addition, less light is reflected underneath structures built with light-absorbing materials (e.g., wood) than from structures built with light-reflecting materials (e.g., concrete or steel). Under-pier light levels have been found to fall below threshold amounts for the photosynthesis of diatoms, benthic algae, eelgrass, and associated epiphytes and other autotrophs. Eelgrass and other macrophytes can be reduced or eliminated, even through partial shading of the substrate, and have little chance to recover (Kenworthy and Hauners 1991). Structures that are oriented north-south produce a shadow that moves across the bottom throughout the day, resulting in a smaller area of permanent shade than those that are oriented east-west (Burdick and Short 1999; Shafer 1999). In a report investigating effects of residential docks in south Florida, Smith and Mezich (1999) found approximately 40 percent of the docks surveyed had additions fixed to them (e.g., boat lifts and cradles, floating docks, finger piers). These structural additions increased the dock area (and seagrass impacts) and ranged from 16 to 77 percent, and contributed to mean seagrass impacts of 47 percent beyond the footprint of the dock.

Similar shading impacts to salt marsh vegetation from docks and piers have been reported. A study in Connecticut measuring the density and average plant height of salt marsh vegetation below docks and adjacent areas found a reduction in vegetative reproductive capacity due to the presence of docks (Kearney *et al.* 1983). This study concluded that the height of the dock was a strong determining factor in the effects to salt marsh vegetation.

Altered Hydrological Regimes

Alterations to wave energy and water transport from overwater structures can impact the nearshore detrital foodweb by altering the size, distribution, and abundance of substrate and detrital materials (Hanson *et al.* 2003). The disruption of longshore transport can alter substrate composition and can present potential barriers to the natural processes that build spits and beaches and provide substrates required for plant propagation, fish and shellfish settlement and rearing, and forage fish spawning (Hanson *et al.* 2003).

Contaminant Releases

Kennish (2002) identified a number of contaminants associated with overwater structures that can be released into the aquatic environment, including detergents, petroleum products, and copper. Treated wood used for pilings and docks releases contaminants into the aquatic environment. Creosote-treated wood pilings and docks commonly release polyaromatic hydrocarbons (PAHs) and other chemicals, such as ammoniacal copper zinc arsenate (ACZA) and chromated copper arsenate (CCA), which are applied to preserve the wood (Poston 2001; Weis and Weis 2002). These chemicals can become available to marine organisms through uptake by wetland vegetation, adsorption by adjacent sediments, or directly through the water column (Weis and Weis 2002). The presence of CCA in the food chain can also cause a localized reduction in species richness and diversity (Weis and Weis 2002). These preservatives are known to leach into marine waters after installation, but the rate of leaching is highly variable and dependent on many factors, including the age of the treated wood. Concrete or steel, on the other hand, are relatively inert and do not leach contaminants into the water.

Benthic Habitat Impacts

Additional impacts associated with overwater structures may include damage to seagrasses and substrate scour from float chains and anchors (Kennish 2002). Docks located in intertidal areas that are exposed during low tides may result in the vessel(s) resting on the substrate, impacting shellfish beds, SAV, and intertidal mudflats. Vessels operating in shallow water to access docks may cause a resuspension of bottom sediments and may physically disrupt aquatic habitats, such as bank and shoreline (Barr 1993) and SAV through "prop dredging" (Burdick and Short 1999). Barr (1993) identified a number of potential impacts to aquatic ecosystems due to resuspension of sediments caused by vessel activity, including reductions in primary productivity (e.g., phytoplankton and SAV), alteration of temperature, dissolved oxygen and pH of the water, abrasion and clogging of fishes gill filaments, and reductions in egg development and the growth of some fishes and invertebrates. Glasby (1999) found that epibiota on pier pilings at marinas subject to shading were markedly different than in surrounding rock reef habitats. Shading by overwater structures may be responsible for the observed reductions in juvenile fish populations found under piers and the reduced growth and survival of fishes held in cages under piers, when compared to open habitats (Able *et al.* 1998; Duffy-Anderson and Able 1999).

Increased Erosion/Accretion

Pilings can alter adjacent substrates with increased deposition of sediment from changes in current fields or shell material deposition from piling communities. Changes in substrate type can alter the nature of the flora and fauna native to a given site. Kearney *et al.* (1983) found that docks and pier walkways cause shading impacts to salt marsh vegetation, which reduces the root mat and may lead to soil erosion in the area of the structures. In the case of pilings, native dominant communities typically associated with sand, gravel, mud, and eelgrass substrates may be replaced by communities associated with shell hash substrates (Penttila and Doty 1990; Nightingale and Simenstad 2001; Haas *et al.* 2002). In addition to impacts to eelgrass habitat from overwater structures, Penttila and Doty (1990) found that changes to current fields around structures caused altered sediment distribution and topography that created depressions along piling lines.

Changes in Predator/Prey Interaction

Fish use visual cues for spatial orientation, prey capture, schooling, predator avoidance, and migration. The reduced-light conditions found under an overwater structure limit the ability of fishes, especially juveniles and larvae, to perform these essential activities (Hanson *et al.* 2003). In addition, the use of artificial lighting on docks and piers creates unnatural nighttime conditions that can increase the susceptibility of some fish to predation and interfere with predator/prey interactions (Nightingale and Simenstad 2001).

Cumulative Effects

While the effect of some individual overwater structures on fishery habitat may be minimal, the overall impact may be substantial when considered cumulatively. For example, although shading impacts on seagrasses may affect a relatively small area around overwater structures, fragmentation of seagrass beds along a highly developed shoreline or within a bay can be considerable. Fragmentation of seagrass habitat can lower the integrity of the remaining seagrass beds, leaving it more susceptible to other impacts (Burdick and Short 1999). The additive effect of these structures increases the overall magnitude of impact, reduces the ability of the habitat to support native plant and animal communities, and makes the habitat more susceptible to damage from storms and disease.

Conservation Measures and Best Management Practices for Overwater Structures (adapted from Hanson *et al.* 2003)

1. Use upland boat storage whenever possible to minimize need for overwater structures.
2. Locate overwater structures in sufficiently deep waters to avoid intertidal and shade impacts, to minimize or preclude dredging, to minimize groundings, and to avoid displacement of SAV, as determined by a pre-construction survey.
3. Design piers, docks, and floats to be multi-use facilities serving multiple homeowners in order to reduce the overall number of such structures and the nearshore habitat that is impacted.
4. Incorporate measures that increase the ambient light transmission under piers and docks. These measures include, but are not limited to, maximizing the height of the structure and minimizing the width of the structure to decrease shade footprint; grated decking material; using the fewest number of pilings necessary to support the structures to allow light into under-pier areas and minimize impacts to the substrate; and aligning piers, docks and floats in north-south orientation to allow arc of sun to cross perpendicular to structure and reduce duration of light limitation.
5. Encourage seasonal use of docks and off-season haul-out.
6. Avoid placing floating docks in areas supporting SAV. Locate floats in deep water to avoid light limitation and grounding impacts to the intertidal zone, and insure that adequate water depth is available between the substrate and the bottom of the float throughout all tide cycles.
7. When it is impracticable or impossible to avoid placing floating docks in water deep enough to avoid contact with the bottom, proposed docks should incorporate float stops to avoid mechanical and/or hydraulic damage to the substrate from the float during low tides. Float stops should be designed to provide a minimum of 2 feet of clearance between the float and substrate to prevent hydraulic disturbances to the bottom. Greater clearances may be necessary in higher energy environments that experience strong wave action.
8. Conduct in-water work during the time of year when managed species and prey species are least likely to be impacted.
9. Avoid the use of treated wood timbers or pilings to the extent practicable. The use of alternative materials such as untreated wood, concrete, or steel is recommended. Concrete and steel pilings

are generally considered to be less damaging, since they help reflect light under docks and generally do not release contaminants into the aquatic environment.

10. Orient artificial lighting on docks and piers such that illumination of the surrounding waters at night is avoided.

Pile Driving and Removal

Pilings provide support for the decking of piers and docks, they function as fenders and dolphins to protect structures, support navigation markers, and are used to construct breakwaters and bulkheads. Materials used in pilings include steel, concrete, wood (both treated and untreated), plastic or a combination thereof, and they are usually driven into the substrate with impact hammers or vibratory hammers (Hanson *et al.* 2003). Impact hammers consist of a heavy weight that is repeatedly dropped onto the top of the pile, driving it into the substrate. Vibratory hammers utilize a combination of a stationary, heavy weight and vibration, in the plane perpendicular to the long axis of the pile, to force the pile into the substrate. While impact hammers are able to drive piles into most substrates (e.g., hardpan, glacial till), vibratory hammers are limited to softer, unconsolidated substrates (e.g., sand, mud, gravel). Piles can be removed using a variety of methods, including vibratory hammer, direct pull, clamshell grab, or cutting/breaking the pile below the mudline. Vibratory hammers can be used to remove all types of pile, including wood, concrete, and steel. Broken stubs are often removed with a clamshell and crane. In other instances, piles may be cut or broken below the mudline, leaving the buried section in place (Hanson *et al.* 2003).

Sound Energy Impacts

Pile driving using impact hammers can generate intense underwater sound pressure waves that may adversely affect fish species and their habitats. These pressure waves have been shown to injure and kill fish (CalTrans 2001; Longmuir and Lively 2001). Injuries directly associated with pile driving include rupture of the swimbladder and internal hemorrhaging, but are poorly studied (CalTrans 2001).

Benthic Habitat Impacts

The extraction of piles can result in altered sediment composition and depressions in the bottom, which may cause erosion and loss of sediment. Bottom depressions may fill in with fine sediments and silt, changing the characteristics of the benthic habitat. Removal of piles may cause sediments to slough off and elevate the suspended sediment concentrations at the work area (Hanson *et al.* 2003). The subsequent sedimentation and turbidity can impact adjacent sensitive habitats, such as SAV.

Increased Sedimentation/Turbidity

The primary adverse effect of removing piles is the suspension of sediments, which may result in harmful levels of turbidity and release of contaminants contained in those sediments. Some turbidity may be generated when piles are installed or removed with hydraulic jets, although this technique may not be widely used in the northeast coastal region. Vibratory pile removal tends to cause the sediments to slough off, resulting in relatively low levels of suspended sediments and contaminants (Hanson *et al.* 2003). Vibratory removal of piles may be preferable in some circumstances because it can be used on all types of piles, providing that they are structurally sound. Breaking or cutting the pile below the mudline may suspend only small amounts of sediment, providing the stub is left in place and little digging is required to access the pile. Direct pull or use of a clamshell to remove broken piles, however, may suspend large amounts of sediment and contaminants. When the piling is pulled from the substrate using these two methods, sediments clinging to the piling will slough off as it is raised through the water column, producing a potentially harmful plume of turbidity and/or contaminants. The use of a clamshell may suspend additional sediment if it penetrates the substrate while grabbing the piling (Hanson *et al.* 2003). For more information on turbidity and sedimentation, consult the chapters on Physical Effects: Water Uptake and Discharge Facilities and Marine Transportation.

Contaminant Releases

Contaminants contained within the sediments in the area of pilings can become available to aquatic plants and animals when pilings are extracted from the substrate. Sediments clinging to the piling will slough off as it is raised through the water column, producing a potentially harmful plume of contaminants. Sediment plumes may also be created around the pilings when they are installed, although it is usually much less than the turbidity created during removal.

Conservation Measures and Best Management Practices for Pile Driving and Removal (adapted from Hanson *et al.* 2003)

1. For intertidal areas, drive piles during low tide periods when substrates are exposed.
2. Use a vibratory hammer to install piles, when possible. Under those conditions where impact hammers are required for reasons of seismic stability or substrate type, it is recommended that the pile be driven as deep as possible with a vibratory hammer prior to the use of the impact hammer.
3. Implement measures to attenuate the sound or minimize impacts to aquatic resources during piling installation. Methods to mitigate sound impacts include, but are not limited to, the following:
   a) Surround the pile with an air bubble curtain system or dewatered cofferdam.
   b) Drive piles during low water conditions for intertidal areas.
   c) Utilize appropriate work windows that avoid impacts during sensitive times of year (e.g., anadromous fish runs, and spawning, larval, and juvenile development periods).
4. For creosote-coated piles, it may be preferable to remove piles completely rather than cutting or breaking off if the pile is structurally sound.
5. Minimize the suspension of sediments and disturbance of the substrate when removing piles. Measures to help accomplish this include, but are not limited to, the following:
   a) When practicable, remove piles with a vibratory hammer, rather than the direct pull or clamshell method.
   b) Remove the pile slowly to allow sediment to slough off at, or near, the mudline.
   c) The operator should first hit or vibrate the pile to break the bond between the sediment and pile to minimize the potential for the pile to break, as well as reduce the amount of sediment sloughing off the pile during removal.
   d) Place a ring of clean sand around the base of the pile. This ring will contain some of the sediment that would normally be suspended.
   e) Encircle the pile, or piles, with a silt curtain that extends from the surface of the water to the substrate.
6. Fill all holes left by the piles with clean, native sediments if possible.
7. Place piles on a barge equipped with a basin to contain all attached sediment and runoff water after removal. Creosote-treated timber piles should be cut into short lengths to prevent reuse, and all debris, including attached, contaminated sediments, should be disposed of in an approved upland facility.
8. Drive broken/cut stubs using a pile driver, sufficiently below the mudline to prevent release of contaminants into the water column as an alternative to their removal.

9. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Marine Debris

Marine debris is a chronic problem along much of the U.S. coast, resulting in littered shorelines and estuaries, and creating hazards for marine organisms. Marine debris consists of a large variety of man-made materials such as generic litter, hazardous wastes, and discarded or lost fishing gear (Hanson *et al.* 2003). It generally enters waterways indirectly through rivers and storm drains, or by direct ocean dumping. Marine debris can have varying degrees of negative effects on the coastal ecosystem and although several legislative laws and regulatory programs exist to prevent or control the problem, marine debris continues to adversely impact our waters (Hanson *et al.* 2003).

The U.S. Congress has passed various legislation, or adopted international agreements, intended to prevent the disposal of marine debris in U.S. ocean waters (e.g., Marine Protection, Research, and Sanctuaries Act, also known as the Ocean Dumping Act; Clean Water Act; International Convention for the Prevention of Pollution from Ships, commonly known as MARPOL; and the International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter). Regulations implementing these acts are intended to control the disposal of industrial wastes and the release of marine debris from ocean sources, including commercial merchant vessels (e.g., galley waste and other trash), recreational boaters and fishermen, offshore oil and gas exploration and facilities, military and research vessels, and commercial fishing vessels (Cottingham 1988). See the Marine Transportation chapter for more information on marine debris.

Legislation and programs have also been enacted and created to address land-based sources of pollution (e.g., BEACH Act; the National Marine Debris Monitoring Program; the Shore Protection Act of 1989; and the Clean Water Act). Land-based sources of marine debris account for approximately 80 percent of the marine debris on the beaches and in the waters of the Gulf of Maine (Hoagland and Kite-Powell 1997), as well as other coastal areas of the U.S. (Hanson *et al.* 2003). Land-based debris can originate from a wide variety of sources, including combined sewer overflows and storm drains, storm-water runoff, landfills, solid waste disposal, manufacturing facilities, poorly maintained garbage bins, floating structures (i.e., docks and piers), and general littering of beaches, rivers and open waters (Cottingham 1988; Hanson *et al.* 2003). Plastics account for 50 to 60 percent of marine debris collected from the Gulf of Maine (Hoagland and Kite-Powell 1997).

Entanglement and Ingestion

Entanglement and ingestion of marine debris by marine species is known to affect individuals of at least 267 species worldwide, including 86 percent of all sea turtle species, 44 percent of all seabird species, and 43 percent of all marine mammal species (Laist 1997). Plastic debris may be ingested by seabirds, fish and invertebrates, sea turtles, and marine mammals, which can obstruct the animal's intestinal tract and cause infections and death (Cottingham 1988). A study of marine debris ingestion by seabirds in the southern Atlantic Ocean found that 73 percent of all birds sampled had ingested some type of marine debris, and plastics comprised 66 percent of all debris occurrences (Copello and Quintana 2003).

Introduction of Invasive Species

Ballast water discharges and marine debris discarded from commercial cargo and recreational vessels are the primary methods of transporting non-indigenous marine life around the world, some of which have become invasive species that can alter the structure and function of aquatic ecosystems (Valiela 1995; Carlton 2001; Niimi 2004). Refer to the chapters on Marine Transportation and Introduced Species, Aquaculture, and Other Biological Threats for more information on invasive species.

Contaminant Releases and Introduction of Pathogens

The type of debris from these land-based sources can include raw or partially treated sewage, litter, hazardous materials (e.g., PAH, paint, solvents), and discarded trash. The typical floatable debris from combined sewer overflows includes street litter, sewage containing viral and bacterial pathogens, pharmaceutical by-products from human excretion, and pet wastes. It may contain condoms, tampons, and contaminated hypodermic syringes, all of which can pose physical and biological threats to fishery habitat (Hanson *et al.* 2003). Toxic substances in plastics, for example, can persist in the environment and bioaccumulate through the food web and can kill or impair fish and invertebrates that use habitat polluted by these materials. Fish diseases and shellfish poisoning (e.g., paralytic, amnesic, and neurotoxic) may be linked to municipal and agricultural runoff.

Conversion of Habitat

Because of the wide range and diversity of sources and materials contributing to marine debris, the affects to aquatic habitats are likewise wide-ranging and diverse. Floating or suspended trash can directly affect fish and invertebrates that may consume, or are entangled by the debris. Debris that settles to the bottom of rivers, estuaries, and open ocean areas may continue to cause environmental problems. Plastics and other materials with a large surface area can cover and suffocate sessile animals and plants. Debris can be transported by currents to other areas where it can become snagged and attached to benthic reefs, damaging these sensitive habitats.

Conservation Measures and Best Management Practices for Marine Debris (adapted from Hanson *et al.* 2003)

1. Require all new commercial construction projects near the coast (e.g., marinas and ferry terminals, recreational facilities, boat building and repair facilities) to develop and implement refuse disposal plans.
2. Encourage proper trash disposal in coastal and ocean settings.
3. Provide resources and technical guidance for development of studies and solutions addressing the problem of marine debris.
4. Provide resources to the public on the impact of marine debris and guidance on how to reduce or eliminate the problem.

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ENERGY-RELATED ACTIVITIES

Petroleum Exploration, Production, and Transportation

Introduction

The exploration, production, and transportation of petroleum have the potential for impacts to riverine, estuarine, and marine environments on the northeast U.S. coast. Petroleum exploration, production, and transportation is a particular concern in areas such as the Gulf of Maine and Georges Bank, which support important fishery resources and represent significant value to the U.S. economy. Although petroleum exploration and production does not currently occur within the northeast coastal and offshore region, the transportation of oil and gas (i.e., pipelines and tankers) and the associated shore-based infrastructure is widespread. It's expected that issues relating to petroleum development will continue to gain importance as world energy costs and demands rise. The Energy Policy Act of 2005 authorizes the Mineral Management Service (MMS) to perform surveys (exploration) for petroleum reserves on the Outer Continental Shelf (OCS) of the U.S. (Pub. L. 109-58, § 357). The OCS is the submerged lands, subsoil, and seabed, lying between the States' seaward jurisdiction and the seaward extent of Federal jurisdiction.

Petroleum exploration involves seismic testing, drilling sediment cores, and test wells in order to locate potential oil and gas deposits. Petroleum production includes the drilling and extraction of oil and gas from known reserves. Oil and gas rigs are permanently placed on the seabed and as oil is extracted from the reservoirs, it's transported directly into pipelines. While rare, in cases where the distance to shore is too great for transport via pipelines, oil is transferred to underwater storage tanks. From these storage tanks, oil is transported to shore via tanker (CEQ 1977). According to the MMS, there are 21,000 miles of pipeline on the U.S. OCS. According to the National Research Council (NRC), pipeline spills account for approximately 1,900 tonnes of petroleum into OCS waters, primarily in the central and western Gulf of Mexico (NRC 2003).

The major sources of oil releases as a result of petroleum extraction include accidental spills and daily operational discharges. The NRC estimates the largest anthropogenic source of petroleum hydrocarbon releases into the marine environment is from petroleum extraction-related activities. Approximately 2,700 tonnes per year in North America and 36,000 tonnes per year worldwide are introduced to the marine environment as a result of "produced waters" (NRC 2003). "Produced waters" are waters that are pumped to the surface from oil reservoirs which cannot be separated from the oil. Produced waters are either injected back into reservoirs or discharged into the marine environment (NRC 2003). Over 90 percent of the oil released from extraction activities is from produced water discharges which contain dissolved compounds (i.e., polycyclic aromatic hydrocarbons, PAH) and dispersed crude oil (NRC 2003*)*. These compounds stay suspended in the water column and undergo microbial degradation, or are sorbed onto suspended sediments and are deposited on the seabed. Elevated levels of PAH in sediments are typically found up to 300 m from the discharge point (NRC 2003).

While petroleum extraction and transportation can result in impacts to the marine environment, it is important to note that natural seeps contribute to approximately 60 percent of all petroleum hydrocarbons that are released into the marine environment **(**NRC 2003**)**. In addition, land-based runoff and discharges by two–stroke recreational boating engines account for nearly 22 percent of the total petroleum released into the marine environment in North America (NRC 2003).

Underwater Noise

Oil and gas activities generate noise from drilling activities, construction, production facility operations, seismic exploration and supply vessel and barge operations that can disrupt or damage living marine resources. The effects of oil exploration-related seismic energy may cause fish to disperse from the acoustic pulse with possible disruption to their feeding patterns (Marten *et al.* 2001). Larvae and young fish are particularly sensitive to noise generated from underwater seismic equipment. Noise in the marine environment may adversely affect marine mammals by causing them to change behavior (e.g., movement and feeding), interfere with echolocation and communication, or may result in injury to hearing organs (Richardson *et al.* 1995). Noise issues related to petroleum tanker traffic can adversely affect fishery resources within the marine environment, particularly within estuarine areas which host much of the nation's petroleum land-based port activities. Refer to the chapters on Marine Transportation and Global Effects and Other Impacts for information regarding impacts to fishery resources from underwater noise.

<u>Habitat Conversion and Loss</u>

Petroleum extraction and transportation can lead to a conversion and loss of habitat in a number of ways. Activities such as vessel anchoring, platform or artificial island construction, pipeline laying, dredging, and pipeline burial can alter bottom habitat by altering substrates used for feeding or shelter. Disturbances to the associated epifaunal communities, which may provide feeding or shelter habitat, can also result. The installation of pipelines associated with petroleum transportation can have direct and indirect impacts on offshore, nearshore, estuarine, wetland, beach, and rocky shore coastal zone habitats. The destruction of benthic organisms and habitat can occur through the installation of pipelines on the sea floor (Gowen 1978). Benthic organisms, especially prey species, may recolonize disturbed areas, but this may not occur if the composition of the substrate is drastically changed or if facilities are left in place after production ends.

The discharge of drilling cuttings (i.e., crushed sedimentary rock) during petroleum extraction operations can result in varying degrees of change to the sea floor and affect feeding, nursery, and shelter habitat for various life stages of marine organisms. Cuttings may adversely affect bottom-dwelling organisms at the site by burial of immobile forms or forcing mobile forms to migrate. The accumulation of drill cuttings on the ocean floor can alter the benthic sedimentary environment (NRC 2003).

Physical damage to coastal wetlands and other fragile areas can be caused by onshore infrastructure and pipelines associated with petroleum production and transportation. Physical alterations to habitat can occur from the construction, presence and eventual decommissioning and removal of facilities such as islands or platforms, storage and production facilities, and pipelines to onshore common carrier pipelines, storage facilities, or refineries. For additional information regarding impacts of pipelines associated with petroleum production, refer to the section on Cables and Pipelines in this chapter of the report.

<u>Contaminant Discharge</u>

A variety of contaminants can be discharged in to the marine environment as a result of petroleum extraction operations. Waste discharges associated with a petroleum facility include drilling well fluids, produced waters, surface runoff and deck drainage, and solid-waste from wells (i.e., drilling mud and cuttings) (NPFMC 1999). In addition to crude oil spills, chemical, diesel, and other contaminant spills can occur with petroleum-related activities (NPFMC 1999).

Produced waters contain finely dispersed oil droplets that can stay suspended in the water column or can settle out into sediments. Produced waters are generally higher in salinity than seawater and contain elevated concentrations of radionuclides, metals, and other contaminants, and elevated levels of contaminated sediments typically extend up to 300 m from the discharge point (NRC 2003). In estuarine waters, higher saline produced waters can affect the salt wedge and form dense saltwater plumes.

The discharge of oil drilling mud can change the chemical and physical characteristics of benthic sediments at the disposal site by introducing toxic chemical constituents. The addition of contaminants can reduce or eliminate the suitability of the water column and substrate as habitat for fish species and their prey. The discharge of oil-based drill cuttings are currently not permitted in U.S. waters; however, where oil-based drill cuttings have been discharged, there is evidence that sediment contamination and benthic impacts can occur up to 2 km from the production platform (NRC 2003).

The petroleum refining process converts crude oil into gasoline, home heating oil and other refined products. The process of refining crude oil into various petroleum products produces effluents, which can degrade coastal water quality. Oil refinery effluents contain many different chemicals at different concentrations including ammonia, sulphides, phenol and hydrocarbons. Toxicity tests have shown that most refinery effluents are toxic, but to varying extents. Some species are more sensitive and the toxicity may vary throughout the life cycle. Experiments have shown that not only can the effluents be lethal but also they can often have sublethal effects on growth and reproduction (Wake 2005). Field studies have shown that oil refinery effluents often have an adverse impact on aquatic organisms (i.e., an absence of all or most species), which is more pronounced in the area closest to the outfall (Wake 2005).

The operation of oil tankers can discharge contaminants into the water column and result in impacts to pelagic and benthic organisms. Older tankers that do not have segregated ballast tanks (i.e., completely separated from the oil cargo and fuel systems) can discharge ballast water containing contaminants (NRC 2003).

Discharge of Debris

Petroleum extraction and transportation can result in the discharge of various types of debris, including domestic wastewater generated from offshore facilities, solid-waste from wells (i.e. drilling mud and cuttings) and other trash and debris from human activities associated with the facility (NPFMC 1999). Debris, either floating on the surface, suspended in the water column, covering the benthos, or along the shoreline, can have deleterious impacts on fish and shellfish within riverine habitat, as well benthic and pelagic habitats in the marine environment (Coe and Rogers 1997, cited in NEFMC 1998). Debris from petroleum extraction and transportation activities can be ingested by fish (Hoagland and Kite-Powell 1997). Reduction and degradation of habitat by debris can alter community structure and affect the sustainability of fisheries.

Oil Spills

In even moderate quantities, discharged oil into the environment can affect habitats and living marine resources. Accidental discharge of oil can occur during almost any stage of exploration, development, or production on the OCS and in nearshore coastal areas, and can occur from a number of sources, including equipment malfunction, ship collisions, pipeline breaks other human error, or severe storms (Hanson *et al.* 2003). Oil spills can also be attributed to support activities associated with product recovery and transportation, and can also involve various contaminants including hazardous chemicals and diesel fuel (NPFMC 1999).

Oil, characterized as petroleum and any derivatives, can be a major stressor to inshore fish habitats. Oil can kill marine organisms, reduce their fitness through sublethal effects, and disrupt the structure and function of the marine ecosystem (NRC 2003). Short-term impacts include interference with the reproduction, development, growth and behavior (e.g., spawning and feeding) of fishes, especially early life-history stages (Gould *et al.* 1994). Petroleum compounds are known to have carcinogenic and mutagenic properties (Larsen 1992). Various levels of toxicity have been observed in Atlantic herring eggs and larvae exposed to crude oil in concentrations of 1 to 20 ml/L (Blaxter and Hunter 1982). Oil spills may cover and degrade coastal habitats and associated benthic communities, or may produce a slick on the surface waters which disrupts the pelagic community. These impacts may eventually lead to disruption of community organization and dynamics in affected regions. Oil can persist in sediments for years after the initial contamination (NRC 2003), interfering with physiological and metabolic processes of demersal fishes (Vandermeulen and Mossman 1996).

Oil spills can have adverse effects to both subtidal and intertidal vegetation. Direct exposure to petroleum can lead to die off of submerged aquatic vegetation in the first year of exposure. Certain species which propagate by lateral root growth rather than seed germination may be less susceptible to oil in the sediment (NRC 2003). Oil has been demonstrated to disrupt the growth of vegetation in estuarine habitats (Lin and Mendelssohn 1996). Kelp located in low energy environments can retain oil in their holdfasts for extended periods of time. Oil spills are known to cause severe and long-term damage to salt marshes through the covering of plants and contamination of sediments. Lighter and more refined oils such as No. 2 fuel oil are extremely toxic to smooth cordgrass, *Spartina alternaflora* (NRC 2003). Impacts to salt marsh habitats from oil spills depend on type, coverage and amount of oil. Oil spills within salt marshes will likely have a greater impact in the spring growing season, compared to the dormant periods in the fall and winter.

Habitats that are susceptible to damage from oil spills include the low-energy coastal bays and estuaries where heavy deposits of oil may accumulate and essentially smother intertidal and salt marsh wetland communities. High-energy cobble environments are also susceptible to oil spills, as oil is driven into sediments through wave action. For example, many of the beaches in Prince William Sound with the highest persistence of oil following the *Exxon Valdez* oil spill were high-energy environments containing large cobbles overlain with boulders. These beaches were pounded by storm waves following the spill, which drove the oil into and well below the surface (Michel and Hayes 1999). Oil contamination in sediments may persist for years. For example, subsurface oil was detected in beach sediments of Prince William Sound twelve years after the *Exxon Valdez* oil spill, much of it unweathered and more prevalent in the lower intertidal biotic zone than at higher tidal elevations (Short *et al.* 2002).

Oil can have severe detrimental impacts on offshore habitats, although the effects may not be as acute as in inshore, sheltered areas. Offshore spills or wellhead blowouts can produce an oil slick on surface waters which can disrupt entire pelagic communities (i.e., phytoplankton and zooplankton). The disruption of plankton communities can interfere with the reproduction, development, growth and behavior of fishes by altering an important prey base.

Physical and biological forces act to reduce oil concentrations (Hanson *et al.* 2003). Generally the lighter fraction aromatic hydrocarbons evaporate rapidly, particularly during periods of high wind and wave activity. Heavier oil fractions typically pass through the water column and settle to the bottom. Suspended sediments can adsorb and carry oil to the seabed. Hydrocarbons may be solubilized by wave action which may enhance adsorption to sediments, which then sink to the seabed and contaminate benthic sediments (Hanson *et al.* 2003). Tides and hydraulic gradients allow movement of soluble and slightly soluble contaminants (e.g., oil) from beaches to surrounding streams in the hyporheic zone (i.e., the saturated zone under a river or stream, comprising substrate with the interstices filled with water) where pink salmon eggs incubate (Carls *et al.* 2003). Oil can reach nearshore areas and affect productive nursery grounds, such as estuaries that support high densities of fish eggs and larvae. An oil spill near a particularly important hydrological zone, such as a gyre where fish or invertebrate larvae are concentrated, could also result in a disproportionately high loss of a population of marine organisms (Hanson *et al.* 2003). Epipelagic biota, such as eggs, larvae and other planktonic organisms, would be at risk from an oil spill. Planktonic organisms cannot actively avoid exposure and their small size means contaminants may be absorbed quickly. In addition, their proximity to the sea surface can increase the toxicity of hydrocarbons several-fold and makes them more vulnerable to photo-enhanced toxicity effects (Hanson *et al.* 2003).

Many factors determine the degree of damage from a spill, including the composition of the oil, the size and duration of the spill, the geographic location of the spill, and the weathering process present (NRC 2003). Although oil is toxic to all marine organisms at high concentrations, certain species and life history stages of organisms appear to be more sensitive than others. In general, the early life stages (i.e., eggs and larvae) are most sensitive, juveniles are less sensitive, and adults least so (Rice *et al.* 2000). Some marine species may be particularly susceptible to hydrocarbon spills if they require specific habitat types in localized areas and utilize enclosed water bodies, like estuaries or bays (Stewart and Arnold 1994).

Small, but chronic oil spills may be a particular problem to the coastal ecosystem because residual oil can build up in sediments. Low-levels of petroleum components from such chronic pollution have been shown to accumulate in fish tissues and cause lethal and sublethal effects, particularly at embryonic stages. Effects on Atlantic salmon from low-level chronic exposure to petroleum components and byproducts (i.e., polycyclic aromatic hydrocarbons, or PAH) has been shown to increase embryo mortality, reduce growth (Heintz *et al.* 2000), and lower the return rates of adults returning to natal streams (Wertheimer *et al.* 2000).

As spilled petroleum products become weathered, the aromatic fraction of oil is dominated by PAH as the lighter aromatic components evaporate into the atmosphere or are degraded. Because of its low solubility in water, PAH concentrations probably contribute little to acute toxicity (Hanson *et al.* 2003). However, lipophilic PAH (those likely to be bonded to fat compounds) may cause physiological injury if it accumulates in tissues after exposure (Carls *et al.* 2003; Heintz *et al.* 2000), and even concentrations of oil that are diluted sufficiently to not cause acute impacts in marine organisms may alter certain behavior or physiological patterns. For example, "fatty change", a degenerative disease of the liver, can occur from chronic exposure to organic contaminants such as oil (Freeman *et al.* 1981).

Sublethal effects that may occur with exposure to PAH include impairment of feeding mechanisms for benthic fish and shellfish, growth and development rates, energetics, reproductive output, juvenile recruitment rates, increased susceptibility to disease and other histopathic disorders (Capuzzo 1987), and physical abnormalities in fish larvae (Urho and Hudd 1989). Effects of exposure to PAH in benthic species of fish include liver lesions, inhibited gonadal growth, inhibited spawning, reduced egg viability and reduced growth (Johnson *et al.* 2002). Gould *et al.* (1994) summarized various toxicity responses to winter flounder exposed to PAH and other petroleum-derived contaminants, including liver and spleen diseases, immunosuppression responses, tissue necrosis, altered blood chemistry, gill tissue clubbing, mucus hypersecretion, altered sex hormone levels, and altered reproductive impairments. For Atlantic cod exposed to various petroleum products, responses included reduced growth rates, gill hyperplasia, increased skin pigmentation, hypertrophy of gall bladder, liver disease, delayed spermatogenesis, retarded gonadal development and other reproductive impairments, skin lesions, and higher parasitic infections (Gould *et al.* 1994).

<u>Siltation, Sedimentation and Turbidity</u>

Exploratory and construction activities may result in resuspension of fine-grained mineral particles, usually smaller than silt, in the water column. Fish and invertebrate habitat may be adversely affected by elevated levels of suspended particles (Arruda *et al.* 1983), which can result in both lethal and sub-lethal impacts to marine organisms (Newcombe and MacDonald 1991; Newcombe and Jensen 1996). Short-term impacts from increases in suspended particles may include high turbidity, reduced light, and sedimentation which may lead to the loss or complexity of benthic habitat (USFWS and NMFS 1999). Suspended particles can reduce light penetration and lower the rate of photosynthesis and the primary productivity of the aquatic area, especially if the turbidity is persistent (Gowen 1978). Groundfish and other fish species can suffer reduced feeding ability and limited growth if high levels of suspended particles persist in the water column. Other problems associated with suspended solids include disrupted respiration and water transport rates in marine organisms, reduced filtering efficiencies in invertebrates, reduced egg buoyancy, disrupted ichthyoplankton development, reduced growth and survival of filter feeders, and decreased foraging efficiency of sight-feeders (Gowen 1978; Messieh *et al.* 1991; Barr 1993). Demersal eggs of fish and invertebrates can be adversely impacted due to sediment deposition and suffocation. For example, hatching is delayed for striped bass and white perch exposed to sediment concentrations as low as 100 mg/L for 1 day (Wilber and Clarke 2001). Berry *et al.* (2004) reported a decreased hatching success for winter flounder eggs with increasing depth of burial by sediment and no hatching occurred at burial depths of approximately 2.0 mm. Breitburg (1988) found the predation rates of striped bass larvae on copepods to decrease by 40 percent when exposed to high turbidity conditions in the laboratory. Anadromous fish passage in estuarine and riverine environments can also be adversely impacted by increased turbidity. For example, rainbow smelt showed signs of increased activity at suspended sediment concentrations as low as 20 mg/L (Chiasson 1993).

Shallow water environments, rocky reefs, nearshore and offshore rises, salt and freshwater marshes (wetlands), and estuaries are more likely to be adversely impacted than open-water habitats. This is due, in part, to their higher sustained biomass and lower water volumes, which decrease their ability to dilute and disperse suspended sediments (Gowen 1978).

<u>Oil Spill Clean-up Activities</u>

There are a number of oil spill response and cleanup methods available. Chemical dispersants are used primarily in open water environments. Dispersants contain surfactant chemical that, under proper mixing conditions and concentrations, attach to oil molecules and reduce the interfacial tension between oil molecules (NOAA 1992). This allows oil molecules to break apart and thus break down the oil slick. Depending on the environmental conditions and biological resource present, dispersants can result in acute toxicity. Exposure to high concentrations of oil dispersants have been shown to block the fertilization of eggs and induce rapid cytolysis of developing eggs and larvae in Atlantic cod (Lonning and Falk-Petersen 1978). Other methods of cleanup for open water spills include *in-situ* burning, and nutrient and microbial remediation. In each case, impacts are dependent on the resources present in the particular location. Other forms of shoreline cleanup include the use of sorbents, trenching, sediment removal, water flooding/pressure washing. Sediment removal and pressure washing will result in direct impact to the benthos. Trampling of salt marsh during cleanup activities damage can be severe, causing damage to plants and forcing oil into the sediments.

<u>Conservation Recommendations and Best Management Practices for Petroleum Exploration, Production, and Transportation</u> (adapted from Hanson *et al.* 2003)

1. Pre-construction biological surveys should be conducted, in consultation with resource agencies, to determine the extent and composition of biological populations or habitat in the proposed impact area.
2. Limit the discharge of produced waters into marine and estuarine environments. Re-inject produced waters into the oil formation whenever possible.
3. Avoid discharge of drilling mud and cuttings into the marine, estuarine, and riverine environment.
4. Avoid placing causeways or structures associated with petroleum exploration and production in the nearshore marine environment. Particular care should be made to avoid submerged aquatic vegetation, intertidal flats, and salt marsh habitat.
5. Use methods to transport oil and gas that limit the need for handling in sensitive fishery habitats.
6. Whenever possible, use horizontal directional drilling for installation of pipelines in areas containing sensitive habitats.
7. Oil extraction, production and transportation facilities should provide for monitoring and leak detection systems that preclude oil from entering the environment.
8. Evaluate impacts to habitat during the decommissioning phase, including impacts during the demolition phase.
9. Schedule dredging activities when the fewest species and least vulnerable life stages are present. Appropriate work windows can be established based on the multiple season biological sampling. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
10. Address cumulative impacts of past, present and foreseeable future dredging operations on aquatic habitats by considering them in the review process.
11. Ensure that oil extraction, production and transportation facilities have developed and implemented adequate oil spill response plans. Assist government agencies responsible for oil spills (e.g., U.S. Coast Guard, state and local resource agencies) in developing response plans and protocols, including identification of sensitive marine habitats and development and implementation of appropriate oil spill-response measures.
12. Potential adverse impacts to marine resources from oil spill clean-up operations should be weighed against the anticipated adverse affects of the oil spill itself. The use of chemical dispersants in nearshore areas where sensitive habitats are present should be avoided.

<u>Liquefied Natural Gas (LNG)</u>

<u>Introduction</u>

Liquefied Natural Gas (LNG) is expected to provide a large proportion of the future energy needs in the northeastern U.S. In recent years there has been an increase in proposals for new LNG facilities, including both onshore and offshore facilities from Maine to Delaware. In the northeastern U.S., there are currently onshore LNG facilities operating in Everett, Massachusetts and Cove Point, Maryland, and two offshore LNG facilities have been proposed for the Boston, Massachusetts area and one in the Long Island Sound.

The LNG process cools natural gas to its liquid form at approximately -260 degrees Fahrenheit (F). This reduces the volume of natural gas to approximately $1/600^{th}$ of its gaseous state volume, making it possible for economical transportation using tankers. Upon arrival at the destination, the LNG is either regasified onshore or offshore and sent out into an existing pipeline infrastructure, or transported onshore for storage and future regasification. The process of regasification occurs when LNG is heated and converted back to its gaseous state. LNG facilities can utilize either "open loop", "closed loop", or "combined loop" systems for regasification. Open loop systems utilize warm seawater for regasification and closed loop systems generally utilize a recirculating mixture of ethylene glycol for regasification. Combined loop systems utilize a combination of the two systems.

Onshore LNG facilities generally include a deepwater access channel, land-based facilities for regasification and distribution, and storage facilities. Offshore facilities generally include some type of a deepwater port with a regasification facility, and pipelines to transport natural gas into existing gas distribution pipelines or onshore storage facilities. Deepwater ports require specific water depths, and generally include some form of exclusion zone for LNG vessel and/or port facility security.

Habitat Conversion and Loss

The conversion of habitat and/or the loss of benthic habitats can occur from the construction and operation of LNG facilities. The placement of pipelines and associated structures on the seafloor can impact benthic habitats due to physical occupation and conversion of the seafloor. The installation of pipelines can impact shellfish beds, hard-bottomed habitats and submerged aquatic vegetation (Gowen 1978). Plowing or trenching for pipeline installation and side-casting of material can lead to a conversion of substrate and habitat. Placement of anchors for the construction of the deepwater port facilities can have direct impact to the substrate and benthos.

Due to the large size of LNG tankers, dredging may need to occur in order to access onshore terminals. The deepening of channel areas and turning basins can result in permanent and temporary dredging impacts to fishery habitat, including the loss of spawning and juvenile development habitat due to changes in bathymetry, suitable substrate type, and sedimentation. Disruption of the areas due to dredging and sedimentation may cause spawning fish to leave the area for more suitable spawning conditions. Dredging, as well as the equipment used in the process such as pipelines, may damage or destroy other sensitive habitats such as emergent marshes and submerged aquatic vegetation (SAV), including eelgrass beds (Mills and Fonseca 2003) and macroalgae beds. The stabilization and hardening of shorelines for the development of upland facilities can lead to a direct loss of SAV, intertidal mudflats, and salt marshes that serve as important habitat for a variety of living marine resources. See the Marine Transportation, Offshore Dredging and Disposal, and Coastal Development chapters for more detailed information on impacts from dredging.

Discharge of Contaminants

Discharge of contaminants can occur as a result of spills during offloading procedures associated with either onshore or offshore facilities. There is limited information and experience regarding the aquatic impacts resulting from an LNG spill, however, due to the toxic nature of natural gas, acute impacts to nearby resources and habitats can be expected.

Biocides (e.g., copper and aluminum compounds) are often utilized in the hydrostatic testing of pipelines. LNG tankers utilize large amounts of seawater for regasification purposes (i.e., open-loop system), for engine cooling, and for ship ballast water. Biocides are commonly utilized to prevent pipeline and engine fouling from marine organisms and are subsequently discharged into surrounding waters. Laboratory experiments have shown high mortality of Atlantic herring eggs and larvae at copper concentrations of 30 µg/L and 1,000 µg/L, respectively, and vertical migration of larvae was impaired at copper concentrations of greater than 300 µg/L (Blaxter 1977). The release of contaminants can reduce or eliminate the suitability of water bodies as habitat for fish species and their prey. In addition, contaminants, such as copper and aluminum, can accumulate in sediments and become toxic to organisms contacting or feeding on the bottom.

Discharge of Debris

LNG facilities can result in the discharge of debris, including domestic waste waters generated from the offshore facility, and other trash and debris from human activities associated with the facility (NPFMC 1999). Impacts from the discharge of debris from LNG are similar to those described in the Petroleum Exploration, Production, and Transportation section of this chapter.

Siltation, Sedimentation and Turbidity

LNG construction activities may result in increased suspended sediment in the water column due to dredging, the installation of pipelines, anchors and chains, and the movement of vessels through confined areas, and upland site development. Impacts from siltation and sedimentation from LNG are similar to those described in the Petroleum Exploration, Production, and Transportation section of this chapter.

Entrainment and Impingement

Intake structures for traditional power plants can result in impingement and entrainment of marine organisms through the use of seawater for cooling purposes (Enright 1977; Helvey 1985; Callaghan 2004). Likewise, intake structures utilized for the LNG regasification process can result in impingement and entrainment of living marine resources. “Open-loop” LNG regasification systems utilize seawater for warming into a gaseous state, and are typically utilized when ambient water temperatures are greater than about 45E F. In addition, “combined loop” systems can utilize seawater for partial regasification. Depending on the geographic location and the water depth of the intake pipe, phytoplankton, zooplankton, and fish eggs and larvae can be entrained into the system. Juvenile fish can also be impinged on screens of water intake structures (Hanson 1977; Hanson *et al.* 2003). Normal ship operations utilize intake structures for ballast water and engine cooling, and can result in additional impingement and entrainment of resources, as well.

The entrainment and impingement impacts on aquatic organisms from LNG facilities have the potential to be substantial. For example, an assessment of impacts of a proposed LNG facility in the Gulf of Mexico determined that an open-loop regasification system (i.e., Port Pelican LNG) could utilize 176 million gallons of water per day, which may entrain 1.6 billion fish and 60 million shrimp larvae per year, 3.3 billion fish eggs per year, and 500 billion zooplankton per year (R. Ruebsamen, pers. comm.). Additional entrainment and impingement impacts were expected for vessel ballast and cooling water uses. In the northeast U.S., an offshore LNG degasification facility with a closed-loop system has been proposed near Gloucester, MA with estimated annual mortality rates due to vessel ballast and cooling water of the eggs and larvae for Atlantic mackerel, pollock, yellowtail flounder, and Atlantic cod of 8.5 million, 7.8 million, 411,000, and 569,000, respectively (USCG 2006).

Alteration of Temperature Regimes
The operation of LNG facilities can result in the alteration of temperature regimes. Discharge of water from engine cooling operations can be at temperatures up to 10E F higher than surrounding waters. Water utilized for the purposes of regasification will be discharged at temperatures colder than the surrounding water by about 10-15E F. Changes in water temperatures can alter physiological functions of marine organisms, including respiration, metabolism, reproduction, and growth. In riverine and estuarine environments, changes to water temperatures can impact the egg and juvenile life stages of Atlantic salmon (USFWS and NMFS 1999). Thermal effluent in inshore habitat can cause severe problems by directly altering the benthic community or adversely affecting marine organisms, especially egg and larval life stages (Pilati 1976; Rogers 1976). The seaward migration of juvenile American shad are cued to water temperatures (Richkus 1974; Mackensie *et al.* 1985), and temperature influences biochemical processes of the environment and the behavior (*e.g.*, migration) and physiology (*e.g.*, metabolism) of marine organisms (Blaxter 1969; Stanley and Colby 1971).

Alteration of Hydrological Regimes
The operation of LNG facilities can affect the hydrology of confined waterbodies, or waterbodies with limited flows such as streams and rivers, and estuaries fed by streams and rivers. Depending upon the characteristics of the waterbody and the nature of the water intake and discharge, altered stream flow can result in reductions in stream flow and subsequent degradation of ecosystem functions (Reiser *et al.* 2004).

Alteration of Salinity Regimes
The operation of LNG facilities can result in the alteration of hydrological regimes due to the discharge of brine from onboard desalination operations. The operation of LNG facilities within riverine and estuarine environments can impact anadromous fish by altering in salinity regimes (Dodson *et al.* 1972; Leggett and O'Boyle 1976) and affecting the ability of fish to access migration corridors.

Underwater Noise
Underwater noise sources generate sound pressure that can disrupt or damage marine life. LNG activities generate noise from construction, production facility operations, and tanker traffic. Larvae and young fish are particularly sensitive to noise generated from underwater seismic equipment. It is also known that noise in the marine environment may adversely affect marine mammals by causing them to change behavior (e.g., movement, feeding), interfere with echolocation and communication, or may result in injury to hearing organs (Richardson *et al.* 1995). Noise issues related to LNG tanker traffic can adversely affect fishery resources in the marine environment, particularly in estuarine areas where some LNG port activities are located or

proposed. A more thorough review of underwater noise can be found in the chapter on Global Effects and other Impacts.

Exclusion Zones

Due to security concerns, LNG tankers and terminals include safety and exclusion areas around the facilities. Different types of restrictions are put in places based on the distance from the facility; however, restrictions on commercial and recreational fishing activities around the LNG facilities can lead to a displacement of fishing effort to other/adjacent areas. This in turn, may increase fishing effort and habitat impacts to more ecologically sensitive areas.

Introduction of Invasive Species

Introductions of non-native invasive species into marine and estuarine waters are a significant threat to living marine resources in the United States (Carlton 2001). Non-native species can be released unintentionally when ships release ballast water (Hanson *et al.* 2003; Niimi 2004). Hundreds of species have been introduced into U.S. waters from overseas and from other regions around North America, including finfish, shellfish, phytoplankton, bacteria, viruses, and pathogens (Drake *et al.* 2005). LNG tankers entering U.S. waters are generally loaded with cargo and do not need to release large amounts of ballast water. However, even small amounts of released ballast water have the potential to contain invasive exotic species. In addition, as vessels are unloaded and ballast is taken on in U.S. waters, the water may contain species that are potentially invasive to other locations. The transportation of nonindigenous organisms to new environments can have severe impacts on habitat (Omori *et al.* 1994), and change the natural community structure and dynamics, lower the overall fitness and genetic diversity of natural stocks, and pass and/or introduce exotic lethal disease. Refer to the chapters on Marine Transportation and Introduced/Nuisance Species and Aquaculture for more information on invasive species and shipping.

Conservation Recommendations and Best Management Practices for LNG Facilities

1. Pre-construction biological surveys should be conducted, in consultation with resource agencies, to determine the extent and composition of biological populations or habitat in the proposed impact area.
2. The use of "closed loop" systems, which minimize the volume of water utilized for regasification should be recommended over "open loop" systems. This will serve to minimize the level of impingement and entrainment of living marine resources.
3. Locate facilities that may use surface waters for regassification to areas other than estuaries, inlets, heads of submarine canyons, rock reefs or small coastal embayments where fisheries resources and their prey concentrate. Discharge points should be located in areas that have low concentrations of living marine resources.
4. Design intake structures to minimize entrainment or impingement.
5. Regulate discharge temperatures (both heated and cooled effluent) such that they do not appreciably alter the temperature regimes of the receiving waters, which could cause a change in species assemblages and ecosystem function. Strategies should be implemented to diffuse the heated effluent.
6. Avoid the use of biocides (e.g., aluminum, copper, chlorine compounds) to prevent fouling where possible. The least damaging antifouling alternatives should be implemented.
7. Operational monitoring plans should be implemented to analyze impacts resulting from intake and discharge structures and should be linked to a plan for adaptive management.
8. Natural gas production and transportation facilities should provide for monitoring and leak detection systems that preclude gas from entering the environment.

9. Schedule dredging activities when the fewest species and least vulnerable life stages are present. Appropriate work windows can be established based on the multiple season biological sampling. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
10. Address cumulative impacts of past, present and foreseeable future dredging operations on aquatic habitats by considering them in the review process. Based on evaluation of the foreseeable impacts to fishery habitats, a determination can be made regarding the most suitable location and operational procedures for LNG facilities. Ideally, such an analysis would be done at the regional or national level based on natural gas usage and need.
11. Ensure that gas production and transportation facilities have developed and implemented adequate gas spill response plans. Assist government agencies responsible for gas spills (e.g., U.S. Coast Guard, state and local resource agencies) in developing response plans and protocols, including identification of sensitive marine habitats and development and implementation of appropriate gas spill-response measures.

Offshore Wind Energy Facilities

Introduction

Offshore wind energy facilities convert wind energy into electricity through the use of turbines. An offshore facility generally consists of a series of wind turbine generators, an inner-array of submarine electric cables that connect each of the turbines, and a single electrical service platform (ESP). Electricity is transmitted from the ESP to an onshore facility through one or a series of submarine cables.

While there are no operating offshore wind facilities in the United States at this time, there are at least two proposals to develop offshore wind facilities within the northeast region. The construction and operation of offshore wind facilities has the potential to adversely affect fishery habitats.

Habitat Conversion and Loss

The construction of offshore wind turbine and support structures can result in benthic habitat conversion and loss due to the physical occupation of the natural substrate. Scour protection around the structures, consisting of rock or concrete mattresses, can also lead to a conversion and loss of habitat. Should scour around cables and the base of structures occur, subsequent stabilization activities could lead to additional impacts to benthic habitat. Likewise, the burial and installation of submarine cable arrays can impact the benthic habitat through temporary disturbance from plowing and from barge anchor damage. In some cases, plowing or trenching for cable installation can permanently convert benthic habitats due to top layers of sediments being replaced with new material. The installation of cables and associated barge anchor damage can adversely affect submerged aquatic vegetation, if those resources are present in the project area. Cable maintenance, repairs, and decommissioning can also result in impacts to benthic resources and substrate.

Siltation, Sedimentation and Turbidity

The construction of wind turbine and support structures can cause increased turbidity in the water column and sedimentation impacts on adjacent benthic habitats. Likewise, the subsurface installation of underwater cables can result in similar impacts. Most of these impacts are relatively short-term and should subside after construction is completed. Maintenance and repairs of wind turbines and submarine electric cables can be expected to persist during the operation of the wind generator facilities. Increased sedimentation and turbidity during the decommissioning of wind energy facilities could be greater than the construction impacts if all submarine structures were to be removed. Impacts from siltation, sedimentation, and turbidity from Offshore Wind Energy projects are similar to those described in the Petroleum Exploration, Production, and Transportation section of this chapter.

Alteration of Hydrological Regimes

The placement of wind energy facilities, especially large arrays or "farms", in marine and estuarine habitats may affect hydrological regimes by altering tidal and current patterns. Altered current patterns could affect the distribution of eggs and larvae and the distribution of species within estuaries and bay, as well as the migration patterns of anadromous fishes.

Alteration of Electromagnetic Fields

Background direct current electric fields originate from the metallic core of the Earth and the electric currents flowing in the upper layer of the Earth's crust. The strength of this geomagnetic field is highest at the magnetic poles and the lowest at the equator. Marine fishes, such as elasmobranches and anadromous fishes, utilize natural electromagnetic fields (EMF's) for navigation and migratory behavior (Gill *et al.* 2005). Studies have shown sharks and rays are capable of detecting artificial EMFs (Meyer *et al.* 2005), and some species have a remarkable sensitivity to electric fields in seawater (Kalmijn 1982). Some species of fish have shown sensitivity to underwater EMFs, including sharks (i.e., *Scyliorhinus canicula, Mustelis canis,* and *Prionace glauca)*, the skate *Raja clavata* (Kalmijn 1982), the sea lamprey *Petromyzon marinus*, eels *Anguilla sp.*, Atlantic cod *Gadus morhua*, plaice *Pleuronectes platessa,* yellowfin tuna *Thunnus albacares* and Atlantic salmon *Salmo salar* (Gill *et al.* 2005). Electrical cables associated with offshore wind energy facilities produce EMFs (and induced electric fields) which could interfere with fish behavior. However, at the present time there is no conclusive evidence that EMFs have an adverse effect on marine species (Gill *et al.* 2005).

Underwater Noise

Underwater noise during construction of turbines may have impacts to hearing in fish, and may cause fish to disperse with possible disruption to their feeding and spawning patterns. Underwater noise from the operation of wind turbines may decrease the effective range for sound communication in fish and mask orientation signals (Wahlberg and Westerberg 2005). Atlantic salmon and cod have been shown to detect offshore windmills at a maximum distance of about .04 km to 25 km at high wind speeds (i.e., >13 m/s), and noise from turbines can lead to permanent avoidance by fish within ranges of about 4 m (Wahlberg and Westerberg 2005). Noise from construction of wind farms (e.g., pile driving) could have significant effects on fish (Hoffmann *et al.* 2000). It is also known that noise in the marine environment may adversely affect marine mammals by causing them to change behavior (e.g., movement, feeding), interfere with echolocation and communication, or may result in injury to hearing organs (Richardson *et al.* 1995). A more thorough review of underwater noise can be found in the chapter on Global Effects and other Impacts.

Alteration of Community Structure

Offshore wind energy facilities have the potential to alter the local community structure of the marine ecosystem. There is significant debate as to whether the presence of underwater vertical structures (e.g., oil platforms) contribute to new fish production by providing additional spawning and settlement habitat or simply attract and concentrate existing fishes (Bohnsack *et al.* 1994; Pickering and Whitmarsh 1997; Bortone 1998). The aggregation of fish in the vicinity of the wind turbine structures may subject certain species to increased fishing. Additive and synergistic effects of multiple stressors, such as the presence of electric cables on the seafloor and underwater sound generated by the turbines, could have cumulative effects on marine ecosystem and community dynamics (e.g., predator-prey population densities, migration corridors).

Discharge of Contaminants

An ESP serves as a connection point for the inner-array of cables as well as a staging area for maintenance activities. Hazardous materials that may be stored at the ESP include fluids from transformers, diesel fuel, oils, greases and coolants for pumps, fans and air compressors. Discharge of these contaminants into the water column can affect the water quality in the vicinity of the offshore wind facility. Further information regarding the impacts of oil spills and contaminants can be found in the Petroleum Exploration, Production, and Transportation section of this chapter, and the chapters on Coastal Development, and Chemical Affects: Water Discharge Facilities of the report.

Conservation Recommendations and Best Management Practices for Offshore Wind Energy Facilities

1. Pre-construction biological surveys should be conducted, in consultation with resource agencies, to determine the extent and composition of biological populations or habitat in the proposed impact area.
2. Cables associated with offshore wind facilities should avoid sensitive benthic habitats, such as submerged aquatic vegetation.
3. Horizontal directional drilling should be utilized to avoid impacts to sensitive habitats, such as salt marshes and intertidal mudflats.
4. Contingency plans and response equipment should be available to respond to spills associated with service platforms.
5. Scour protection for turbines and associated structures and cables should be used to the minimum practicable in order to avoid alteration and conversion of benthic habitat.
6. Cables should be buried to an adequate depth in order to minimize the need for maintenance activities and to reduce conflicts with other ocean uses.
7. Construction of facilities should be timed to avoid impacts to sensitive life stages and species. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Wave and Tidal Energy Facilities

Introduction

Wave power facilities involve the construction of stationary or floating devices that are attached to the ocean floor, the shoreline, or a marine structure like a breakwater with exposure to adequate "wave climate". Ocean wave power systems can be utilized in the offshore or nearshore environments. Offshore systems can be situated in deep water, typically in depths greater than 40 m (131 ft). Some examples of offshore systems include the Salter Duck, which uses the bobbing motion of the waves to power a pump that creates electricity. Other offshore devices use hoses connected to floats that move with the waves. The rise and fall of the float stretches and relaxes the hoses, which pressurizes the water, which in turn rotates a turbine. In addition, some seagoing vessels can be built to capture the energy of offshore waves. These floating platforms create electricity by funneling waves through internal turbines.

Wave energy can be utilized to generate power from the nearshore area in three ways:

1) Floats or pitching devices generate electricity from the bobbing or pitching action of a floating object. The object can be mounted to a floating raft or to a device fixed on the ocean floor. A similar device, the pendulor, is a wave-powered device consisting of a rectangular box, which is open to the sea at one end. A flap is hinged over the opening and the action of the waves causes the flap to swing back and forth. The motion powers a hydraulic pump and a generator.
2) Oscillating water columns generate electricity from the wave-driven rise and fall of water in a cylindrical shaft. The rising and falling water column drives air into and out of the top of the shaft, powering an air-driven turbine.
3) Wave Surge or focusing devices, also called "tapered channel" or "tapchan" systems, rely on a shore-mounted structure to channel and concentrate the waves, driving them into an elevated reservoir. Water flow out of this reservoir is used to generate electricity, using standard hydropower technologies (USDOE 2005).

Generally, tidal energy facilities are designed to generate power in tidal estuaries through the use of turbines. A barrage, or dam, can be placed across a tidal river or estuary. This design utilizes a build-up of water within a headpond to create a differential on either side (depending on the tide), then the water is released to turn the turbines. While less efficient, tidal power facilities can also utilize water currents to turn turbines. Turbines can be designed in a number of ways and include the “helical-type” turbines, as well as the “propeller-type” turbines. Turbines are generally placed within areas of fast moving water with strong currents to take advantage of both ebb and flow tides.

Habitat Conversion and Loss

The construction of tidal and wave energy facilities includes the placement of structures within the water column, thus converting open water habitat to structure. The placement of support structures, transmission lines, and anchors on the substrate will result in a direct impact to benthic habitats which serve as feeding or spawning habitats for various species. Large-scale tidal power projects which utilize a barrage, can cause major changes in the tidal elevations of the headpond which can affect intertidal habitat. Alterations in the range and duration of tide flow can adversely affect intertidal communities that rely on specific hydrological regimes. Mud and sand flats may be converted to sub-tidal habitat, while high saltmarsh areas that may be normally flooded only on the highest spring tides, can become colonized by terrestrial vegetation and invasive species (Gordon 1994).

Siltation, Sedimentation, and Turbidity

Construction of tidal facilities in riverine and estuarine areas can result in increased sedimentation. Structures placed within riverine and estuarine habitats can reduce the natural transport of sediments and cause an accretion of silt and sediments within impoundments. Deposition of sediments can adversely impact benthic spawning habitats of various anadromous fish species, including riffle and pool complexes. Clean gravel substrates, which are preferred by rainbow smelt and Atlantic salmon, can be subjected to increased siltation due to the alterations in the sediment transport. Shallow water environments, rocky reefs, nearshore and offshore rises, salt, and freshwater marshes (wetlands), and estuaries are more likely to be adversely impacted than open-water habitats. This is due, in part, to their higher sustained biomass and lower water volumes, which decrease their ability to dilute and disperse suspended sediments (Gowen 1978). Impacts from siltation and sedimentation from wave and tidal power facilities are similar to those described in the Petroleum Exploration, Production, and Transportation section of this chapter.

Alteration of Hydrological Regimes

Water circulation patterns and the tidal regimes can be altered during the operation of a barrage-type tidal facility. This can result in poor tidal flushing of the headwaters of estuaries and rivers, and lead to decreased water quality and increases in water temperature (Rulifson and Dadswell 1987). Altered current patterns could affect the distribution of eggs and larvae and the distribution of species within estuaries and bays, as well as the migration patterns of anadromous fishes.

Entrainment, Impingement, and Other Impacts to Migration

Water control structures, such as dams, alter the flow, volume and depth of water within impoundments and below the structures. Water impoundments tend to stratify the water column, increasing water temperatures and decreasing dissolved oxygen levels. Projects operating as 'store and release' facilities can drastically affect downstream water flow and depth, resulting in dramatic fluctuations in habitat accessibility, acute temperature changes and an over all decline in water quality (NEFMC 1998). The construction of dams, with either inefficient or non-existent fish ways, has been a major cause of the population decline of U.S. Atlantic salmon, *Salmo salar* (USFWS and NMFS 1999). Tidal energy facilities located within estuaries or riverine environments have the potential to directly impact migrating fish (Dadswell *et al.* 1986). Dadswell and Rulifson (1994) reported various physical impacts to fish traversing low-head, tidal turbines in the Bay of Fundy, Canada, including mechanical strikes with turbine blades, shear damage, and pressure- and cavitation-related injuries/mortality. They found between 21 and 46 percent mortality rates for tagged American shad passing through the turbine. The physical presence of tidal power facilities can impact the return of diadromous fishes to natal rivers (Semple 1984). Refer to the chapter on Alterations of Freshwater Systems for further information on impacts from water control structures.

Alteration of Electromagnetic Fields

Background direct current DC electric fields originate from the metallic core of the Earth and the electric currents flowing in the upper layer of the Earth's crust. The strength of this geomagnetic field is highest at the magnetic poles and the lowest at the equator. Marine fishes, such as elasmobranches and anadromous fishes, utilize natural EMFs for navigation and migratory behavior (Gill *et al.* 2005). Electrical distribution cables associated with ocean wave-power facilities produce EMFs similar to offshore wind energy facilities, and may interfere with fish behavior (Gill *et al.* 2005). However, at the present time there is no conclusive evidence that EMFs have an adverse effect on marine species (Gill *et al.* 2005).

Conservation Recommendations and Best Management Practices for Ocean Wave Power Facilities

1. Barrage-type tidal facilities should not be permitted due to the potential for large impacts to the ecosystem and migratory fishery resources.
2. Pre-construction assessments for analysis of potential impacts to fishery resources should be required for all projects. Assessments should include comprehensive monitoring of the timing, duration, and utilization of the area by diadromous and resident species, potential impacts from the project, and contingency planning using adaptive management.
3. Projects should not be sited in areas that may result in adverse effects to sensitive marine and estuarine resources and habitats.
4. Project siting of any wave or tidal energy facility within riverine, estuarine and marine ecosystems utilized by diadromous species should be avoided.
5. Construction of facilities should be timed to avoid impacts to sensitive life stages and species. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Cables and Pipelines

Introduction

With the continued development of coastal regions comes greater demand for the installation of cables, utility lines for power and other services, and pipelines for oil and gas. The installation of pipelines, utility lines, and cables can have direct and indirect impacts on the offshore, nearshore, estuarine, wetland, beach, and rocky shore coastal zone habitats.

Habitat Conversion and Loss

The installation of cables and pipelines can result in the loss of benthic habitat due to dredging and plowing through the seafloor. This can result in a direct loss of benthic organisms, including shellfish. Construction impacts can result in long-term or permanent damage, depending on the degree and type of habitat disturbance and best management practices employed for a project. The installation of pipelines can impact shellfish beds, hard-bottomed habitats and submerged aquatic vegetation (Gowen 1978). Cables can damage complex habitats containing epifaunal growth during installation, if cables are allowed to "sweep" along the bottom while being positioned into the correct location. Shallow water environments, rocky reefs, nearshore and offshore rises, salt, and freshwater marshes (wetlands), and estuaries are more likely to be adversely impacted than open-water habitats. This is due to their higher sustained biomass and lower water volumes, which decrease their ability to dilute and disperse suspended sediments (Gowen 1978). Benthic organisms, especially prey species, may recolonize disturbed areas, but this may not occur if the composition of the substrate is drastically changed or if pipelines are left in place after production ends.

Pipelines installed on the seafloor or over coastal wetlands can alter the environment by causing erosion and scour around the pipes, resulting in escarpments on coastal dune and salt marshes, and on the seafloor. Alterations to the geomorphology of coastal habitats from pipelines can exacerbate shoreline erosion and fragment wetlands. Because vegetated coastal wetlands provide forage and protection to commercially important invertebrates and fish, marsh degradation due to plant mortality, soil erosion, or submergence will eventually decrease productivity.

Pipelines are generally buried below ground by digging trenches or canals, which have the potential to change the hydrology of coastal areas by: 1) facilitating rapid drainage of interior marshes during low tides or low precipitation; 2) reducing or interrupting freshwater inflow and associated littoral sediments; and 3) allowing saltwater to move farther inland during periods of high tides (Chabreck 1972). Saltwater intrusion into freshwater marsh often causes a loss of salt-intolerant emergent plants and submerged aquatic vegetation (Chabreck 1972; Pezeshki *et al.* 1987). Soil erosion and a net loss of organic matter may also occur (Craig *et al.* 1979).

Conversion of benthic habitat can occur if cables and pipelines are not buried sufficiently within the substrate. Conversion of habitats can also occur in areas where a layer of fine sediment is underlain with coarser materials. Once these materials are plowed for pipeline/cable installation, they can be mixed with underlying coarse sediment, and thus, alter the substrate composition. This can adversely affect the habitat of benthic organisms which rely on soft sand or mud habitats. The armoring of pipeline with either rock or concrete can result in permanent habitat alterations if placed within soft substrate. The placement of cables and pipelines often necessitates removal of hard bottom or rocky habitats in the pipeline corridor. These habitats are removed by using explosives or mechanical fracturing, and can result in a reduction of available hard bottom substrate and habitat complexity.

Subsea pipelines that are placed on the substrate have the potential to create physical barriers to benthic invertebrates during migration and movement. In particular, the migration of American lobster between inshore and offshore habitats can be adversely affected if pipelines are not buried to sufficient depths (Fuller 2003). Furthermore, erosion around pipelines and cables can lead to uncovering of structure. This in turn can lead to impacts resulting to migratory patters of benthic resources.

Siltation, Sedimentation and Turbidity

The installation of cables and pipelines can lead to increased turbidity and subsequent sedimentation, due to either the plowing or jetting method of installation. Elevated siltation and turbidity during cable and pipeline installation is typically short-term and restricted to the area surrounding the cable and pipeline corridor. However, pipelines that are left unburied and exposed can cause erosion of the substrate, and cause persistent siltation and turbidity in the surrounding area. Maintenance activities related to cables and pipelines, as well as removal for decommissioned cables and pipelines, can release suspended sediments into the water column. Long-term effects of suspended sediment include reduced light penetration, and lowered photosynthesis rates and the primary productivity of the area (Gowen 1978). Impacts from siltation, sedimentation, and turbidity from cables and pipelines are similar to those described in the Petroleum Exploration, Production, and Transportation section of this chapter.

Release of Contaminants

Petroleum products can be released into the environment if pipelines are broken or ruptured due to unintentional activities, such as shipping accidents or deterioration of pipelines, or through intentional activities, such as terrorist acts. A review of impacts from petroleum spills can be found in the Petroleum Exploration and Production section of this chapter. In addition, resuspension of contaminants in sediments, such as heavy metals and pesticides, during pipeline installation can have lethal and sublethal effects to fishery resources (Gowen 1978). Contaminants may have accumulated in coastal sediments from past industrial activities, particularly in heavily urbanized areas. Heavy metals may initially inhibit reproduction and development of marine organisms, but at high concentrations, they can directly or indirectly contaminate or kill fish and invertebrates. The early life-history stages of fish are the most susceptible to the toxic impacts associated with heavy metals (Gould *et al.* 1994). The release of contaminants can reduce or eliminate the suitability of water bodies as habitat for fish species and their prey. In addition, contaminants, such as copper and aluminum, can accumulate in sediments and become toxic to organisms contacting or feeding on the bottom.

Impacts to sensitive wetland habitats and subtidal habitats can be avoided during pipeline and cable installation using horizontal directional drilling techniques, which allow the pipe or cable to be installed in a horizontal drill hole below the substrate. “Frac-outs” (i.e., releases of drilling mud or other lubricants, such as bentonite mud) can occur during the drilling process and escape through fractures in the underlying rock. This typically happens when the drill hole encounters a natural fracture in the rock or when insufficient precautions are taken to prevent new fractures from occurring. Fishery habitats can be adversely affected if a “frac-out” occurs during the installation process and discharges drilling mud or other contaminants into the surrounding area. Cranford *et al.* (1999) found that that chronic intermittent exposure of sea scallops to dilute concentrations of operational drilling wastes, characterized by acute lethal tests as practically non-toxic, can affect growth, reproductive success and survival.

Maintenance of cables and pipelines can also result in subsequent impacts to the aquatic environment. The maintenance of pipelines includes the "pigging" of pipelines to clean out residual materials from time-to-time. The release of these materials into the surrounding environment can lead to water quality impacts and contamination of adjacent benthic habitats. For example, biocides (e.g., copper and aluminum compounds) are often utilized in the hydrostatic testing of pipelines and are subsequently discharged into surrounding waters. Laboratory experiments have shown high mortality of Atlantic herring eggs and larvae at copper concentrations of 30 μg/L and 1,000 μg/L, respectively, and vertical migration of larvae was impaired at copper concentrations of greater than 300 μg/L (Blaxter 1977).

Alteration of Electromagnetic Fields

Underwater electrical distribution cables produce EMFs that may interfere with fish behavior (Gill *et al.* 2005). However, at the present time there is no conclusive evidence that EMFs have an adverse effect on marine species (Gill *et al.* 2005). See also the discussion of underwater EMFs in the Offshore Wind Energy Facilities section of this chapter and the Global Effects and Other Impacts chapter of the report.

Underwater Noise

The installation of cables and pipelines can produce underwater noise that may disrupt or damage fishery resources. Noise from construction activities (e.g., pile driving) can have significant effects on fish (Wahberg 1999; Hoffmann *et al.* 2000). Larvae and young fish are particularly sensitive to noise generated from underwater explosives due to blasting. It is also known that noise in the marine environment may adversely affect marine mammals by causing them to change behavior (movement, feeding), interfere with echolocation and communication, or may result in injury to hearing organs (Richardson *et al.* 1995).

Alteration of Community Structure

The construction of pipelines and other underwater structures have the potential to alter the local community structure of the marine ecosystem. There is significant debate as to whether the presence of underwater vertical structures (e.g., oil platforms) contribute to new fish production by providing additional spawning and settlement habitat or simply attract and concentrate existing fish within an area (Bohnsack *et al.* 1994; Pickering and Whitmarsh 1997; Bortone 1998). Underwater pipelines represent man-made structures that could have similar attraction and production issues relating to fishery management. As with wind turbines and offshore LNG facilities, aggregation of fishes in the vicinity of pipeline structures may subject certain species to increased fishing pressures. By altering the age and species composition in the area around pipelines, predator/prey interactions and reproduction can be altered that may have community-level affects on fisheries.

Conservation Recommendations and Best Management Practices for Cables and Pipelines (adapted from Hanson *et al.* 2003)

1. Align crossings along the least environmentally damaging route. Sensitive habitats such as hard-bottom (e.g., rocky reefs), submerged aquatic vegetation, oyster reefs, emergent marsh, sand and mud flats, should be avoided.
2. Use horizontal directional drilling where cables or pipelines would cross sensitive habitats, such as intertidal mudflats and vegetated intertidal zones, to avoid surface disturbances. Measures should be employed to avoid/minimize impacts to sensitive fishery habitats from potential frac-outs, including:

a. The use of non-polluting, water-based lubricants should be required.
b. Drill stem pressures should be monitored closely so that potential frac-outs can be identified.
c. Drilling should be halted, if frac-outs are suspected.
d. Above ground monitoring should be employed to identify potential frac-outs.
e. Spill clean-up plan and protocols should be developed, and clean-up equipment should be on-site to quickly respond to frac-outs.

3. Avoid construction of permanent access channels since they disrupt natural drainage patterns and destroy wetlands through excavation, filling, and bank erosion.
4. Backfill excavated wetlands with either the same or comparable material capable of supporting similar wetland vegetation. Original marsh elevations should be restored.
5. Use existing rights-of-way whenever possible to lessen overall encroachment and disturbance of wetlands.
6. Bury pipelines and submerged cables where possible. Unburied pipelines or pipelines buried in areas where scouring or wave activity eventually exposes them can result in impacts to invertebrate migratory patterns.
7. Silt curtains or other type sediment control should be utilized in order to protect sensitive habitats and resources
8. Access for equipment should be limited to the immediate project area and should avoid sensitive resources.
9. The use of open trenching for installation should be avoided. Methods in which the trench is immediately backfilled, reduces the impact duration, and should therefore be employed when possible.
10. Conduct construction during the time of year that will have the least impact on sensitive habitats and species. Appropriate work windows can be established based on the multiple season biological sampling. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
11. Evaluate impacts to habitat during the decommissioning phase, including impacts during the demolition phase and impacts resulting from permanent habitat losses.
12. Address cumulative impacts of past, present and foreseeable future dredging operations on aquatic habitats by considering them in the review process.

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ALTERATIONS OF FRESHWATER SYSTEMS

Introduction

Freshwater riverine and riparian habitats located along the northeastern coastal U.S. provide important habitat for the growth, survival, and reproduction of diadromous fishes, and are critical to maintaining healthy estuarine ecosystems. In the northeast, diadromous fish (species that migrate between freshwater and saltwater for specific life history functions) include Atlantic salmon, alewife, blueback herring, rainbow smelt, Atlantic sturgeon, American shad, and American eel. Not only are diadromous fishes subject to environmental impacts in the marine environment, they encounter dams, pollution, effects of urbanization and habitat changes in freshwater (Moring 2005). In addition, some forage species that are important prey for marine fisheries depend upon freshwater habitats for portions of their life cycle. The health and availability of freshwater systems, and the preservation and maintenance of associated functions and values, is vital to the diversity, health and survival of healthy marine fisheries.

Free flowing rivers, ponds, and lakes act as migratory corridors, spawning, nursery, and rearing areas, and provide forage and refuge for life stages of these species. Riverine and riparian corridors, and palustrine and lacustrine wetlands provide important functions and values for resident and migratory fish, freshwater mussels, reptiles, amphibians and insects (Chabreck 1988). Riparian corridors provide cooling shade, nutrients, and habitat enhancing debris in riverine systems (Bilby and Ward 1991), which are essential elements necessary for these aquatic resources to thrive. In addition to supporting aquatic resources, freshwater wetlands perform important broader ecological functions by reducing erosion, attenuating floodwater velocity and volume, improving water quality by the uptake of nutrients, and reducing sediment loads (Howard-Williams 1985; De Laney 1995; Fletcher 2003). Freshwater habitats are intricately connected to terrestrial and coastal ecosystems, making them vulnerable to a wide array of anthropogenic disturbances that can alter the functions, values, quantity and accessibility of freshwater wetlands used by migratory fish (Beschta *et al.* 1987; Naiman 1992).

Biological, chemical, and physical threats to freshwater environments from terrestrial and aquatic sources have led to habitat fragmentation and degradation (Bodi and Erlhein 1986; Wilbur and Pentony 1999; USEPA 2000; Kerry *et al.* 2004). In particular, non-fishing activities, such as mining, dredging, fill placement, dam construction and alterations to hydrologic regimes, thermal discharges, and non-point source pollution have degraded and eliminated freshwater habitats (Zwick 1992; Wilbur and Pentony 1999; Hanson *et al.* 2003). The federal Clean Water Act (CWA) has eliminated certain types of disposal activities, limited fill activities, and otherwise resulted in improved protection of the Nation's wetland and waterways. Despite these and other regulations to protect aquatic habitat, anthropogenic impacts continue, dramatically affecting fish habitat, including prey species, and fisheries (Wilson and Gallaway 1997; Bodi and Erlhein 1986; Hanson *et al.* 2003; Ormerod 2003; Kerry *et al.* 2004).

Dam Construction and Operation

Among the major identified causative factors of the population demise of Atlantic salmon, dam construction and operation may be the most dramatic (NEFMC 1998; Parrish *et al.* 1998; USFWS and NMFS 1999). In the United States, 76,000 dams have been identified in the National Inventory of Dams by the U.S. Army Corps of Engineers and the Federal Emergency Management Agency (Heinz Center 2002). This number may be as high as 2 million when small-scale dams are included (Graf 1993). Fish passages in any given river system may not be consistent or effective throughout, limiting the ability for Atlantic salmon, and many other migratory and resident species, to reach necessary habitat. Sections 18 and 10j of the Federal Power Act require fish passage and protection, and mitigation for damages to fish and wildlife, respectively, at hydroelectric facilities. Dam construction and operation in the northeastern U.S. has occurred for centuries to provide power generation, navigation, fire and farm ponds, reservoir formation, recreation, irrigation and flood control. By the 1950s, less than 2 percent of the original habitat for Atlantic salmon in New England was accessible to the fish due to damming of rivers (Buchsbaum 2005). Important for the local economy when originally constructed, today many of these structures are obsolete, unused, abandoned, or decaying.

The effects of dam construction and operation on fisheries and aquatic habitat include: 1) complete or partial upstream and downstream migratory impediment; 2) water quality and flow patterns alteration; 3) thermal impacts; 4) alterations of the riparian landscape and associated functions and values; 5) habitat fragmentation; and 6) limitations on gene flow within populations. The history and effects of dam construction on passage and habitat is well documented (Larinier 2001; Heinz Center 2002).

<u>Impaired Fish Passage</u>

The construction of dams with either no fish passage or ineffective passage was the primary agent of the population decline of U.S. Atlantic salmon (USFWS and NMFS 1999; NEFMC 1998). By 1950, less than 2 percent of the original habitat for Atlantic salmon in New England was accessible due to dams (Buchsbaum 2005). Dams physically obstruct passage and alter a broad range of habitat characteristic essential for passage and survival. Without any mechanism to get around a dam, there is no upstream passage to spawning and nursery habitat. Fish that gather at the base of the dam will either spawn in inadequate habitat, die, or return downstream without spawning. The presence of a fish passage structure does not necessarily ensure access to upstream habitat. Even with a structure in place, passage is contingent on many factors, including water-level fluctuations, altered seasonal and daily flow regimes, elevated temperatures, reduced water velocities and discharge volumes (Haro *et al.* 2004).

Safe, timely and effective downstream passage by fish is also hindered by dams. The time required for downstream migration is greatly increased due to reduced water flows within impoundments (Raymond 1979; Spence *et al.* 1996; PFMC 1999). This delay results in greater mortality associated with predation and the physiological stress associated with migration. Downstream passage is also hindered for fish passing over spillways and through turbines (Ruggles 1980; NEFMC 1998), and entrainment and impingement on structures associated with a hydroelectric facility. Dadswell and Rulifson (1994) reported on the physical impacts observed in fish traversing low-head, tidal turbines in the Bay of Fundy, Canada, which included mechanical strikes with turbine blades, shear damage, and pressure- and cavitation-related injuries/mortality. They found between 21 and 46 percent mortality rates for experimentally tagged American shad passing through the turbine.

Fragmentation of aquatic habitat due to dams can result in a loss of genetic diversity and spawning potential that may make populations of fish more vulnerable to local extirpation and extinctions, particularly for species functioning as a metapopulation (Morita and Yamamoto 2002).

<u>Altered Hydrologic, Salinity and Temperature Regimes</u>

Dams and dam operations alter flow, volume and depth of water within impoundments and below the dam. Water temperatures tend to increase, water columns become stratified, and dissolved oxygen levels decrease in water impoundments. Projects operating as 'store and release' facilities can drastically affect downstream water flow and depth, resulting in dramatic fluctuations in habitat accessibility, acute temperature changes and over all water quality. Water spilling over dams or through turbines can cause dissolved gas supersaturation, resulting in injury or death to fish traversing the dam (NEFMC 1998).

Tidal fresh habitat is limited to a narrow zone in river systems where the water is tidally influenced, yet characteristically fresh (i.e., <5.0 ppt salinity). This narrow habitat type may be altered or lost due to dam construction and operations.

<u>Alteration of Stream Bed and Stream Morphology</u>
The construction of a dam fragments habitat, altering both upstream and downstream biogeochemical processes and resulting in a wide array of direct and indirect cumulative impacts (Poff *et al.* 1997; Heinz Center 2002). Multiple habitat variables are affected by dams, principally streambed properties (Spence *et al.* 1996), the transport of sediments and large woody debris (Spence *et al.* 1996; PFMC 1999), and overall stream morphology.

<u>Altered Sediment/LWD Transport</u>
Large woody debris (LWD) and other organic matter are often removed from wetland areas for a variety of reasons, including aesthetics, dam operation, road and bridge maintenance, and commercial and recreational uses. Organic debris provides habitat for a variety of aquatic organisms, including Atlantic salmon, by promoting habitat complexity, such as the formation of pool and riffle complexes and undercut banks (Montgomery *et al.* 1995; Abbe and Montgomery 1996; Spence *et al.* 1996). Removing organic debris may change the structure, function and value of the river system. From a broader perspective, removal of LWD from a river system disrupts a link between the forest and the sea (Maser and Sedell 1994; NRC 1996; Collins *et al.* 2002; Collins *et al.* 2003).

<u>Riparian Zone Development and Alteration of Wetlands</u>
Riparian wetlands may be lost to water level increases upstream and flow alterations downstream of the dam. Lost wetlands results in a loss of floodplain and flood storage capacity, and thus a reduced ability to provide flood control during storm events. A healthy riparian corridor is well vegetated, harboring prey items, contributes necessary nutrients, provides LWD that creates channel structure and cover for fish, and provides shade, which controls stream temperatures (Bilby and Ward 1991; Hanson *et al.* 2003). When vegetation is removed from riparian areas, water temperatures tend to increase and LWD is less common. The result is less refuge for fish, fundamental changes in channel structure (e.g., loss of pool habitats), instability of stream banks, and alteration of nutrient and prey sources within the river system (Hanson *et al.* 2003). Riparian zone development can be considered a secondary effect of dam construction. Residential, recreational and commercial uses may result from the associated impoundment.

<u>Changes to Native Aquatic Communities</u>
Impoundments can concentrate predators and disease carrying organisms, and disrupt fish development, thereby altering the community structure at various trophic levels and potentially changing the natural habitat and fishery dynamics of the aquatic habitat. In addition, the loss of wetlands by the increased impoundment level and reduction of freshwater input and sediments

below the dam can have potentially serious impacts on both fish and invertebrate populations (NEFMC 1998).

Impoundments also create an opportunity for non-native species to become established. Carp, northern pike, and walleye are a few examples. In some instances, introduced species such as smallmouth bass become managed as a sport fish and to the exclusion of native species. Over time, these introduced species become accepted as part of the 'natural' condition. Like the changes associated with creating an impoundment, these introduced species can change the community dynamics of the riverine system.

<u>Recommended Conservation Measures and Best Management Practices for Dam Construction and Operation</u> (adapted from Hanson *et al.* 2003 and PFMC 1999).

1. Avoid the construction of new dam facilities, where possible.
2. Retrofit existing dams with efficient and functional upstream and downstream fish passage structures.
3. Construct and design facilities with efficient and functional upstream and downstream adult and juvenile fish passage which ensures safe, effective and timely passage.
4. Construct dam facilities with the lowest hydraulic head practicable for the project purpose. Site the project at a location where dam height can be reduced.
5. Consider all upstream passage types, including natural-like bypass channels, denil-type and vertical slot fishways, Alaskan steeppass, fishlifts, etc. Volitional passage is preferable to trap and truck methods.
6. Downstream passage should prevent adults and juveniles from passing through the turbines and provide sufficient water downstream for safe passage.
7. Operate facilities to create flow conditions that provide for passage, water quality, proper timing of life history stages, and properly functioning channel conditions, and to avoid strandings and redd (i.e., spawning nest) dewatering. Run-of-river, such that the volume of water entering an impoundment exits the impoundment with minimal fluctuation of the headpond, is the preferred mode of operation for fishery and aquatic resource interests. Water flow monitoring equipment should be installed upstream and downstream of the facility. Generally, fluctuations in headpond water levels should be kept between 6 and 12 inches.
8. Maintenance and operations which require drawdown of the impoundment should be coordinated with state and federal resource agencies to minimize impacts to aquatic resources.
9. For construction, maintenance, and operations of dams, seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
10. Develop water and energy conservation guidelines for integration into dam operation plans and into regional and watershed-based water resource plans.
11. Encourage the preservation of LWD, whenever possible. If possible, relocate debris as opposed to complete removal. Remove LWD only to prevent damage to property or threat human health and safety.
12. Consider the removal of a dam when it is feasible (see the follow section on dam removal).

<u>Dam Removal</u>

A number of factors may be considered in determining the efficacy of removing a dam, including habitat restoration, safety, and economics (Babbitt 2002; Heinz Center 2002). Dam removal provides overall environmental benefits to freshwater habitats and aquatic resources. The recovery of some anadromous species, such as Atlantic salmon and rainbow smelt, may be dependant on targeted dam removals, principally those dams blocking passage to high quality spawning and rearing habitat. Dam removal reconnects previously fragmented habitat, allowing the natural flow of water, sediment, nutrients, and the genetic diversity of fish populations, and re-establishes floodplains and riparian corridors (Morita and Yokota 2002; Nislow *et al.* 2002). However, because dams alter sediment and nutrient transport processes and raise water levels upstream of the structure, dam removal can result in short and long-term impacts upstream and downstream. The effects of dam removal on fisheries and aquatic habitat include: 1) release of contaminants; 2) short-term water quality degradation; 3) flow pattern alteration; 4) loss of benthic and sessile invertebrates; and 5) alterations of the riparian landscape and associated functions and values.

<u>Release of Contaminated Sediments</u>

Dam removal typically results in an increased transfer of sediments downstream of the dam, while the spatial and temporal extent of sediment transfer depends on the size of the dam and total sediment load. Sediments accumulated behind dams can bind and adsorb contaminants that, when remobilized after the removal of a dam, have the potential to adversely affect aquatic organisms including the eggs, larvae and juvenile stages of finfish, filter feeders and other sedentary aquatic organisms (Heinz Center 2002). For example, a reduction in macroinvertebrate abundance, diatom richness, and algal biomass has been attributed to the downstream transport of fine sediments previously stored within a dam impoundment (Thomson *et al.* 2005). However, as fine sediment loads are reduced and replaced by coarser materials in the streambed, macroinvertebrate and finfish assemblages should recover from the disturbance (Thomson *et al.* 2005). Dam removal can impact overall water quality during and after the demolition phase, although these are typically temporary effects that generally do not result in chronic water quality degradation (Nechvatal 2004; Thomson *et al.* 2005).

<u>Alteration of Wetlands</u>

Lowering the water level will alter the wetland structure upstream of the old dam site and the associated wildlife assemblage. Lowering of impoundments can result in the alteration of existing wetlands (Nislow *et al.* 2002). As water levels recede, fringing wetlands may be lost as new wetlands are formed along the new riparian border. Newly exposed stream banks may need armoring or other erosion control methods to protect them. The history of the project, geomorphology of the watershed and location in the river system, among other factors, will dictate the types of environmental issues dam removal will present. Geomorphic effects of downstream sediment transport may have long-term implications (Pizzuto 2002). However, many of these impacts are short-term, dissipating with time as the river system comes to a natural equilibrium (Bushaw-Newton *et al.* 2002; Thomson *et al.* 2005).

The Heinz Center (2002) provides a thorough overview of environmental, economic and social issues to consider when evaluating dam removal. Because there are a number of concerns and interests surrounding dams and their use, the overall benefits of dam removal must be weighed against all potential adverse impacts. For many local residents, the impoundments created by these dams define a way of life for the community. Changing the existing conditions may not necessarily be perceived as good for all parties. For example, an impoundment may contain stocked game fish which provide recreational opportunities for the community. Dam removal may eliminate these species or bring about interactions with formerly excluded diadromous species.

Recommended Conservation Measures and Best Management Practices for Dam Removal (adapted from Hanson *et al.* 2003)

1. Prior to the decision to remove a dam, a comprehensive evaluation of the hydrology, hydraulics, and sediment transport should be conducted to assess possible adverse effects of the removal of the structure.
2. Sufficient testing to evaluate the type, extent and level of contamination upstream of the dam should be conducted prior to the decision to remove a dam. Contaminated sediments, if extensively present, may require mechanical or hydraulic removal prior to the removal of the dam.
3. Conduct sufficient evaluation of the streambed within the impoundment to plan for any necessary streambed modifications.
4. If sediments are expected to be released downstream, removal of the dam in stages may be necessary to control the release of sediments.
5. Dam removal should occur during the less sensitive time of year for aquatic resources, particularly outside the expected migratory period. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
6. Plan for revegetating the newly exposed stream bank with native vegetation.
7. Establish a contingency plan in the event that the stream channel needs modification – addition of riffle and pool complex, added features to create habitat complexity, meanders, etc. - to facilitate fish passage and habitat functions.
8. Establish a monitoring protocol to evaluate success of the restoration for fish passage and utilization.
9. Conduct outreach to the public to provide an understanding of the benefits of dam removal.

Stream Crossings

Stream crossings are characterized as any structure providing access over a stream, river or other water body for transportation purposes (e.g., roads, utilities). The feasibility of effective fish passage at stream crossings may be complex. Land ownership, utility crossing, flood protection for low-lying properties, and safety along the transportation corridor must be considered. Unfortunately, many transportation corridors interact and interfere with fisheries corridors (i.e., streams and rivers). These transportation corridors require structures for crossing rivers, streams and other water bodies. If improperly designed, stream crossings can alter, degrade, fragment or eliminate aquatic habitat and potentially impede, or eliminate, passage for resident and migratory species (Evans and Johnston 1980; Belford and Gould 1989; Clancy and Reichmuth 1990; Furniss *et al.* 1991; USGAO 2001; Jackson 2003). Until recently, the primary concern related to designing these structures was cost, designed load capacity and hydraulics. Furthermore, common practice for repairing deficient structures often resulted in maintaining inadequate stream crossing conditions (e.g., "slip-lining" with smaller diameter pipe, lining of culvert with concrete, or replacing the structure in-kind).

Impacts to Fish Passage

Improperly designed stream crossings can block fish and aquatic organism passage in a variety of ways including: perched culverts constructed with the bottom of the structure above the level of the stream, effectively acting as a dam and physically blocking passage; hydraulic barriers to passage are created by undersized culverts which constrict the flow and create excessive water velocities; smooth-bore (high density plastic) liners help meet the goal of passing water and protecting roadways from flooding, but they greatly increase flow velocities through the passage (Evans and

Johnston 1980; Belford and Gould 1989; Furniss *et al.* 1991; Jackson 2003). Conversely, oversized culverts with large, flat bottom surfaces reduce water depth. Insufficient water depths may also be another hydraulic impediment to passage (Haro *et al.* 2004). In situations where water velocities are not physically limiting and water depths are sufficient, the impediments to passage may be a lack of resting pools. Many stream crossings, particularly longer culverts, are placed over wide stretches of river. Fish may not be capable of burst speeds and sustained swimming throughout the length of the crossing. Under such conditions, migrating fish are unable to reach spawning habitat.

Alteration of Hydrologic Regimes

Undersized and/or improperly placed stream crossings can also affect water quality. Undersized structures can act as dams, impounding water and increasing water temperature. In extreme cases, if flows are sufficiently reduced and the impounded area deep enough, increased surface temperatures can create thermal stratification and reduce dissolved oxygen. In addition, as water flows through the structure the temperature of the water can rise, affecting aquatic organisms downstream. Undersized culverts can also cause flooding upstream of the crossing, affecting upland and riparian habitat.

Some U.S. states and Canadian Provinces have recognized the concerns relating to fish passage and stream crossings. For example, the Maine Department of Transportation and Massachusetts Riverways Program, among others, have independently published guidelines for addressing fish passage at stream crossings (MEDOT 2004; MRP 2005). The Canadian Department of Fisheries and Oceans has also published design criteria for stream crossings in the Maritime Provinces (Savoie and Haché 2002). Underlying goals of these documents include fish and aquatic organism passage, habitat continuity, and wildlife passage. These and similar documents provide extensive information regarding stream crossing requirements for environmentally sound, safe transportation across streams, rivers, and other waterbodies.

Conservation Measures and Best Management Practices for Stream Crossings

1. Stream crossings should be designed for the target finfish species and various age classes. Other aquatic species, such as amphibians, reptiles, and mammals, should also be considered in the designs, as they play a role in healthy ecosystems.
2. Structures should provide safe and timely passage to minimize injury and limit excessive predation.
3. New structures should be designed and installed in a manner not to interfere with fish and aquatic organism passage and complies with all applicable regulations.
4. Structures should provide sufficient water depth and maintain suitable water velocities for target species during the migration season. Consider seasonal headwater and tailwater levels and how variations in them could affect passage of all aquatic life stages. Design considerations may include constructing a low flow channel, weir structure, energy dissipation pools, and designing structures for bank full width.
5. The presence of non-native, invasive aquatic species should be considered in fish passage design for stream crossings, particularly where the crossing may present an existing barrier to passage.
6. The structure should maintain or replicate natural stream channel and flow conditions to the greatest extent practicable. An open bottom arch or bridge is preferred. The structure should be able to pass peak flows in accordance with state and federal policy. Ensure sufficient hydrologic data has been collected.

7. Culverts and pipes should be buried sufficiently to replicate a natural streambed. Doing so will also provide habitat functions, such as resting pools and reduced water velocities for longer structures.
8. The gradient of the stream crossing should match the natural stream channel grade. Perched culverts should be removed, wherever practicable.
9. Upstream and downstream channel and bank conditions should be maintained or stabilized if the stream crossing structure may cause erosion or accretion problems. Use of native vegetation should be required for erosion control and sediment stabilization.
10. The location and overall design of the fish passage structure and the stream crossing should be compatible with local stream conditions and stream geomorphology.
11. Materials for the fish passage structure should be non-toxic to fish and other aquatic organisms. Pressure treated lumber should be avoided.
12. Construction methods for repair and replacement of stream crossings should take into account fish passage requirements.
13. In-water construction activities should be conducted during a time of year that is least sensitive and fewest life stages are present (e.g., low flow seasons). Temporary diversions and coffer dams may be suitable alternatives with proper planning. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Water Withdrawal and Diversion

Freshwater is becoming limited because of natural events (e.g., droughts), increasing commercial and residential demand of potable water, and inefficient use. Freshwater is diverted for human use from groundwater, lakes and riverine environments, or is stored in impoundments. The withdrawal and or impoundment of water can alter natural current and sedimentation patterns, water quality, water temperature, and associated biotic communities (NEFMC 1998). Natural freshwater flows are subject to alteration through water diversion and use, and modifications to the watershed such as deforestation, dams, tidal restrictions, and stream channelization (Boesch *et al.* 1997). Water withdrawal for freshwater drinking supply, power plant cooling systems, and irrigation occurs along urban and agricultural areas and may have potentially detrimental effects on aquatic habitats. Increased water diversion is associated with human population growth and development (Gregory and Bisson 1997). Water diversion is not only associated with water withdrawal and impoundment, it also represents water discharges, which alter the flow and velocity and have associated water quality issues (Hanson *et al.* 2003).

The effects of water withdrawal and diversion on fishery habitat can include: 1) entrainment and impingement; 2) impaired fish passage; 3) alteration of flow and flow rates, and processes associated with proper flows; 4) degradation of water quality (e.g., water temperature, dissolved oxygen) associated with proper water depth, drainage and sedimentation patterns; 5) loss and/or degradation of riparian habitat; and 6) loss of prey and forage.

Entrainment and Impingement

The diversion of water for power plant cooling and other reservoirs results in entrainment and impingement of invertebrates and fishes (especially early life-history stages of fish) (NEFMC 1998). Fish and invertebrate populations may be adversely affected by adding this source of mortality to the early life stage which often determines recruitment and strength of the year-class. Important habitat for aquatic organisms around water intakes may become unavailable for recruitment and settlement (Travnichek *et al.* 1993).

Impaired Fish Passage and Altered Hydrologic Regimes

Water diversion, and the withdrawal or discharge of water, can result in a physical barrier to fish passage (Spence *et al.* 1996). Excessive water withdrawal can greatly reduce the usable river channel. Rapid reductions or increases in water flow, associated with dam operations for example, can greatly affect fish migratory patterns. Depending on the timing of reduced flows, fish can become stranded within the stream channel, in pools, or just below the river in an estuary system.

Water Quality Degradation

The release of water with poor quality (e.g., altered temperatures, low dissolved oxygen, and the presence of toxins) affects migration and migrating behavior. The discharge of irrigation water into a freshwater system can degrade aquatic habitat (NRC 1989) by altering currents, water quality, water temperature, depth, and drainage and sedimentation patterns. Both water quantity and quality can greatly affect the usable zone of passage within a channel (Haro *et al.* 2004). Altered temperature regimes have the ability to affect the distribution, growth rates, survival, migration patterns, egg maturation and incubation success, competitive ability, and resistance to parasites, diseases, and pollutants of aquatic organisms (USEPA 2003). In freshwater habitats of the northeastern U.S., the temperature regimes of cold-water fish such as salmon, smelt, and trout, may be exceeded leading to extirpation of the species in an area. Some evidence indicates that elevated water temperatures in freshwater streams and rivers in the northeastern U.S. may be responsible for increased algal growth, which has been suggested as a possible factor in the diminished stocks of rainbow smelt (Moring 2005).

Release of Contaminants

Irrigation discharges are often associated with contaminants and toxic materials (e.g., heavy metals, pesticides, fertilizers, salts and nutrients) and possibly introduced pathogens, all of which stress the habitat and aquatic organisms (USEPA 2003). Studies evaluating pesticides in runoff and streams generally find that concentrations can be relatively high near the application site and soon after application, but are significantly reduced further downstream and with time (USEPA 2003). However, some pesticides used in the past (*e.g.*, DDT) are known to persist in the environment for years after application.

Soil transported from irrigated croplands and rangelands usually contains a higher percentage of fine and less dense particles, which tend to have a higher affinity for adsorbing pollutants such as insecticides and herbicides (Duda 1985; USEPA 2003). In addition, irrigation water has a natural base load of dissolved mineral salts, and return flows convey the salt to the receiving streams or groundwater reservoirs. If the amount of salt in the return flow is low in comparison to the total stream flow, water quality may not be degraded to the extent that aquatic functions are impaired. However, if the process of water diversion and the return flow of saline drainage water is repeated many times along a stream or river, downstream habitat quality can become progressively degraded (USEPA 2003).

Siltation and Sedimentation

Water diversions can alter sediment and nutrient transport processes (Christie *et al.* 1993; Fajen and Layzer 1993), which can hinder benthic processes and communities. Suspended sediments in aquatic environments can reduce the availability of sunlight to aquatic plants, interfere with filtering capacity of filter feeders, and clog and harm the gills of fish (USEPA 2003). In addition, sediment that is flushed through rivers or streams with excessively high flows or sediments that are accreted due to artificially low flows can degrade or eliminate spawning and rearing habitats of aquatic organisms. Breitburg (1988) found the predation rates of striped bass larvae on copepods to decrease by 40 percent when exposed to high turbidity conditions in the laboratory.

Loss of Wetlands and Flood Storage
Healthy riparian corridors are well vegetated, support abundant prey items, maintain nutrient fluxes, provides LWD that creates channel structure and cover for fish, and provides shade, which controls stream temperatures (Bilby and Ward 1991; Hanson *et al.* 2003). Riparian wetland vegetation can be affected by long-term or frequent changes in water levels due to water withdrawals and diversions. Removal of riparian vegetation can impact fish habitat by reducing cover and shade, reducing water temperature fluctuations, and by affecting the overall stability of water quality characteristics (Christie *et al.* 1993). As river and stream water levels recede due to withdrawals, fringing wetlands may be lost and armoring or other erosion control method may be needed to protect newly exposed stream banks. The result is less refuge for fish, fundamental changes in channel structure (e.g., loss of pool habitats), instability of stream banks, and alteration of nutrient and prey sources within the river system (Hanson *et al.* 2003). The changes to the natural habitat caused by irrigation water discharges can potentially lead to large-scale aquatic community changes. Changes in flow patterns may affect the availability of prey and forage species. In conjunction with anthropogenic watershed changes, water diversions and associated riparian impacts have been associated with the increase in some harmful algal blooms (Boesch *et al.* 1997) which further impact an array of aquatic habitat characteristics. Lost wetlands correlates to a loss of floodplain and flood storage capacity, and thus a reduced ability to act as flood control during storm events.

For additional information on water diversion impacts, refer to the chapters on Physical Affects: Water Uptake and Discharge Facilities, Chemical Affects: Water Discharge Facilities, and Agriculture and Silviculture.

Recommended Conservation Measures and Best Management Practices for Water Withdrawal/ Diversion (Adapted from Hanson *et al.* 2003).

1. Design projects to create flow conditions adequate to provide for passage, water quality, proper timing for all life history stages, and avoidance of juvenile stranding and redd (i.e., spawning nest) dewatering, as well as to maintain and restore properly functioning channel, floodplain, riparian, and estuarine conditions.
2. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
3. Establish adequate instream flow conditions for anadromous fish.
4. Design intakes with minimal flows to prevent impingement/entrainment.
5. Screen water diversions on fish-bearing streams, as needed.
6. Thermal discharges should be designed such that ambient stream temperatures are maintained, or a zone of passage is provided maintaining suitable temperatures for fish passage.
7. Incorporate juvenile and adult fish passage facilities on all water diversion projects.

Dredging and Filling

The dredging and filling of riparian and freshwater wetlands directly removes potentially important habitat and alters the habitat surrounding the developed area. Expansion of navigable waterways is associated with economic growth and development, and generally adversely affects benthic and water-column habitats. Routine dredging is required to maintain the desirable depth as the created channel fills with sediment. Direct removal of riverine habitat from dredge and fill activities may be one of the biggest threats to riverine habitats and anadromous species (NEFMC 1998).

Dredge and fill activities in riverine and riparian habitats can affect fisheries habitat in a number of ways including: reducing the ability of the wetland to retain floodwater; uptake nutrients and other such functions; decreasing the amount of detrital food source available to communities; conversion of habitats by altering water depth or altering the substrate type (i.e., substrate conversion); removal of aquatic vegetation and preventing natural revegetation; and hindering physiological processes to aquatic organisms (e.g., photosynthesis, respiration) due to increased turbidity and sedimentation (Arruda *et al.* 1983; Dennison 1987; Cloern 1987; Barr 1993; Benfield and Minello 1996; Nightingale and Simenstad 2001). In addition, dredge and fill activities in riverine and riparian habitats may result in the following impacts: direct elimination of sessile or semi-mobile aquatic organisms via entrainment or smothering (Larson and Moehl 1990; McGraw and Armstrong 1990; Barr 1993; Newall *et al.* 1998); altered water quality parameters (i.e., temperature, oxygen concentration, and turbidity); and release of contaminants such as petroleum products, heavy metals, nutrients (USEPA 2000). In addition to reducing dissolved oxygen through reduced photosynthesis, dissolved oxygen may be depleted through chemical processes associated with the release of reactive compounds in the sediment (Nightingale and Simenstad 2001).

For more detailed discussion on dredging and filling impacts, refer to the chapters on Offshore Dredging and Disposal Activities, Marine Transportation, and Coastal Development.

<u>Conservation Measures and Best Management Practices for Dredging and Filling</u> (adapted from Hanson *et al.* 2003).

1. Avoid the filling of wetlands and riparian habitat whenever possible. Ensure proposed dredge and fill projects in wetlands are water-dependent.
2. Utilize best management practices (BMPs) to limit and control the amount and extent of turbidity and sedimentation. Standard BMPs may include constructing silt fences, coffer dams, and operational modification (e.g., hydraulic dredge rather than mechanical dredge).
3. When appropriate, require the use of multiple-season biological sampling data (both pre- and post-construction), to assess the potential and resultant impacts on habitat and aquatic organisms.
4. Test sediment compatibility for open-water disposal per the U.S. EPA and U.S. Army Corps of Engineers requirements for inshore and offshore unconfined disposal.
5. Dredging and filling activities should avoid submerged aquatic vegetation and special aquatic sites. This may include the placement of pipes for hydraulic dredging and anchoring of barges and other vessels associated with the dredging project.
6. The dredge footprint should avoid littoral zone habitat, and appropriate buffers should be in place to protect these areas from wind driven waves and boat wakes.
7. Schedule dredging activities when the fewest species and least vulnerable life stages are present. Appropriate work windows can be established based on the multiple season biological sampling. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
8. Address cumulative impacts of past, present and foreseeable future dredging operations on aquatic habitats by considering them in the review process.

9. Reference all dredging projects in a geographical information system (GIS) compatible format for long-term evaluation.
10. Identify sources of sedimentation within the watershed that may exacerbate repetitious maintenance activities. Implement appropriate management techniques to control these sources.

Mining

Mining is a potential problem within riverine habitats and may result in direct and indirect chemical, biological, and physical impacts to the habitat of the mining site and surrounding regions during all stages of operations (NEFMC 1998). Some of the impacts associated with the extraction of alluvial material from within or near a streambed include: 1) disruption of pre-existing balance between sediment supply and transporting capacity, leading to channel incision and bed degradation; 2) increased suspended sediment, sediment transport, turbidity, and gravel siltation; 3) alteration in the morphology of the channel and decreased channel stability; 4) direct impacts to fish spawning and nesting habitats (redds) and juveniles, and prey items; 5) alteration of the channel hydraulics during high flows due to material stockpiled or left abandoned; 6) removal of instream roughness, including LWD; 7) reduced groundwater elevations and stream flows due to dry pit or wet pit mining; and 8) the destruction of riparian zone during extraction operations (Pearce 1994; Packer *et al.* 2005). On-site mining activities include exploration, site preparation, mining and milling, waste management, decommissioning and reclamation, and abandonment. In addition, structures used in mining extraction and transportation often cause additional impacts to wetland and riverine habitats (Starnes and Gasper 1996). Other impacts include modification of hydrologic conditions, fragmentation and conversion of habitat, altered temperature regimes, decrease in oxygen concentration, and the release of toxic materials. Mining operations often occur in urban settings or around existing or historic mining sites; however, mining in remote settings where human activity has caused little disruption and aquatic resources are most productive may cause significant impacts (NRC 1999). Existing regulations have been designed to control and manage changes to the landscape to avoid various impacts associated with mining operations. However, the nature of mining will always result in some alteration of habitat and natural resources (NRC 1999).

<u>Mineral Mining</u>

Effects of mineral mining on riverine habitat depend on the type, extent, duration and location of the mining activity. Surface mining involves suction dredging, hydraulic mining, panning, sluicing, strip mining, and open-pit mining. Surface mining has a greater potential impact on riverine habitat than underground, or shaft mining, depending on other aspects of the mining activities, including processing, and degree of disturbance (Spence *et. al.* 1996; Hanson *et al.* 2003). Elimination of vegetation, topographic alterations, alteration of soil and subsurface geological structure and alteration of surface and groundwater hydrologic regimes are potential effects of surface mining (Starnes and Gasper 1996). Soil erosion and sediment run-off may be the greatest impact of surface mining, contributing a greater sediment load per area of disturbance compared with other activities because of the degree of soil, topographic, and vegetation disturbance (Nelson *et al.* 1991). Long-term mine sites can potentially change natural habitats and associated fish and shellfish populations (Wilk and Barr 1994).

<u>Sand and Gravel Mining</u>

Gravel and sand mining operations can involve wet-pit mining (removal of material below the water table), dry pit mining on beaches, exposed bars and ephemeral streambeds, or subtidal mining. Impacts associated with sand and gravel mining in riverine environments are similar to mineral mining impacts, and include: turbidity plumes and resuspension of sediment and nutrients, removal of spawning habitat, alteration of stream channel morphology. These physical perturbations often lead to alteration of migration patterns, physical and thermal barriers to upstream and downstream migration, increased fluctuation in water temperature, decrease in dissolved oxygen, high mortality of early life stages, increased susceptibility to predation and loss of suitable habitat. For additional information on impacts associated with mining and dredging, refer to the chapter on Offshore Dredging and Disposal).

Alteration of Stream Bed and Stream Morphology

Mining can also alter channel morphology by making the stream channel wider and shallower and removing the natural sediment load. Consequently, the suitability of stream reaches as rearing habitat may decrease, especially during summer low-flow periods when deeper waters are important for survival. A reduction in pool frequency may adversely affect migrating adults that require holding pools (Spence *et al.* 1996). Changes in the frequency and extent of bedload movement and increased erosion and turbidity can also remove spawning substrates, scour redds, resulting in a direct loss of eggs and young, or reduce their quality by deposition of increased amounts of fine sediments. This change is crucial to early life stages of Atlantic salmon which exhibit an affinity for specific habitat types (Fitzsimons *et al.* 1999; Hedger *et al.* 2005). Extraction of sand and gravel in riverine ecosystems can directly eliminate the amount of gravel available for spawning if the extraction rate exceeds the deposition rate of new gravel in the system. Gravel excavation also reduces the supply of gravel to downstream habitats. The extent of suitable spawning habitat may be reduced where degradation reduces gravel depth or exposes bedrock (Spence *et al.* 1996). Associated with stream morphology alterations are resultant increased temperatures from reduction in summer base flows, altered width to depth ratios, and decreases in riparian vegetation; decreases in dissolved oxygen concentration as water temperatures increase; decreased nutrients from loss of floodplain connection and riparian vegetation; and decreased food production (e.g., loss of invertebrate prey populations) (Spence *et al.* 1996).

Sedimentation and Siltation

Sedimentation effects of mining may be immediate during mining or delayed. Sedimentation may be a delayed effect, because gravel removal typically occurs at low flow when the stream has the least capacity to transport fine sediments out of the system. Increased sedimentation results when the spring freshet inundates an extraction area that is less stable than before mining operations. The unstable sediment washes freely into the system, acting as a migratory barrier to anadromous fish, such as Atlantic salmon, and resulting in a loss and/or affecting the quality of spawning and rearing habitat within the system (Spence *et al.* 1996).

Release of Contaminants

Mining operations can release harmful or toxic materials directly from mining operations, including processing and machinery. Mining can introduce into waterways high levels of heavy metals, sulfuric acid, mercury, cyanide, arsenic and processing reagents. Water pollution by heavy metals and acids is associated with mineral mining because ores, rich in sulfides, are commonly mined to extract gold, silver, copper, zinc and lead (NRC 1999). In combination with anoxic conditions, sulfur-containing sediments can create additional levels of toxicity in addition to acid conditions (Brouwer and Murphy 1995). The improper handling or discharge of tailings and settling ponds can result in a direct loss of living aquatic resources as a result of decreased water quality and increased concentration levels of toxic substances. Locating settling ponds in unstable or landslide prone upland sites are prone to dangerous, instantaneous release of large quantities of toxins.

Groundwater and surface water may be incidentally contaminated by leaching of toxic substances from upland settling ponds.

Release of Nutrients/Eutrophication

Sand and gravel mining may release excessive nutrients to the aquatic environment by re-suspending organic matter during excavation, which can degrade habitat and water quality (ASMFC 1992; NOAA 1997a; NOAA 1997b). Nutrient enrichment can result in eutrophication and disrupt habitat functions, including lower dissolved oxygen levels, excessive turbidity and algal blooms, and inhibited denitrification processes (O'Reilly 1994; Wilk and Barr 1994). Severe eutrophication can result in decreased or depleted aquatic vegetation (Muller and Stadelmann 2004), lead to mass die-offs of aquatic organisms, spread of disease, and cause the long-term alteration of community dynamics. Such dramatic changes could make available habitat suitable for invasive species to establish and possibly dominate.

Peat Mining

Deposits of peat are found in the watersheds of eastern Maine and are extracted through mining activities (USFWS 1999). The impacts associated with peat mining include the release of contaminants (i.e., peat fiber, arsenic residues, and other toxic chemicals), accelerated run-off from roads and other unvegetated areas, and altered hydraulic flow regimes (NEFMC 1998). Peat mining has been associated with acidic conditions in eastern Maine watersheds, such as Narraguagus River, and has been identified as a potential contributor to Atlantic salmon declines (USFWS 1999).

Conservation Measures and Best Management Practices for Mining (adapted from Hanson *et al.* 2003).

1. Upland aggregate sources should be utilized before any mining activities in active channels or floodplains.
2. Avoid mining operations in rivers and streams identified as important migratory pathways, spawning, and nursery habitat for anadromous fish.
3. Schedule necessary in-water activities when the fewest species and least vulnerable life stages are present. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
4. Identify upland or off-channel (where channel will not be captured) gravel extraction sites as alternatives to gravel mining in or adjacent to rivers and streams identified as important pathways for anadromous fish, if possible.
5. Use an integrated environmental assessment, management, and monitoring package in accordance with state and federal law. Allow for adaptive operations to minimize adverse impacts.
6. Prior to gravel removal, a thorough assessment of sediments and point and non-point sources of contaminants be conducted.
7. Utilize best management practices to avoid spills of dirt, fuel, oil, toxic materials, and other contaminants. Prepare a spill prevention plan and maintain appropriate spill containment and water repellent/oil absorbent cleanup materials on the project location.
8. Treat wastewater (e.g., acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams. Treat wastewater before discharge for compliance with state and federal clean water standards.

9. Reclaim mining wastes that contain contaminants such as heavy metal, acids, arsenic or other substances if leachate could enter aquatic habitats through surface or groundwater.
10. Design, manage, and monitor sand and gravel mining operations to minimize potential direct and indirect impacts to riverine habitat if operations cannot be avoided. This includes, but is not limited to, migratory corridors, foraging and spawning areas, and stream/river banks.
11. Minimize the spatial extent and the depth of mine extraction.
12. Use best management practices to minimize opportunities for sediment to enter streams and waterways. Methods such as contouring, mulching, silt curtains, and settling ponds should be part of the operations plan. Monitor turbidity during operations and alter operations if turbidity levels reach or exceed a pre-determined level.
13. Include restoration, mitigation, and monitoring plans in sand/gravel extraction plans.
14. Develop a monitoring program at the site for an appropriate period of time to evaluate performance and need for corrective measures.

Emerging Issues for Freshwater Systems

Endocrine Disruptors and Nanoparticles

New and emerging issues that are being identified as potentially harmful to aquatic ecosystems have included endocrine disruptors and nanotechnology waste. Growing concerns have mounted in response to the effects of endocrine-disrupting chemicals on humans, fish and wildlife (Kavlock *et al.* 1996; Kavlock and Ankley 1996). These chemicals act as "environmental hormones" that may mimic the function of the sex hormones androgen and estrogen (Thurberg and Gould 2005). Adverse effects include reduced or altered reproductive functions, which could result in population-level impacts. Some of the chemical shown to be estrogenic include PCB congeners, dieldrin, DDT, phthalates and alkylphenols (Thurberg and Gould 2005), which have had or still have applications in agriculture and may be present in irrigation water. Heavy metals have also been implicated in disrupting endocrine secretions of marine organisms, potentially disrupting natural biotic processes (Brodeur *et al.* 1997).

Other recent concerns are the release of substances referred to as nanoparticles into the aquatic environment. Nanoparticles, such as fullerenes (e.g., 60-carbon molecules often referred to as "buckyballs") may have great potential for use in the pharmaceutical, lubricant, and semiconductor industries, as well as applications in energy conversion. However, the micro-fine particulate waste generated from the production and use of nanoparticles, may adversely affect the distribution, feeding, ecology, respiration and nutrient regeneration of microorganisms, such as bacterivorous and herbivorous protozoa, protists, phagotrophic or mixotrophic microalgae (Colvin 2003).

Harmful Algal Blooms

Impervious surfaces and stormwater drain systems can increase the rate and volume of storm water runoff from land and into rivers and streams. This direct flushing of water generates large pulses of freshwater into estuaries and coastal areas, carrying with it nutrients and a wide-range of pollutants. Biological wastes and nutrients entering estuarine and coastal habitats from upland sources are associated with harmful algal blooms, which can deplete the oxygen in the water during bacterial degradation of algal tissue, and can result in hypoxic or anoxic "dead zones" and large-scale fish kills (Deegan and Buchsbaum 2005). Algal blooms may contain species of phytoplankton such as dinoflagellates that produce toxins. Toxic algal blooms, such as red tides, can decimate large numbers of fish, contaminate shellfish species, and cause health problems in humans. Shellfish sequester toxins from the algae and become dangerous to consume. Toxic algal blooms could increase in the future due to the fact that many coastal and estuarine areas are currently moderately to severely eutrophic (Goldburg and Triplett 1997). Heavily developed watersheds tend to have reduced stormwater storage capacity, and the high flow velocity and pulse of contaminants from freshwater systems can have long-term, cumulative impacts to estuarine and marine ecosystems. Refer to the Coastal Development and Introduced/Nuisance Species and Aquaculture chapters for more information on harmful algal blooms.

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MARINE TRANSPORTATION

Introduction

The demand for increased capacity of marine transportation vessels, facilities, and infrastructure is a global trend that is expected to continue in the future. This demand is fueled by a need to accommodate growing vessel operations for cargo handling activities and human population growth in coastal areas. As coastal areas continue to grow there is a concomitant increase in the demand for water transportation services and recreational opportunities.

It is also important to note that coastal areas under high developmental pressure are often located adjacent to productive and sensitive aquatic environments. Historically, human settlements in the northeast U.S. were probably established on the basis of availability to food resources and marine transportation. Coastal features such as estuaries and embayments satisfied these needs as they are highly productive ecosystems ideal for fishing, farming or hunting and are sheltered waters that provide access to rivers and the ocean for transportation purposes. Today, urban growth and development in coastal areas is growing at a rate approximately five times that in other areas of the country and over one-half of all Americans live within 50 miles of the coast (Markham 2006). The continued demand on the coast today is likely attributed to the highly desirable aesthetic quality and recreational opportunities, including access to fishing, beaches and boating.

The expansion of port facilities, vessel operations, and commercial and recreational marinas can have adverse impacts on fishery habitat. The growth of the marine transportation industry is accompanied by land-use changes, including over-water or in-water construction, filling of aquatic habitat and wetlands, and increased maintenance activities. Although some categories of habitat impacts resulting from activities related to port and marina construction and maintenance and vessel operations may be minimal and site specific, the cumulative effects of these activities over time can have substantial impacts on habitat.

The construction of new ports and marinas typically involves the removal of sediments by dredging from intertidal and subtidal habitats in order to create navigational channels, turning basins, anchorages, and berthing docks for the size and types of vessels expected to use the facilities. For existing ports and marinas, dredging is generally conducted on a routine basis in order to maintain the required depths as sediment is transported and deposited into the channels, basins, anchorages, and docks. The construction of new ports and marinas, or the expansion of existing facilities, is often referred to as "improvement" dredging; whereas, dredging existing ports and marinas in order to maintain an assigned or authorized depth is generally referred to as "maintenance" dredging. Because the chemical, physical and biological impacts associated with both "improvement" and "maintenance" dredging is similar in nature, both types of dredging are discussed in the Navigation Dredging and Inshore Disposal section of this chapter. Other impacts associated with newly constructed and expanded ports and marinas are covered under the Construction and Expansion of Ports and Marinas section of this chapter.

Construction and Expansion of Ports and Marinas

Construction of ports and marinas can change physical and chemical habitat parameters such as tidal prism, depth, water temperature, salinity, wave energy, sediment transport and current velocity. Alterations to physical characteristics of the coastal ecosystems can cause adverse effects to biological parameters, such as the composition, distribution, and abundance of shellfish and submerged aquatic vegetation (SAV). These changes can impact the distribution of nearshore habitats and affect aquatic food webs.

Loss and Conversion of Habitat

Port and marina facilities are typically located in areas containing highly productive intertidal and subtidal habitats, including saltmarsh wetlands and SAV. Coastal wetlands provide a number of important ecological functions, including foraging, spawning/breeding, protection from predators, as well as nutrient uptake and release, and retention of storm and floodwaters. Vegetated wetlands and intertidal habitats are some of the most highly productive ecosystems in the world, and support one or more life stages of important commercial and recreational fishery resources in the U.S. (Dahl 2006). One of the most obvious habitat impacts related to the construction of a port or marina facility is alteration or loss of physical space taken up by the structures required for such a facility. The construction of ports and marinas can alter or replace salt marsh, submerged aquatic vegetation, and intertidal mud flat habitat with "hardened" structures such as concrete bulkheads and jetties that provide relatively few ecological functions. Boston Harbor, Massachusetts exemplifies a northeast coastal port transformed by expansive dredging and filling of former shallow estuarine waters and salt marsh wetlands. Between 1775 and 1980, wetland filling within the harbor extensively altered the shoreline, with the airport alone amounting to 2,000 acres of filled intertidal salt marsh wetlands (Deegan and Bushbaum 2005).

Over-water structures, such as commercial and residential piers and docks, floating breakwaters, barges, rafts, booms, and mooring buoys are associated with port and marina facilities and are constructed over both subtidal and intertidal habitats. Although they generally have less direct physical contact with benthic habitats than in-water structures, float, raft, and barge groundings at low tides, and the scouring of the substrate by the structures and anchor chains can be substantial. Piles and other in-water structures can alter the substrate below and adjacent to the structures by providing a surface for encrusting communities of mussels and other sessile organisms, which can create shell deposits and shift the biota normally associated with sand, gravel, mud, and eelgrass substrates to those communities associated with shell hash substrates (Penttila and Doty 1990; Nightingale and Simenstad 2001a).

Shoreline armoring is an in-water structure activity associated with the construction and operation of marinas and ports. Shoreline armoring is intended to protect inland structures from storm and flood events and prevent erosion that is often a result of increased boat traffic. Armoring of shorelines to prevent erosion and maintain or create shoreline development simplifies habitats, reduces the amount of intertidal habitat, and affects nearshore processes and the distribution of aquatic communities (Williams and Thom 2001). Hydraulic effect alterations to the shoreline include increased energy seaward of the armoring from reflected wave energy, which can exacerbate erosion by coarsening the substrate and altering sediment transport (Williams and Thom 2001). Installation of breakwaters and jetties can also result in community changes, including burial or removal of resident biota, changes in cover and preferred prey species and predator interaction, as well as the movement of larvae (Williams and Thom 2001). Chapman (2003) found a paucity of mobile species associated with seawalls in a tropical estuary, compared with surrounding areas.

Altered Light Regimes and Loss of Submerged Aquatic Vegetation

Alterations of the light regimes in coastal waters can affect primary production, including the distribution and density of SAV, as well as the feeding and migratory behavior of fish. Over-water structures shade the surface of the water and attenuate the sunlight available to the benthic habitat under and adjacent to the structures. The height, width, construction materials used, and the orientation of the structure in relation to the sun can influence how large a shade footprint an over-water structure may produce and how much of an adverse impact that shading effect may have on the localized habitat (Fresh *et al.* 1995; Burdick and Short 1999; Shafer 1999; Fresh *et al.* 2001). High, narrow piers and docks produce more diffuse shadows which have been shown to reduce shading impacts to SAV (Burdick and Short 1999; Shafer 1999).

The density of pilings can also determine the amount of light attenuation created by dock structures. Piling density is often higher in larger, commercial shipping ports than in smaller recreational marinas, as larger vessels and structures often require a greater number of support structures such as fenders and dolphin piles. Light limitations due to pilings can be reduced through adequate spacing of the pilings and the use of light reflecting materials (Thom and Shreffler 1996; Nightingale and Simenstad 2001a). In addition, piers constructed over solid structures, such as breakwaters or wooden cribs, would further limit light transmittance and increase shading impacts on SAV.

Although shading impacts are greatest directly under a structure, the impacts on SAV may extend to areas adjacent to the structure as shadows from changing light conditions and adjacent boats or docks create light limitations (Burdick and Short 1999; Smith and Mezich 1999). A decrease in SAV and primary productivity can impact the nearshore food web, alter the distribution of invertebrates and fish, and reduce the abundance of prey organisms and phytoplankton in the vicinity of the over-water structure (Kahler *et al.* 2000; Nightingale and Simenstad 2001a; Haas *et al.* 2002).

The sharp light contrasts created by over-water structures due to shading during the day and artificial lighting at night can alter the feeding, schooling, predator avoidance and migratory behaviors of fish (Nightingale and Simenstad 2001a; Hanson *et al.* 2003). Fish, especially juveniles and larvae, rely on visual cues for these behaviors. Shadows create a light-dark interface which may increase predation by ambush predators and increase starvation through limited feeding ability (Able *et al.* 1999; Hanson *et al.* 2003). In addition, the migratory behavior of some species may favor deeper waters away from shaded areas during the day and lighted areas may affect migratory movements at night, contributing to increased risk of predation (Nightingale and Simenstad 2001a).

<u>Altered Temperature Regimes</u>
Shoreline modifications, including the construction of seawalls and bulkheads, can alter nearshore temperature regimes and natural communities. Modified shorelines invariably contain less shoreline vegetation than natural shorelines, which can reduce shading in the nearshore intertidal zone and cause increases in water temperatures (Williams and Thom 2001). Conversely, seawalls and bulkheads constructed along north facing shorelines may unnaturally reduce light levels and reduce water temperatures in the water column adjacent to the structures (Williams and Thom 2001).

<u>Siltation, Sedimentation and Turbidity</u>
The construction of a new port or marina facility is usually associated with profound changes in land use and in-water activities. Because a large proportion of the shoreline associated with a port is typically replaced with impervious surfaces such as concrete and asphalt, stormwater runoff is exacerbated and can increase the siltation and sedimentation loads in estuarine and marine habitats. The upland activities related to building roads and buildings may cause erosion of topsoil which can

be transported through stormwater runoff to the nearshore aquatic environment, increasing sedimentation and burying benthic organisms. Construction and expansion of ports and marinas generally include dredging channels, anchorages and berthing areas for larger and greater numbers of vessels, which contributes to localized sedimentation and turbidity. In addition, the use of underwater explosives to construct bulkheads, seawalls, and concrete docks may temporarily resuspend sediments and cause excessive turbidity in the water column and impact benthic organisms. Refer to the subsection on Navigation Dredging and Inshore Disposal later in this chapter for information on channel dredging.

Impacts associated with increased suspended particles in the water column include high turbidity levels, reduced light transmittance, and sedimentation which may lead to reductions or loss of SAV and other benthic habitats. Elevated suspended particles have also been shown to adversely affect the respiration of fishes, reduce filtering efficiencies and respiration of invertebrates, reduce egg buoyancy, disrupt ichthyoplankton development, reduce the growth and survival of filter feeders, and decrease the foraging efficiency of sight-feeders (Messieh *et al.* 1991; Barr 1993).

Structures such as jetties and groins may be constructed to reduce the accretion of sediment in navigable channels, so by design they alter littoral sediment transport and change sedimentation rates. These structures may reduce sand transport and cause beach and shoreline erosion to down drift areas, and may also interfere with the dispersal of larvae and eggs along the coastline (Williams and Thom 2001). Substrate disturbance from pile driving and removal can increase turbidity, interfere with fish respiration and smother benthic organisms in adjacent areas (Mulvihill *et al.* 1980). In addition, contaminates in the disturbed sediments may be resuspended into the water column, exposing aquatic organisms to potentially harmful compounds (Wilber and Pentony 1999; USEPA 2000; Nightingale and Simenstad 2001b). Refer to the Coastal Development chapter for a more detailed discussion impacts related to pile driving and removal.

<u>Contaminant Releases</u>

The construction of ports and marinas can alter natural currents and tidal flushing, and may exacerbate poor water quality conditions by decreasing water circulation. Bulkheads, jetties, docks, and pilings can create water traps that accumulate contaminants or nutrients washed in from land based sources, vessels, and facility structures. These conditions may create areas of low dissolved oxygen, dinoflagellate blooms, and elevated toxins.

Contaminants can be released directly into the water during construction activities associated with new ports and marinas, or indirectly through storm water runoff from land-based operations. Accidental and incidental spills of petroleum products and other contaminants, such as paint, degreaser, detergents and solvents, can occur during construction operations of a facility. Large amounts of impervious surfaces at ports and marinas can increase, and in some cases direct, stormwater runoff and contaminants into aquatic habitats. The use of certain types of underwater explosives to construct bulkheads, seawalls, and concrete docks may release toxic chemicals (e.g., ammonia) in the water column that can impact aquatic organisms.

Wood pilings and docks used in marina and port construction are often treated with chemicals such as chromated copper arsenate, ammoniacal copper zinc, and creosote to help extend the service of the structures in the marine environment. These preservatives can leach harmful chemicals into the water that have been shown to produce toxic affects on fish and other organisms (Weis *et al.* 1991). Creosote-treated wood for pilings and docks has also been used in marine environments and has been shown to release poly-aromatic hydrocarbons (PAHs) continuously and for long periods of time after installation or treatment; whereas other chemicals that are applied to the wood, such as ammoniacal copper zinc arsenate (ACZA) and chromated copper arsenate (CCA), tend to leach into the environment for shorter durations (Poston 2001). Affects from exposure of aquatic organisms to PAHs include carcinogenesis, phototoxicity, immunotoxicity and disturbance of hormone regulation (Poston 2001). The rate and duration that these preservatives can be leached into marine waters after installation is highly variable and dependent on many factors, including the length of time since the treatment of the wood and the type of compounds used in the preservatives. The toxic effects of metals such as copper on fish are well known, and include body lesions, damage to gill tissue and interrupted cellular functions (Gould *et al.* 1994). These chemicals can become available to marine organisms through uptake by wetland vegetation, adsorption by adjacent sediments, or directly through the water column (Weis and Weis 2002). The presence of CCA in the food chain may cause localized reductions in species richness and diversity (Weis and Weis 2002). Concrete, steel, or non-treated wood are relatively inert and generally do not leach contaminants into the water.

Dredging and filling of intertidal and subtidal habitats can resuspend sediments into the water column that may have been contaminated by nearby industrial activities. Information on contaminant releases due to dredging can be found in the Navigation Dredging and Nearshore Disposal section of this chapter and the Chemical Effects: Water Uptake and Discharge Facilities chapter of the report.

Altered Tidal, Current and Hydrologic Regimes

One of the main functions of a marina or port is to shelter and protect boats from wave energy. In-water structures of ports and marinas such as bulkheads, breakwaters, jetties, and piles result in localized changes to tidal and current patterns. These alterations may exacerbate poor water quality conditions in these facilities by reducing water circulation. In addition, in-water structures interfere with longshore sediment transport processes resulting in altered substrate amalgamation, bathymetry, and geomorphology. Changing the type and distribution of sediment may alter key plant and animal assemblages, starve nearshore detrital-based foodwebs, and disrupt the natural processes that build spits and beaches (Nightingale and Simenstad 2001a; Hanson *et al.* 2003).

The protected, low energy nature of marinas and ports may alter fish behavior as juvenile fish show an affinity to structure and may congregate around breakwaters or bulkheads (Nightingale and Simenstad 2001a). These alterations in behavior may make them more susceptible to predation and may interfere with normal migratory movements.

Underwater Blasting and Noise

Noise from underwater blasting and in-water construction generates intense underwater sound pressure waves that may adversely affect marine organisms. These pressure waves have been shown to injure and kill fish (Caltrans 2001; Longmuir and Lively 2001; Stotz and Colby 2001). Fish are known to use sound for prey and predator detection as well as social interaction (Richard 1968; Myrberg 1972; Myrberg and Riggio 1985; Hawkins 1986; Kalmijn 1988), and underwater blasting and noise may alter the their distribution and behavior (Feist *et al.*1996).

Generally, aquatic organisms that possess air cavities (i.e., lungs and swim bladders) are more susceptible to underwater blasts than those without (Keevin *et al*. 1999). In addition, smaller fish are more likely to be impacted by the shock wave of underwater blasts than larger fish, and the eggs and embryos tend to be particularly sensitive; however, fish larvae tend to be less sensitive to blasts than eggs or post-larvae fish, probably because the larvae stages do not yet possess air bladders (Wright 1982; Keevin *et al.* 1999).

Blasting may used for dredging new navigation channels and boat basins or expanding existing channels in areas containing rock substrates, boulders and ledges. The construction of new in-water structures, such as bulkheads, seawalls and concrete docks also may involve blasting. Blasting represents a single point of disturbance with a restricted, and often predictable, mortality zone; in addition, blasting engineers purposefully focus the blast energy towards fracturing rock substrate and preventing excess energy from being released into the water column (Keevin *et al.* 1999). Techniques used to prevent blasting damage to structures in the vicinity of a project, such as bubble curtains, may be effective mitigation measures for reducing blasting impacts on aquatic biota (Keevin *et al.* 1999). Although the use of bubble curtains have been shown to be effective at minimizing pressure wave impacts on fish (Keevin *et al*. 1997; Longmuir and Lively 2001), the difficulty of deploying bubble curtains in field conditions may reduce the efficacy of this technology in mitigating these effects (Keevin *et al*. 1997).

Unlike blasting, pile driving is a repeating sound disturbance that can last for extended periods of time during construction. There are several factors which affect the type and intensity of sound pressure waves during pile driving, including the size and material of the piling, the firmness of the substrate and the type of pile-driving hammer that is used (Hanson *et al*. 2003). Wood and concrete piles produce lower sound pressures than steel piles, while pile driving in firmer substrate, which requires more energy, will produce more intense sound pressures (Hanson *et al.* 2003). Both impact hammers and vibratory hammers are commonly used when driving pilings into the substrate. Vibratory hammers produce sounds with more energy in the lower frequencies (15-26 Hz), compared to higher frequency noise generated by impact hammers (100-800 Hz) (Carlson *et al.* 2001). The behavioral response elicited by fish differs in these two ranges of sound frequencies. Fish respond to sounds similar to vibratory hammers by consistently displaying an avoidance response and not habituating to the sound despite repeated exposure (Dolat 1997; Knudsen *et al.* 1997; Sand *et al.* 2000). In contrast, fish are initially startled by an impact hammer but eventually become habituated and no longer respond to the stimuli. This behavior may place fish in more danger as they remain in range of potentially harmful sound pressure waves (Dolat 1997). Refer to the chapter on Global Effects and Other Impacts for additional information on underwater noise impacts to aquatic organisms.

<u>Conservation Recommendations and Best Management Practices for Construction and Expansion of Ports and Marinas</u>

1. Encourage federal, state and local authorities to assist port authorities and marinas in developing management plans that avoid and minimize impacts to the coastal environment and that are consistent with coastal zone management plans.
2. Encourage implementation of environmental management systems for ports and marinas that incorporate strong operational controls and BMPs into existing job descriptions and work instruction.
3. Encourage marinas to participate in NOAA/U.S. EPA’s Coastal Nonpoint Program and the Clean Marina Initiative.
4. Explore alternative port developments such as satellite ports and offshore terminals, which may decrease some impacts associated with traditional inshore port facility developments.

5. For new or proposed expansion of port and marina facilities, site suitability analyses should be completed to reduce and avoid habitat degradation or loss. Some of the analyses that should be conducted include identifying alterations to current and circulation patterns, water quality, bathymetric and topographic features, fisheries utilization and species distributions, and substrate features.
6. Pre- and post-project biological surveys, conducted over multiple growing seasons should be conducted to assess impacts submerged and emergent aquatic vegetation communities.
7. To the maximum extent practicable, new or expansions of port and marina facilities should be sited in deep-water areas to avoid the need for dredging. Areas that are subject to rapid shoaling or erosion will likely require more frequent maintenance dredging, and should be avoided.
8. Areas identified as supporting high abundance and diversity of species (e.g., SAV beds, intertidal mudflats, emergent wetlands, fish spawning areas) should be avoided when locating new or expanded port and marina facilities.
9. Encourage the use of pre-project surveys by qualified biologists/botanists to identify and map invasive plants within the proposed project area, and develop and implement an eradication plan for non-native species.
10. In general, excavated uplands should be considered a less-damaging alterative compared to converting intertidal or shallow subtidal habitat for creating new or expanded port and marina facilities. However, water quality modeling should be conducted to evaluate potential impacts associated with enclosed and poorly flushed marinas.
11. Marine riparian buffers should be retained and preserved to maintain intertidal microclimate, flood and stormwater storage capacity, and nutrient cycle.
12. Low-wake vessel technology and appropriate vessel routes should be considered in the facility design and permitting process to minimize impacts to shorelines and shallow water habitats. Vessel speeds should be adapted to minimize wake damage to shorelines, and no-wake zones should be considered in highly sensitive areas, such as fish spawning habitat and SAV beds.
13. New port and marina facilities should not be located in areas that have reduced tidal exchange and/or shallow water habitats, such as enclosed bays, salt ponds, and tidal creeks.
14. New ports and marinas should implement construction designs to facilitate good tidal exchange and surface water movement and provide an adequate migratory corridor for fish. When possible, structures that impede tidal exchange and that may interfere with the movement of marine organisms, such as solid breakwaters, should be avoided.
15. Ensure that new port and marina incorporate best management practices in the construction operation plans that prevent and minimize the release of contaminants and debris due to construction equipment and activities. The plan should include a spill response plan and training, and spill response equipment should be installed and maintained properly on-site.
16. When necessary, seasonal restrictions should be implemented to avoid construction-related impacts to habitat during species critical life history stages (e.g., spawning and egg development periods).
17. For structures located over SAV, the amount of light reaching vegetation below the dock should be maximized by providing adequate height over the water, minimizing the width of the dock, and orienting the length of the dock in a north-south direction.
18. The use of wood preservatives, such as creosote, ACZA and CCA should be avoided, where possible. If CCA treated wood must be used, the wood can be pre-soaked for several weeks or the wood can be coated with plastic sheath to reduce/eliminate leaching. Concrete and steel pilings are generally considered to be less damaging, since they reflect light more than wood docks and generally do not release contaminants into the aquatic environment. However,

concrete pilings and docks generally increase the overall size of the overwater structure and may not be preferable in areas containing SAV.

19. Floating docks, which limit light transmittance more than elevated structures, should be sited only in non-vegetated areas. When used, floating docks should either be located in areas of adequate depth so that adequate clearance between the float and the bottom is maintained, or fitted with structures (i.e., float stops) that prevent the float from contacting the bottom. Float stops should be designed to provide a minimum of 2 feet of clearance between the float and substrate to prevent hydraulic disturbances to the bottom. Greater clearances may be necessary in higher energy environments that experience strong wave action.
20. Orient night lighting such that illumination of the surrounding waters is avoided.
21. Sound pressure impacts during pile installation can be reduced by using wood or concrete piles, rather than hollow steel piles which produce intense, sharp spikes of sound that are more damaging to fish.
22. Use technologies that have been designed to reduce the adverse effects of underwater sound pressure waves such as air bubble curtains and metal or fabric sleeves to surround the pile. Air bubble systems must have adequate airflow and the pile is fully contained to ensure that sound attenuation is successful.
23. Pile driving should be conducted during low tides in intertidal and shallow subtidal areas.
24. When removing old piles, vibratory hammers can be employed to help minimize the release of suspended sediments, silt and contaminants into the water column, and may be preferable over direct pull or the use of a clamshell dredge.
25. To remove old piles it may be preferable to cut the pile off below the mudline and leave the stub in place, which can reduce or eliminate the amount of sediment released into the water column.
26. Impacts to marine organisms, particularly those with air cavities (i.e., swim bladders and lungs), from underwater blasting can be mitigated by employing BMPs such as focusing the blast energy towards a solid rock substrate rather than the water column, installing noise attenuating devices such as air curtains, conducting the blasting during periods of low-water or low-tide, delayed blasts that produce sequenced, lesser-charged explosions that reduce the shockwave, stemming (capping) the charge bore hole with material that contains the blast, and repelling charges that frighten fish from the blast area prior to blasting (Keevin 1998).
27. Federal and state resource agencies should be consulted prior to work that involves blasting to assess the marine resource utilization of the area. Biological surveys may be required to assess the presence of fishery resources. Time-of-year restrictions should be employed to avoid impacting sensitive species and life history stages that use the area. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
28. Integrate measures to reduce non-point source (NPS) pollution, such as a stormwater management plan into the design, maintenance and operation of a port or marina. Some examples of BMPs for stormwater management include (adapted from Amaral *et al.* 2005):
    a. Minimize the amount of impervious surfaces surrounding the port or marina facility and maintain a buffer zone between the coastal zone and upland facilities.
    b. Implement runoff control strategies to decrease the amount of contaminants entering marine waters from upland sources. This can be accomplished by using alternative surface materials such as crushed gravel, decreasing the slope of surfaces towards the waters' edge, and installing filtering systems or settling ponds.
    c. Designate specific enclosed areas for maintenance activities such as sanding, painting, engine repairs. Use tarp enclosures or spray booths for abrasive blasting will also prevent residue from reaching surface waters.

d. Provide and maintain appropriate storage, transfer, containment, and disposal facilities for liquid hazardous material, such as solvents, antifreeze, and paints.

Operation and Maintenance of Ports and Marinas

Existing ports and marinas can be a source of impacts to fishery resources and habitat that may differ from those relating to construction and expansion of new facilities. These impacts may be associated with the operation of the facilities, equipment impacts and stormwater runoff. Examples of port or marina impacts include chronic pollution releases, underwater noise, altered light regimes, and repeated physical disturbances to benthic habitats.

Contaminate Release and Storm Water Runoff

Ports and marinas can be a source of contaminates directly associated with facility activities and by stormwater runoff from the facility and the surrounding urbanized areas. The long-term operation of a marina or port can provide a chronic presence of contaminants to the localized area that can have an adverse effect on the quality of fishery habitat and population dynamics (Wilbur and Pentony 1999).

The oil and fuel that accumulates on dock surfaces, facilities properties, adjacent parking lots and roadways may enter coastal waters through stormwater runoff and snowmelt. Oil and fuel contains polyaromatic hydrocarbons (PAHs) and other contaminants that are known to bioaccumulate in marine organisms and impact the marine food web (Nightingale and Simenstad 2001a; Amaral *et al.* 2005). In addition, these contaminants can persist in bottom sediments where they can be resuspended through a variety of activities such as propeller scouring and dredging. Marina activities such as vessel refueling and engine repair, or through accidental vessel sinking, may increase the risk of fuel and oil contamination of the surrounding environment (Amaral *et al.* 2005).

Marina facilities such as storage areas for paint, solvents, detergents and other chemicals may pose a risk of introducing additional contaminates to the marine environment resulting in both acute and chronic toxicity to marine biota (Amaral *et al.* 2005). These products are often a routine and essential part of marina or port operations, and if handled and stored improperly can increase the risk of accidental spillage. Various port and vessel maintenance activities may contribute to heavy metal contamination to the surrounding waters. For example, elevated levels of copper are often associated with ports and marinas, especially those with a high density of recreational boats due to the type of antifouling paints used on those boats. A number of other heavy metals have been detected in the sediments and surface waters of marinas, including arsenic (used in paints and wood preservatives), zinc (leached from anodes used to reduce corrosion of boat hulls and motors), mercury (used in float switches for bilge and other storage tank pumps), lead (used in batteries), nickel and cadmium (used in brake linings) (USEPA 2001). However, stormwater runoff may be the primary source of copper in most marinas in urban areas (Warnken *et al*. 2004).

Wooden pilings and docks in marinas and ports are typically treated with some type of preservative, such as chromated copper arsenate, ammoniacal copper zinc, and creosote. These preservatives can leach harmful chemicals into the water that have been shown to have toxic effects on fish and other organisms (Weis *et al.* 1991). Concrete, steel, or non-treated wood are relatively inert and do not leach contaminants into the water. Refer to this chapter's section on Construction and Expansion of Ports and Marinas and the Coastal Development chapter for more information on the affects of copper and other wood preservatives on aquatic resources.

Because marinas and ports typically contain large areas of impervious surfaces and are located at the interface between land and water, stormwater runoff can be greater at these facilities compared with other types of land uses. The organic particulates that are washed into marine waters from the surrounding surfaces can add nutrients to the water and cause eutrophication in bays and estuaries. A number of sources of organic matter from ports and marinas can degrade water quality and reduce dissolved oxygen concentrations, including sewage discharges from recreational and commercial boats, trash tossed overboard, fish wastes disposed of into surface waters, pet wastes, fertilizers, and food wastes (USEPA 2001). Eutrophication often leads to abnormally high phytoplankton populations, which in turn can reduce the available light to SAV beds. Changes in water quality due to eutrophication can sometimes have a more severe impact on seagrass populations than shading from over-water structures or physical uprooting by vessel and float groundings (Costa *et al.* 1992; Burdick and Short 1999).

Release of Debris

Solid waste is another problematic issue associated with port and marina operations. A great deal of solid waste is generated through daily operations of a commercial port as well as the recreational activities of a marina. This waste may include plastics such as fishing line, bottles, tarps, food containers, and shopping bags, in addition to paper products and other materials, which can be released as debris into the surface waters through accidental loss from vessels or through stormwater runoff from upland facilities. Activities such as sanding, pressure washing, sand blasting, discarded rags and oil/fuel filters can contribute to marine debris if improper handling and disposal is allowed (USEPA 2001). If this waste is collected and disposed of properly the impacts to the environment can be minimized (Amaral *et al.* 2005). Plastics comprise a large component of the trash released into marine waters, accounting for 50 to 60 percent of marine debris collected from the Gulf of Maine (Hoagland and Kite-Powell 1997). Plastics contain toxic substances that can persist in the environment and bioaccumulate through the food web and impair metabolic functions in fish and invertebrates that use habitats polluted by plastic debris. Some chemicals found in plastics, known as "endocrine disruptors", may interfere with the endocrine system of aquatic organisms (Kavlock *et al.* 1996; Kavlock and Ankley 1996). These chemicals act as "environmental hormones" that may mimic the function of the sex hormones androgen and estrogen (Thurberg and Gould 2005). Adverse effects include reduced or altered reproductive functions, which could result in population-level impacts.

Marine debris can directly affect fish and invertebrates that may consume, or are entangled by the debris. Plastic debris may be ingested by seabirds, fish and invertebrates, sea turtles, and marine mammals, which can cause infections and death of the animal (Cottingham 1988). Debris can be transported by currents to other areas where it can become snagged and attached to benthic habitat, damaging sensitive reef habitat. Additional information on impacts associated with marine debris can be found under Vessel Operation and Maintenance of this chapter and in the Coastal Development chapter of this report.

Underwater Noise

The ambient noises emanating from ports and marinas are from a combination of boat propellers, engines, pumps, generators, and other equipment within vessels and shore-side equipment. In coastal areas the sounds of cargo and tanker traffic are multiplied by complex reflected paths from scattered and reverberated noises due to littoral geography. Commercial and private fishing boats, pleasure craft, personal watercraft (i.e., jet skis), industrial vessels, public transport ferries, and shipping safety and security services such as tugs boats, pilot boats, U.S. Coast Guard and coastal agency support craft generate sounds that can impact marine organisms, particularly fish and marine mammals. Exposure to continuous noise may also create a shift in hearing thresholds for marine organisms resulting in hearing losses at certain frequency ranges (Jasny 1999). Refer to the Global Effects chapter, and the Vessel Operations and the Construction and Expansion of Ports and Marinas sections in this chapter for more information on underwater noise.

Derelict Structures

Increased vessel activity in and around port and marina operations increase the probability of the grounding of vessels, which may not always be removed immediately from the aquatic environment. In addition to being public health and navigational hazards, derelict or abandoned vessels can cause various impacts to coastal habitats. Grounded vessels can physically damage and smother benthic habitats, create changes in wave energy and sedimentation patterns, and scatter debris across sensitive habitats (Precht *et al.* 2001; Zelo and Helton 2005). However, the most common environmental threat of a derelict or abandoned vessel is the release of oil or other pollutants. These hazardous materials may be part of a vessel's cargo, fuel and oil related to vessel operations, or chemicals contained within the vessel's structure which may be released over time through decay and corrosion. Refer to the Vessel Operation and Maintenance section of this chapter for more information on impacts associated with derelict structures and grounded vessels.

Mooring and Floating Dock Impacts

Vessel mooring impacts, although localized, can reduce habitat quality and complexity. Accidental vessel groundings can smother or crush shellfish, scour vegetation, and disturb substrates (Nightingale and Simenstad 2001a). Disturbance of substrates can lead to increased turbidity, reduced light penetration, decreased dissolved oxygen levels, and the possible resuspension of contaminates. In addition, moored vessels contacting the bottom during low tides can cause the bottom habitat in the area of the mooring to be unavailable for fish and other marine biota during the time the vessel is resting on the bottom. Vessels that contact the bottom can create scouring of the substrate and result in permanent alteration or loss of benthic habitats, such as eelgrass. Demersal eggs (e.g., Atlantic herring) and larvae that utilize an area can also be destroyed from the impact of the vessel or shading. Floating piers and docks may also alter wave energy, current patterns and longshore sediment transport, especially in areas that experience strong current velocities (Nightingale and Simenstad 2001a).

Depending upon the type and configuration, the mooring tackle itself may cause impacts to substrate and benthos, including SAV. Typical vessel moorings consist of an anchor connected to a surface buoy by a long length of heavy chain. In most moorings, some portion of the anchor chain drags and often scours the bottom and forms a depression in the sediment surface (Walker *et al.* 1989). In areas influenced strongly by tides and currents or wind, the bottom scouring takes on a circular or "V" configuration when the anchor chain is allowed to drag along the bottom as the vessel or buoy swings with the tide or wind (Nightingale and Simenstad 2001a). The resulting scour holes allow further erosion and loss of the physical integrity of the habitat, which can lead to fragmentation of seagrass meadows (Walker *et al.* 1989; Hastings *et al.* 1995). Hastings *et al.* (1995) attributed an approximate 18 percent direct loss of seagrass habitat from boat moorings in one bay in Western Australia. Refer to the Coastal Development chapter of this report for a more detailed discussion on impacts from overwater structures.

Alteration of Light Regimes

As discussed in other sections of this chapter, overwater structures shade the surface of the water and attenuate the light available to benthic habitat under and adjacent to the structures. The height, width, construction materials used, and the orientation of the structure in relation to the sun can influence how large a shade footprint an over-water structure may produce and how much of an adverse impact that shading effect may have on the benthic habitat (Burdick and Short 1999; Shafer 1999; Fresh *et al.* 2001; Nightingale and Simenstad 2001a). Refer to the chapter on Coastal Development and the Construction and Expansion of Ports and Marinas section of this chapter for more information on docks structures and light attenuation.

<u>Conservation Recommendations and Best Management Practices for the Operation and Maintenance of Ports and Marinas</u> (adapted from Amaral *et al.* 2005; Hanson *et al.* 2003)

1. Consider environmental impacts through port development and operations plans, including:
    a. assess all activities at facility and identify potential environmental impacts
    b. determine compatibility with port environmental practices and assess available control technologies
    c. evaluate and monitor effectiveness of control technologies
    d. develop and implement environmental management
2. Encourage marinas to participate in NOAA/U.S. EPA's Coastal Nonpoint Program and the Clean Marina Initiative.
3. Ensure that marina and port facilities operations have an oil-spill response plan in place, which has been shown to improve the response and recovery times of oil spills.
4. Ensure that marina or port facilities have adequate oil-spill response equipment accessible and clearly marked. Oil spill response equipment may include oil booms, absorbent pads, and oil dispersant chemicals.
5. Dispersants that remove oils from the environment should be utilized, rather than dispersants that simply move them from the surface to the ocean bottom.
6. Automatic shut-off nozzles should be installed at fuel dispensing sites and the use of fuel/air separators on air vents or tank stems of inboard fuel tanks to reduce the amount of fuel oil spilled into surface waters during fueling of boats should be required for vessels using fuel stations.
7. Promote the use of oil-absorbing materials in the bilge areas of all boats with inboard engines.
8. Place containment berms around fixed pieces of machinery that use oil and gas within the facility.
9. Encourage public education and signage to promote proper disposal of solid debris and polluting materials.
10. Encourage the proper disposal of materials produced and used by the operation, cleaning, maintenance, and repair of boats to limit the entry of solid and contaminated waste into surface waters.
11. Recommend the placement of garbage containers to supervised areas and use containers that have lids in order to reduce the potential for litter to enter the marine environment.
12. Promote the use of pumpout facilities and restrooms at marinas and ports to reduce the release of sewage into surface waters. Ensure that these facilities are maintained and operational, and provide these services at convenient times, locations, and reasonable cost. In addition promote the use of these facilities through public education and signage.
13. Develop a harbor management plan which addresses the maintenance and operation of pumpout facilities.

14. Prevent the disposal of fish waste or other nutrient laden material in marina or port basins through the use of public education, signage, and by providing alternate fish waste management practices.
15. Ensure that measures to reduce NPS pollution, such as a stormwater management plan, are integrated into the maintenance and operation of a port or marina.
16. Recommend site-specific solutions to NPS pollution by considering the frequency of marina operations and potential pollution sources. Management practices should be tailored to the specific issues of each marina.
17. Encourage the removal of unnecessary impervious surfaces surrounding the port or marina facility and maintain a buffer zone between the aquatic zone and upland facilities.
18. Ensure that stormwater runoff from parking lots and other impervious surfaces is collected and treated to remove contaminants prior to delivery to any receiving waters. This can be accomplished by using alternative surface materials such as crushed gravel, decreasing the slope of surfaces towards the waters' edge, and installing filtering systems or settling ponds.
19. Recommend that specific, enclosed areas are designated for maintenance activities such as sanding, painting, engine repairs. Using tarp enclosures or spray booths for abrasive blasting will also prevent residue from reaching surface waters.
20. Ensure that facilities provide for appropriate storage, transfer, containment, and disposal facilities for harmful liquid material, such as solvents, antifreeze, and paints.
21. Recommend that facilities provide a containment system and a filtering and treatment system for vessel wash down wastewater.
22. Ensure that floating structures, including barges, mooring buoys, and docks are located in adequate water depths to avoid propeller scour, and grounding of vessel and floating structures. When floating docks cannot be located in adequate depth to avoid contact on the bottom at low tides, recommend that float stops (structural supports to prevent the float from resting on the bottom) are installed. Float stops should be designed to provide a minimum of 2 feet of clearance between the float and substrate to prevent hydraulic disturbances to the bottom. Greater clearances may be necessary in higher energy environments that experience strong wave action.
23. Recommend anchoring techniques and mooring designs that avoid scouring from anchor chains. For example, anchors that do not require chains (e.g., helical anchors) or moorings that use subsurface floats to prevent anchor chains from dragging the bottom are some designs that should be considered.
24. When moorings with anchor chains cannot be avoided, recommend that areas prone to high current and wind velocity be avoided, where the sweep of the anchor chain on the bottom can cause the greatest damage.
25. To avoid the leaching of contaminates associated with wood preservatives, recommend the use of concrete, non-treated wood or steel dock materials.

Operation and Maintenance of Vessels

Vessel activity in coastal waters is generally proportional to the degree of urbanization and port and harbor development within a particular area. Benthic, shoreline, and pelagic habitats may be disturbed or altered by vessel use, resulting in a cascade of cumulative impacts in heavy traffic areas (Barr 1993). The severity of boating-induced impacts on coastal habitats may depend on the geomorphology of the impacted area (e.g., water depth, width of channel or tidal creek), the current velocity, the sediment composition, the vegetation type and extent of vegetative cover, as well as the type, intensity and timing of boat traffic (Yousef 1974; Karaki and vanHoften 1975; Barr 1993). Recreational boating activity mainly occurs during the warmer months which coincide with increased biological activity in east coast estuaries (Stolpe and Moore 1997; Wilbur and Pentony 1999). Similarly, frequently traveled routes such as those traveled by ferries and other transportation vessels can impact fish spawning, migration, and recruitment behaviors through noise and direct disturbance of the water column (Barr 1993).

Other common impacts of vessel activities include vessel wake generation, anchor chain and propeller scour, vessel groundings, the introduction of invasive or nonnative species, and the discharge of contaminants and debris (Hanson *et al.* 2003).

Impacts to Benthic Habitat

Vessel operation and maintenance activities can have a wide range of impacts to benthic habitat, ranging from minor (e.g., shading of SAV) to potentially large-scale impacts (e.g., ship groundings and fuel or toxic cargo spills). Direct disturbances to bottom habitat can include propeller scouring and vessel wake impacts on SAV and other sensitive benthic habitats and direct contact by groundings, or by resting on the bottom at low tides while moored. Propeller scarring can result in a loss of benthic habitat, decrease productivity, potentially fragment SAV beds, and lead to further erosion and degradation of the habitat (Uhrin and Holmquist 2003). Eriksson *et al.* (2004) found that boating activities can have direct and indirect impacts on SAV, including drag and tear on plant tissues resulting from increased wave-action, reduction in light availability due to elevated turbidity and resuspension of bottom sediments, and altered habitat and substrate that causes plants to be uprooted and can inhibit recruitment. The disturbance of sediments and rooted vegetation decreases habitat suitability for fish and shellfish resources and can effect the spatial distribution and abundance of fauna (Nightingale and Simenstad 2001a; Uhrin and Holmquist 2003; Eriksson *et al.* 2004).

Resuspension of Bottom Sediments/Turbidity

The degree of sediment resuspension and turbidity that is produced in the water column due to vessel activity is complex, but is generally dependent upon the wave energy and surge produced by the vessel, as well as the size of the sediment particles, the water depth, and the number of vessels passing through an area (Karaki and vanHoften 1975; Barr 1993). These activities typically increase turbidity and sedimentation on SAV and other sensitive benthic habitats (Klein 1997; Barr 1993; Nightingale and Simenstad 2001a; Eriksson *et al.* 2004). Studies investigating sedimentation impacts on eelgrass have found that experimental burial of 25 percent of the plant height can result in greater than 50 percent mortality (Mills and Fonseca 2003). Klein (1997) reported that turbidity generated by boats operating in shallow waters can exceed safe levels by up to 34-fold.

The resuspension of sediments can affect habitat suitability for fish and shellfish resources and effect the spatial distribution and abundance of fauna (Nightingale and Simenstad 2001a; Uhrin and Holmquist 2003; Eriksson *et al.* 2004). The egg and larval stages of marine and estuarine fish are generally highly sensitive to suspended sediment exposures (Wilber and Clark 2001), and, juvenile fish may be susceptible to gill injury when suspended sediment levels are high (Klein 1997). Sedimentation and turbidity impacts associated with boating may be more pronounced in areas that contain shallow water habitat where the bottom is composed of fine sediments (Klein 1997).

Shoreline Erosion

Wave energy caused by industrial and recreational shipping and transportation can have substantial impacts on aquatic shoreline and backwater areas which can eventually cause the loss and disturbance of shoreline habitats (Karaki and vanHoften 1975; Barr 1993; Klein 1997). Vessel wakes along frequently traveled routes can cause shoreline erosion, damage aquatic vegetation, disturb substrate, and increase turbidity. Wave energy and surge produced by vessels are dependent upon a number of factors, including the size and configuration of the vessel hull, the size of the vessel, and the speed of the vessel (Karaki and vanHoften 1975; Barr 1993). The degree of erosion on shorelines caused by vessels is complex, but generally dependent upon the wave energy and surge produced by the vessel and the slope of the shoreline, the type of sediment (e.g., clay, sand), and the type and amount of shoreline vegetation, as well as the characteristics of the water body (e.g., water depth and bottom topography) and distance between the vessel and shoreline (Karaki and vanHoften 1975; Barr 1993).

Contaminant Spills and Discharges
A variety of substances can be discharged or accidentally spilled into the aquatic environment, such as gray water (i.e., sink, laundry effluent), raw sewage, engine cooling water, fuel and oil, vessel exhaust, bottom paint sloughing, boat washdown water, and other vessel maintenance and repair activities that may degrade water quality and contaminate bottom sediments (Cardwell *et al.* 1980; Cardwell and Koons 1981; Krone *et al.* 1989; Waite *et al.* 1991; Hall and Anderson 1999; Hanson *et al.* 2003).

Industrial shipping and recreational boating can be sources of heavy metals such as arsenic, cadmium, copper, lead, and mercury (Wilbur and Pentony 1999). Heavy metals are known to have toxic effects on marine organisms. For example, laboratory experiments have shown high mortality of Atlantic herring eggs and larvae at copper concentrations of 30 μg/L and 1,000 μg/L, respectively, and impairment of vertical migration for larvae at copper concentrations greater than 300 μg/L (Blaxter 1977). Copper may also bioaccumulate in bacteria and phytoplankton (Milliken and Lee 1990). Heavy metals may enter the water through various vessel maintenance activities such as bottom washing, paint scraping and application of antifouling paints (Amaral *et al.* 2005). For example, elevated copper concentrations in the vicinity of shipyards have been associated with vessel maintenance operations such as painting and scraping of boat hulls (Milliken and Lee 1990). Studies have shown a positive relationship between the number of recreational boats in a marina and the copper concentrations in the sediments of that marina (Warnken *et al.* 2004). Copper and an organotin, called tributyltin (TBT), are common active ingredients in antifouling paints (Milliken and Lee 1990). The use of TBT is primarily used for large industrial vessels to improve the hydrodynamic properties of ship's hulls and fuel consumption, while recreational vessels typically use copper-based antifouling paints due to restrictions introduced in the Organotin Antifouling Control Act of 1988 (33 U.S.C. 2401), which bans its use on vessels less than 25 m in length (Milliken and Lee 1990; Hofer 1998).

Herbicides are also used in some antifouling paints to inhibit the colonization of algae and the growth of seaweeds on boat hulls and intake pipes (Readman *et al.* 1993). Similar to copper, the highest concentrations of herbicides in nearshore waters are associated with recreational marinas, which may be due to a lower frequency of use for pleasure boats compared to commercial vessels (Readman *et al.* 1993). The leaching of these chemicals into the marine environment could affect community structure and phytoplankton abundance (Readman *et al.* 1993).

Fuel and oil spills can affect animals directly or indirectly through the food chain. Fuel, oil, and some hydraulic fluids contain PAHs which can cause acute and chronic toxicity in marine organisms (Neff 1985). Toxic effects of exposure to PAHs has been identified in finfish at concentrations from 5-50 ppm, and larvae of aquatic species showing toxic effects at concentrations from 0.1 to 1.0 ppm (Milliken and Lee 1990). Small, but chronic oil spills are a potential problem because residual oil can build up in sediments and affect living marine resources. Even though individual releases are small, they are also frequent and when combined they contribute nearly 85 percent of the total input of oil into aquatic habitats from human activities (ASMFC 2004). Incidental fuel spills involving small vessels are probably common events, but these spills typically involve small amounts of material and may not necessarily adversely affect fishery resources. Larger spills may have significant acute adverse affects, but these events are relatively rare and usually involve small geographic areas.

Outboard engines, as opposed to inboard engines that are generally used for larger, commercial vessels, are unique in that their exhaust gases cool rapidly and leave some hydrocarbon components condensed and in the water column rather than being released into the atmosphere (Moore and Stolpe 1995). Outboard engine pollution, particularly from two-cycle engines, can contribute to the concentrations of hydrocarbons in the water column and sediment (Milliken and Lee 1990). Two-cycle outboard engines accomplish fuel intake and exhaust in the same cycle, and tend to release unburned fuel along with the exhaust gases. In addition, two-cycle engines mix lubricant oil with the fuel, so this oil is released into the water along with the unburned fuel. There are over 100 hydrocarbon compounds in gasoline, including additives to improve the efficiency of the fuel combustion (Milliken and Lee 1990). Once discharged into the water, petroleum hydrocarbons may remain suspended in the water column, concentrate on the surface, or settle to the bottom (Milliken and Lee 1990).

Any type of fuel or oil spill has the potential to cause impacts to organisms and habitats in the water column, on the bottom, and on the shoreline, but it is unknown as to what extent these effects are individually or cumulatively significant. Effects on fish from low-level chronic exposure may increase embryo mortality, reduce growth, or alter migratory patterns (Heintz *et al.* 2000; Wertheimer *et al.* 2000). For more details on the impacts of oil or fuel spills, see the section on Energy-Related Activities.

Gray water and sewage discharge from boats may impact water quality by increasing nutrient loading and biological oxygen demand of the local area, and through the release of disease causing organisms and toxic substances (Thom and Shreffler 1996; Klein 1997). Positive correlations between boating activity levels and elevated levels of fecal coliform bacteria in nearshore coastal waters have been reported (Milliken and Lee 1990). Although the Clean Water Act of 1972 makes it illegal to discharge untreated wastes into coastal waters and the Federal Water Pollution Control Act requires recreational boats be equipped with marine sanitation devices (MSD), it is legal to discharge treated wastes and illegal discharges of untreated waste may be common (Milliken and Lee 1990; Amaral *et al.* 2005). Despite these laws, many vessels may not be equipped with MSDs and on-shore pumpout stations are not common (Amaral *et al.* 2005). Impacts from vessel waste discharges may be more pronounced in small, poorly flushed waterways where pollutant concentrations can reach unusually high levels (Klein 1997).

<u>Underwater Noise</u>
The noise generated by vessel operations, which is usually concentrated in ports, marinas and heavily used shipping lanes or routes, may impact fish spawning, migration, and recruitment behaviors (Hildebrand 2004). Exposure to continuous noise may also create a shift in hearing thresholds for marine organisms resulting in hearing losses at certain frequency ranges (Jasny 1999). Reducing vessel noise is a difficult task due to the economic incentives that encourage the

expansion of commercial shipping and the lack of alternatives for efficient global transport of large and high tonnage material (Hildebrand 2004).

Small craft with high-speed engines and propellers (e.g., recreational boats with outboard engines) typically produce higher frequency noise than larger vessels that generate substantial low-frequency noise due to their size and large, slow-speed engines and propellers (Kipple and Gabriele 2004). Their noise study of three size-classes of vessels (i.e., small, 17-30 feet; medium, 50-100 feet; and large, >100 feet) in Glacier Bay, Alaska found that, on average, overall sound levels were higher for the larger vessel categories (Kipple and Gabriele 2004). However, vessel sound levels in this study were generally measured at vessel speeds less than 10 knots, and the investigators found increasing sound levels with greater vessel speed (Kipple and Gabriele 2004). Scholik and Yan (2002) reported significant elevation of the auditory threshold of flathead minnows, *Pimephales promelas*, after exposure to noise from an idling 55 horsepower outboard motor. Furthermore, the frequencies of the noise from the outboard engine corresponded to the frequencies of the fish's auditory threshold shifts, specifically in the species most sensitive hearing range (1.0-2.0 kHz).

Commercial shipping vessels are a major source of low frequency (5-500 Hz) noise in the marine environment and may be one of the most pervasive sources of anthropogenic ocean noise (Jasny 1999; Stocker 2002; Hildebrand 2004). Low frequencies travel long distances in the marine environment, which is probably why these frequencies are also used by marine mammals for communication (Jasny 1999). Ship noise is generated from the use of engines and other on-board mechanical devices such as pumps, cooling systems, and generators, as well as movement of water across the hull and propellers (Stocker 2002; Hildebrand 2004). These sounds are amplified and transferred to the water through the ship's hull (Stocker 2002). The size and frequency of use for commercial vessels traversing the ocean and nearshore waters may explain why they are considered a major source of noise impacts compared to the more numerous fishing and pleasure craft found in coastal waters (Hildebrand 2004).

There are several factors which influence sound attenuation in shallow coastal waters including temperature variations or thermoclines, bottom geography, and sediment composition. Vessel noise may reverberate or scatter off geological features and manmade structures in the water (Stocker 2002).

Sonar is another source of anthropogenic noise attributed to vessel operation. It is used for various purposes such as depth sounding and fish finding and can vary in range depending on the use (15-200 kHz for commercial navigation, 1-20 kHz for other positioning and navigation, and 100-3,000 Hz for long range sonar) (Stocker 2002). Refer to the Global Effects and Other Impacts chapter of this report for more information on ocean noise.

<u>Release of Debris</u>

As discussed in the Operation and Maintenance of Ports and Marinas section of this chapter, the release of solid waste in coastal waters is a considerable concern. Billions of pounds of debris are dumped into the oceans each year (Milliken and Lee 1990), and vessel traffic is a significant source of this waste due to accidental loss, routine practices of dumping waste and illegal dumping activities (Cottingham 1988). Entanglement in or ingestion of this debris can cause fish, marine mammals, and sea birds to become impaired or incapacitated, leading to starvation, drowning, increased vulnerability to predators, and physical wounds (Milliken and Lee 1990). Marine debris can also cause direct physical damage to habitat features through smothering or physical disturbance.

Plastics are an especially persistent form of solid waste. Plastics tend to concentrate along coastal areas because they float on the surface and can be transported by ocean currents (Milliken and Lee 1990). Commercial fishing, merchant vessel, cruise ship, and recreational boats are major contributors to marine plastic debris (Cottingham 1988; Milliken and Lee 1990). Cottingham (1988) estimated that merchant vessels are the primary source of plastic refuse in New England. Refer to the Operation and Maintenance of Ports and Marinas section in this chapter for information on plastic debris, and the Coastal Development chapter of this report for more information on general marine debris.

Abandoned and Derelict Vessels

Derelict or abandoned vessels can cause a variety of impacts to habitats as well as being public health and navigational hazards. Grounded vessels may physically damage and smother benthic habitats, create changes in wave energy and sedimentation patterns, and scatter debris across sensitive habitats (Precht *et al.* 2001; Zelo and Helton 2005). The potential impact footprint of a grounded vessel can be much larger than the vessel itself as vessels move or break up during storm events, which can scour bottom habitat, amplify impacts, and complicate removal (Zelo and Helton 2005). The physical impacts of a grounded vessel can be greater in shallow water since the wreck is more likely to be unstable and move, may break up more rapidly due to wave and current forces, and is more likely to need urgent removal due to navigation concerns which may lead to additional resource impacts (Michel and Helton 2003). Refer to the Offshore Dredging and Disposal chapter of this report for information regarding intentional sinking of vessels for disposal and/or creation of artificial reefs.

The most common environmental threat of a derelict or abandoned vessel is the release of oil or other pollutants. These hazardous materials may be part of a vessel's cargo, fuel and oil related to vessel operations, or from chemicals contained within the vessel's structure which may be released through decay and corrosion over time. Rusting vessel debris can also cause iron enrichment in enclosed areas, which has been associated with harmful algal blooms (Helton and Zelo 2003; Michel and Helton 2003).

The historical focus of laws regarding derelict or abandoned vessels was the protection of the property rights of shipowners and the recovery of cargo (Michel and Helton 2003). Existing federal laws and regulations do not provide clear authority or funding to any single agency for the removal of grounded or abandoned vessels that harm natural resources but which are not otherwise obstructing or threatening to obstruct navigation, or threatening a pollution discharge (Helton and Zelo 2003). In many cases vessels are abandoned and are left to continually damage the marine environment because a responsible party cannot be identified or a funding source for removal cannot be secured (Zelo and Helton 2005). Physical impacts, in particular, can persist for decades when vessels are left in the marine environment and in some cases simply removing a vessel is enough to allow natural recolonization of benthic organisms (Zelo and Helton 2005).

Removal of a derelict vessel will ensure that the vessel does not become a navigation hazard to other ships and that hazardous materials are not released during storms which can damage the wreckage further. It also ensures that abandoned vessel do not become illegal dumpsites for oil, industrial waste and other hazardous materials, including munitions (Helton and Zelo 2003).

Salvage and wreck removal activities can result in unintended habitat impacts. For example, fuel spillage may occur during salvage operations of a wrecked vessel. The potential for collateral impacts should be considered when planning a salvage operation (Michel and Helton 2003). Wrecks in shallow water are often removed and scuttled in deep water to prevent further damage to more vulnerable, nearshore benthic habitats and to avoid the risks involved in bringing an unstable vessel into port (Michel and Helton 2003).

Although many of the habitat impacts described above can be averted if derelict vessels are removed while still afloat, abandoned and neglected floating vessels can also create habitat impacts (Zelo and Helton 2005). These vessels may shade seagrass beds, scour subtrates with anchor chains, or release pollutants from decaying hull materials and paints (Sunda 1994; Negri *et al.* 2002; Smith *et al.* 2003; Zelo and Helton 2005).

Non-Native and Invasive Species

Non-native species, some of which are invasive, have been introduced to coastal areas through industrial shipping and recreational boating (Omori *et al.* 1994; Wilbur and Pentony 1999; Hanson *et al.* 2003; Pertola *et al.* 2006). These introductions can be in the form of fouling organisms on the bottom of vessels as they are transported between water bodies, or through the release of ballast water from large commercial vessels. Modern ships can carry 10 to 200 thousand tons of ballast water at a time and transport marine organisms across long distances and in relatively short time periods (Hofer 1998). This expeditious travel increases the risk that the organisms taken up in ballast water will be viable when introduced into a distant port or marina during deballasting (Wilbur and Pentony 1999). Pertola *et al.* (2006), in an investigation of dinoflagellates and other phytoplankton from the ballast tank sediments of ships at ports in the North-Eastern Baltic Sea, found a large assemblage of germinated dinoflagellate cysts in 90 percent of all ships and at all ports sampled. Ship traffic can transport, in large numbers, non-native and invasive species of phytoplankton that can be harmful to native aquatic species (Pertola *et al.* 2006). The non-native green alga, *Codium fragile*, is an example of a species that has invaded the northeastern U.S. coast, the eastern Atlantic Ocean, Mediterranean Sea, and New Zealand, and has displaced native species of *Codium* (Walker and Kendrick 1998; Tyrell 2005). Shipping has been implicated as the major agent of spread of this species (Walker and Kendrick 1998), as well as the zebra mussel, *Dreissena polymorpha* (Strayer *et al.* 2004). This invasive species has been shown to have had an adverse effect on the populations of some native species of fish (e.g., *Alosa* spp.), as well as phytoplankton, zooplankton, aquatic vegetation, water chemistry, and zoobenthos (Strayer *et al.* 2004).

Introduced species can adversely impact habitat qualities and functions by altering the community structure, competing with native species, and introducing exotic diseases (Omori *et al.* 1994; Wilbur and Pentony 1999; Carlton 2001). Additional discussion of the effects of introduced species can be found in the chapters on Introduced Species, Aquaculture, and Other Biological Threats and Physical Effect: Water Uptake and Discharge Facilities.

Conservation Recommendations and Best Management Practices for Vessel Operation and Maintenance

1. Encourage marinas to participate in NOAA/U.S. EPA’s Coastal Nonpoint Program and the Clean Marina Initiative.
2. Ensure that commercial ships and port facilities have oil-spill response plans in place, which improves response and recovery in the case of accidental spillage.

3. Ensure that commercial ships and or port facilities have adequate oil-spill response equipment accessible and clearly marked.
4. Dispersants that remove oils from the environment should be utilized, rather than dispersants that simply move them from the surface to the ocean bottom.
5. Promote the use of oil-absorbing materials in the bilge areas of all boats with inboard engines.
6. Promote the use of fuel/air separators on air vents or tank stems of inboard fuel tanks to reduce the amount of fuel and oil spilled into surface waters during fueling of boats.
7. Encourage recreational boats be equipped with marine sanitation devices (MSD) to prevent untreated sewage to be pumped overboard.
8. Encourage ship designs that include technologies capable of reducing noise generated and transmitted to the water column, such as the use of muffling devices already required for land-based machinery that may help reduce the impacts of vessel noise.
9. The effects of proposed and existing vessel traffic and associated underwater noise should be assessed for potential impacts to sensitive areas such as migration routes and spawning areas for marine animals.
10. Exclusion of vessels, or specific vessel activities such as high intensity, low-frequency sonar, to known sensitive marine areas may be necessary if evidence indicates that these activities have a substantial adverse effect to marine organisms.
11. Promote education and signage on all vessels to encourage proper disposal of solid debris at sea.
12. Encourage the use of innovative cargo securing and stowing designs that may reduce solid debris in the marine environment from the transportation of commercial cargo.
13. Salvage and removal of grounded vessels should be accomplished using appropriate equipment and techniques, and follow all necessary state and federal laws and regulations. If possible, avoid using the propulsion systems of salvage tugs that can cause propeller wash and scour the bottom. Instead, moor the tugs and use a ground tackle system to provide maneuvering and pull.
14. When a derelict vessel has to be dragged across the seafloor to deep water, consider following the same ingress path, to minimize additional seafloor damage. Alternatively, identify the least sensitive, operationally feasible towpath. Dismantling derelict vessels in place when stranded close to shore may cause less environmental impact than dredging or dragging a vessel across an extensive shallow habitat.
15. When a submerged derelict vessel contains hazardous aqueous solutions that pose limited environmental risks, such as mild acids and bases, it may be appropriate to allow the release of the cargo under controlled conditions rather than risk a sudden release of the entire cargo. The controlled release plan can include water-quality monitoring to validate the calculated dilution rates and plume distance assumptions. All applicable state and federal laws and regulations regarding the release of chemicals into the water should be followed.
16. A contingency plan should be developed for uncontrolled releases during vessel salvage operations. The salvage plan should include a risk assessment to determine the most likely release scenarios and use the best practices of the industry.
17. For non-emergency salvage operations, scheduling of operations should include environmental considerations to minimize potential impacts on natural resources. Environmental considerations include periods when few sensitive species are present, avoidance of critical reproductive periods, and weather patterns that influence the trajectory of potential releases during operations
18. The scuttling site for a derelict vessel should generally be in a deep-water location in Federal or EEZ waters, and should not include any sensitive resources or geological hazards. Ensure that all proposed disposal of vessels in the open ocean adheres to state and federal guidance and

regulations, including section 102(a) of the Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act), and under 40CFR § 229.3 of the U.S. EPA regulations. Refer to the Offshore Dredging and Disposal chapter for information on the intentional disposal of vessels.

Navigation Dredging

Introduction

Channel dredging is a ubiquitous and chronic maintenance activity associated with port and harbor operation and vessel activity (Barr 1987; NEFMC 1998). Navigational dredging occurs in rivers, estuaries, bays and other areas where ports, harbors and marinas are located (Messieh and El-Sabh 1998). The locations of these facilities often coincide with sensitive aquatic habitats that are vital for supporting fishery production (Newell *et al.* 1998).

For the purposes of navigation, dredging can be generally classified as either creating new or expanded waterways with greater profiles, depths, and scope, or maintenance of existing waterways for the purpose of maintaining established profiles, depths, and scope. Although the latter category represents the most common dredging scenario, new construction, or "improvement" dredging as it is sometimes called, has become increasingly common at larger ports and harbors throughout the U.S. Several corresponding factors have likely led to greater need for navigational "improvements" and increases in the operating depths and the sizes of existing ports and harbors, including: 1) increased demand for marine cargo and transportation; 2) expansion of commercial fleets; 3) increased demand for larger capacity commercial and recreational vessels; and 4) increased urbanization and infrastructure development along the coast (Messieh *et al.* 1991; Wilber and Pentony 1999; Nightingale and Simenstad 2001b). In particular, this demand for larger capacity commercial cargo vessels has led to an increased competition among the major coastal ports to provide facilities to accommodate these vessels. Improvement dredging may occur in areas that have not previously been subjected to heavy vessel traffic and dredging activities, such as new commercial marinas or the creation of a new channel or turning basin in an existing port or marina facility. Because improvement dredging is often conducted in areas that have been less affected by previous dredging and vessel activities, the impacts are generally more severe than the impacts associated with regular maintenance dredge activities unless the sediments involved in the maintenance dredging contain high levels of contaminants (Allen and Hardy 1980).

Maintenance dredging is generally required in most navigation channels and port and marina facilities due to the continuous deposition of sediments from freshwater runoff or littoral drift. Navigation channels require maintenance dredging to remove accumulated sediments, typically conducted on a temporal scale of one to ten years (Nightingale and Simenstad 2001b). Alterations in sedimentation patterns of estuaries resulting from increased coastal development and urbanization often increases the sediment influx and the frequency for maintaining existing channels and ports. Dredging for other purposes, such as aggregate mining for sand and gravel, conveyance of flood flows, material for beach nourishment, and removal of contaminated sediments or construction of subtidal confined disposal of contaminated sediments, may be done separately or in conjunction with navigation dredging (Nightingale and Simenstad 2001b). Refer to the Offshore Dredging and Disposal chapter of this report for more information on offshore aggregate mining, and the Coastal Development chapter of this report contains information on the affects of beach nourishment and other coastal development activities.

There is a variety of methods and equipment used in navigation dredging and a detailed explanation and assessment is beyond the scope of this report. However, one can categorize dredging activities as either using hydraulic or mechanical equipment. The type of equipment used for navigation dredging primarily depends on the nature of the sediments to be removed and the type of disposal required. Some of the factors that determine the equipment type used are the characteristics of the material to be dredged, the quantities of material to be dredged, the dredging depth, the distance to the disposal area, physical environmental factors of the dredging and disposal area, the contamination level of sediments, the methods of disposal, the production (i.e., rate of material removed) required, and the availability of the dredge equipment (Nightingale and Simenstad 2001b).

Hydraulic dredging involves the use of water mixed with sediments that forms a slurry, which is pumped through a pipeline onto a barge or a hopper bin for off-site disposal. To increase the productivity of the dredging operation (i.e., maximizing the amount of solid material transported to the disposal site), some of the water in the sediment slurry may be allowed to overflow out of the hopper which can increase the turbidity in the surrounding water column. If the disposal site is relatively close to the dredge site, the slurry may be pumped through a pipeline directly to the disposal site (e.g., beach disposal).

Mechanical dredging typically involves the use of a clamshell dredge, which consists of a bucket of hinged steel that is suspended from a crane. The bucket, with its jaws open, is lowered to the bottom and as it is hoisted up, the jaws close and carry the sediments to the surface. The sediments are then placed in a separate barge for transport to a disposal site. Bucket dredges tend to increase the suspended sediment concentrations compared to hydraulic dredges due to the resuspension created as sediment spills through the tops and sides of the bucket when the bucket contacts the bottom, during withdrawal of the bucket through the water column, and when it breaks the water's surface (Nightingale and Simenstad 2001b). Closed or "environmental" buckets are designed to reduce the sediment spill from the bucket by incorporating modifications such as rubber seals or overlapping plates, and are often used in projects involving contaminated sediments.

The location and method of disposal for dredged material depends on the suitability of the material determined through chemical analyses conducted prior to the dredging project. Generally, sediments determined to be unacceptable for open water disposal are placed in confined disposal facilities or contained aquatic disposal sites and capped with uncontaminated sediments. Sediments that are determined to be uncontaminated may be placed in open-water disposal sites or used for beneficial uses. Beneficial uses are intended to provide environmental or other benefits to the human environment, such as shoreline stabilization and erosion control, habitat restoration/enhancement, beach nourishment, capping contaminated sediments, parks and recreation, agriculture, strip mining reclamation and landfill cover, and construction and industrial uses (Nightingale and Simenstad 2001b). Open water disposal sites can be either predominantly nondispersive (i.e., material is intended to remain at the disposal site) or dispersive (i.e., material is intended to be transported from the disposal site by currents and/or wave action (Nightingale and Simenstad 2001b). The potential for environmental impacts is dependent upon the type of disposal operation used, the physical characteristics of the material, and the hydrodynamics of the disposal site. Refer to the chapter on Offshore Dredging and Disposal for more detailed information on dredge material disposal.

Dredging to deepen or maintain ports, marinas and navigational channels involve a number of environmental effects to fishery habitats, including the direct removal or burial of demersal and benthic organisms and aquatic vegetation, alteration of physical habitat features, the disturbance of bottom sediments (resulting in increased turbidity), contaminant releases in the water column, light attenuation, releases of oxygen consuming substances and nutrients, entrainment of living organisms in dredge equipment, noise disturbances, and the alteration of hydrologic and temperature regimes. Dredging is often accompanied by a significant decrease in the abundance, diversity, and biomass of benthic organisms in the affected area and an overall reduction in the aquatic productivity of the area (Allen and Hardy 1980; Newell *et al.* 1998). The rate of recovery of the benthic community is dependent upon an array of environmental variables which reflect interactions between sediment particle mobility at the sediment-water interface and complex associations of chemical and biological factors operating over long time periods (Newell *et al.* 1998).

Loss or Conversion of Benthic Habitat and Substrate

Alterations in bathymetry, benthic habitat features, and substrate types due to navigational dredging activities may have long-term effects on the functions of estuarine and other aquatic environments. The effects of an individual project is proportional to the scale and time required for a project to be completed, with small-scale and short-term dredging activities having less impact on benthic communities than long-term and large-scale dredging projects (Nightingale and Simenstad 2001b). Dredging can have cumulative effects on benthic communities, depending upon the dredging interval, the scale of the dredging activities, and the ability of the environment to recover from the impacts. The new exposed substrate in a dredged area may be composed of material containing more fine sediments than before the dredging, which can reduce the recolonization and productivity of the benthos and the species that prey upon them.

The impacts to benthic communities vary greatly with the type of sediment, the degree of disturbance to the substrate, the intrinsic rate of reproduction of the species, and the potential for recruitment of adults, juveniles, eggs and larvae (Newell *et al.* 1998). Following a dredging event, sediments may be nearly devoid of benthic infauna and those that are the first to recolonize are typically opportunistic species which may have less nutritional value for consumers (Allen and Hardy 1980; Newell *et al.* 1998).

In general, dredging can be expected to result in a 30 to 70 percent decrease in species diversity and 40 to 95 percent reduction in number of individuals and biomass (Newell *et al.* 1998). Recovery of the benthic community is generally defined as the establishment of a successional community which progresses towards a community that is similar in species composition, population density and biomass to that previously present, or at non-impacted reference sites (Newell *et al.* 1998). The factors which influence the recolonization of disturbed substrates by benthic infauna are complex, but the suitability of the post-dredging sediments for benthic organisms and the availability of adjacent, undisturbed communities which can provide a recruitment source are important (Barr 1987; ICES 1992). Rates of benthic infauna recovery for disturbed habitats may also depend upon the type of habitat being affected and the frequency of natural and anthropogenic disturbances. Benthic infauna recovery rates may be less than one year for some fine-grained mud and clay deposits, where a frequent disturbance regime is common, while gravel and sand substrates, which typically experience more stability, may take many years to recover (Newell *et al.* 1998). Post-dredging recovery in cold waters at high-latitudes may require additional time because these benthic communities can be comprised of large, slow-growing species (Newell *et al.* 1998).

Loss of Submerged Aquatic Vegetation

Submerged aquatic vegetation provides food and shelter for many commercially and recreationally important species, attenuates wave and current energy, and plays an important role in the chemical and physical cycles of coastal habitats (Thayer *et al*. 1997). The loss of vegetated shallows results in a reduction in important rearing and refugia functions utilized by migrating and resident species. Seagrass beds are more difficult to delineate and map compared to some other subtidal habitats due to their spatial and temporal dynamic nature, making these habitats more venerable to being inadvertently dredged (Thayer *et al*. 1997; Deegan and Buchsbaum 2005). Dredging causes both direct and indirect impacts to SAV. The physical removal of plants through dredging is a direct impact, while the reduction in light penetration and burial or smothering that is a result of the turbidity plumes and sedimentation created by the dredge are indirect impacts (Deegan and Buchsbaum 2005). While SAV may regrow in a dredged area if the exposure to excessive suspended sediments are not protracted and the are removed by currents and tides after dredging ceases (Wilber *et al.* 2005), the recolonization by SAV may be limited if the bottom sediments are destabilized or the composition of the bottom sediments are altered (Thayer *et al*. 1997). Even when the area's bottom sediments are stabilized and conducive to SAV growth, channel deepening may result in the area having inadequate light regimes necessary for the recolonization of SAV (Barr 1987).

Dredge and fill operations require a permit review process which is regulated by state and federal agencies. Advancement in understanding the physical impacts of dredging on SAV, and recognition of the ecological significance of these habitats has allowed special consideration for SAV beds during the permit review process. Most reviewing agencies discourage dredging activities in or near SAV beds, as well as in areas that have been historically known to have SAV, and areas that are potential habitats for SAV recruitment (Orth *et al*. 2002).

While the physical disturbance to SAV beds due to dredge activities may have significant localized effects, water quality problems such as eutrophication, pollution and sedimentation have resulted in large-scale declines to SAV in some areas of the northeast U.S. coast (Goldsborough 1997; Deegan and Buchsbaum 2005; Wilber *et al*. 2005). The small, localized disturbance of SAV associated with dredging may be viewed as a significant impact in the context of diminished regional health and distribution due to stressors such as poor water quality and cumulative effects such as dredging, boating (propeller scour), and shoreline alteration (Goldsborough 1997; Thayer *et al*. 1997; Deegan and Buchsbaum 2005).

<u>Loss of Intertidal Habitat and Wetlands</u>
Intertidal habitats and wetland are valuable coastal habitats which support high densities and diversities of biota by supporting biological functions such as breeding, juvenile growth, feeding, predator avoidance, and migration (Nightingale and Simenstad 2001b). These valuable habitats are also some of the most vulnerable to alterations through coastal development, urbanization and the expansion of ports and marinas.

The loss of intertidal habitat and the deepening of subtidal habitat during dredging for marina development and for navigation can alter or eliminate the plant and animal assemblages associated with these habitats (Nightingale and Simenstad 2001b). Dredging in intertidal habitats can alter the tidal flow, currents, and tidal mixing regimes of the dredged area as well as other aquatic habitats in the vicinity, leading to changes in the environmental parameters necessary for successful nursery habitats (Barr 1987). Dredging in tidal wetlands can also encourage the spread of non-native invasive organisms by removing or disturbing the native biota and altering the physical and chemical properties of the habitat (Hanson *et al.* 2003; Tyrell 2005).

Navigational dredging converts shallow subtidal or intertidal habitats into deeper water environments through the removal of sediments (Nightingale and Simenstad 2001b, Deegan and Buchsbaum 2005). The historical use of dredged materials was to infill wetland, salt marshes and tidal flats in order to create more usable land. The Boston Harbor, Massachusetts area is a prime example of this historical trend, where thousands of acres of salt marsh and intertidal wetlands have been filled over time (Deegan and Buchsbaum 2005). Filling wetlands eliminates the biological, chemical and physical functions of intertidal habitat such as flood control, nutrient filter or sink, and nursery habitat. Although direct dredging and filling within intertidal wetlands is relatively rare in recent times, the lost functions and values of intertidal wetlands and the connectivity between upland and subtidal habitat is difficult and costly to create and restore (Nightingale and Simenstad 2001b).

Underwater Noise

Fish can detect and respond to sounds for many life history requirements, including locating prey and avoiding predation, spawning and various social interactions (Myrberg 1972; Myrberg and Riggio 1985; Kalmijn 1988). The noise generated by pumps, cranes, and by the mechanical action of the dredge itself has the ability to alter the natural behavior of fish and other aquatic organisms. Feist *et al.* (1996) reported that pile-driving operations had an affect on the distribution and behavior of juvenile pink and chum salmon. Fish may leave an area for more suitable spawning grounds or may avoid a natural migration path due to noise disturbances.

The noise levels and frequencies produced from dredging depend on the type of dredging equipment being used, the depth and thermal variations in the surrounding water, and the topography and composition of the surrounding sea floor (Nightingale and Simenstad 2001b; Stocker 2002). However, dredging activities from both mechanical and hydraulic dredges produce underwater sounds that are strongest at low frequencies and because of rapid attenuation of low frequencies in shallow water, dredge noise normally is undetectable underwater at ranges beyond 20-25 km (Richardson *et al.* 1995). Although the noise levels from large ships may exceed those from dredging, single ships usually do not produce strong noise in one area for a prolonged period of time (Richardson *et al.* 1995). The noise created during dredging can produce continuous noise impacts for extended periods of time (Nightingale and Simenstad 2001b).

Siltation/Sedimentation/Turbidity

Dredging degrades habitat quality through the resuspension of sediments which creates turbid conditions and can release contaminants into the water column, in addition to impacting benthic organism and habitat through sedimentation. Alterations in bottom sediments, bottom topography, and altered circulation and sedimentation patterns related to dredge activities can lead to shoaling and sediment deposition on benthic resources such as spawning grounds, SAV, and shellfish beds (Wilber *et al*. 2005). Early life history stages (eggs, larvae, and juveniles) and sessile organisms are the most sensitive to sedimentation impacts (Barr 1987; Wilber *et al*. 2005). Some estuarine and coastal habitats are prone to natural sediment loads and sediment resuspension due to the relatively dynamic nature of the ecosystems; therefore, most organisms adapted to these environments have tolerance to some level of suspended sediments and sedimentation (Nightingale and Simenstad 2001b).

The reconfiguration of sediment type and the removal of biogenic structure during dredging may decrease the stability of the bottom and increase the ambient turbidity levels (Messieh *et al.* 1991). This increased turbidity and sedimentation can reduce the light penetration of the water column which, in turn, can adversely affect SAV and reduce primary productivity (Cloern 1987; Dennison 1987; Wilbur and Pentony 1999; Mills and Fonseca 2003; Wilbur *et al.* 2005). The combination of decreased photosynthesis and the interaction of the suspended material with dissolved oxygen in the water may result in short-term oxygen depletion (Nightingale and Simenstad 2001b).

If suspended sediment loads remain high, fish may experience respiratory distress and reduced feeding ability due to sight limitations, while filter feeders may suffer a reduction in growth and survival (Messieh *et al.*1991; Barr 1993; Benfield and Minello 1996; Nightingale and Simenstad 2001b). Prolonged exposure to suspended sediments can cause gill irritation, increased mucus production, and decreased oxygen transfer in fish (Nightingale and Simenstad 2001b; Wilber *et al*. 2005). Reduced dissolved oxygen concentrations and increased water temperatures may be cumulative stressors that exacerbate the effects of respiratory distress on fish from extended exposure to suspended sediments (Nightingale and Simenstad 2001b). In addition, mobile species may leave an area for more suitable feeding or spawning grounds, or avoid migration paths due to turbidity plumes created during navigational dredging.

Increased turbidity and sedimentation may also bury benthic organisms and demersal fish eggs. The depth of burial and the density of the substrate may limit the natural escape response of some organisms that are capable of migrating vertically through the substrate (Barr 1987; Wilber *et al*. 2005). In addition, anoxic conditions in the disturbed sediments may decrease the ability of benthic organisms to escape burial (Barr 1987). Short-term burial, where sediment deposits are promptly removed by tides or storm events, may have minimal effects on some species (Wilber *et al*. 2005). However, even thin layers of fine sediment have been documented to decrease gas exchange in fish eggs and adversely affect the settlement and recruitment of bivalve larvae (Wilber *et al*. 2005). An in-situ experiment with winter flounder eggs exposed to sediment deposition from a navigational dredging project found a slightly lower larval survival rate compared to control sites, but the differences were not statistically significant (Klein-MacPhee *et al.* 2004). However, the viability of the larvae in this experiment was not monitored beyond burial escapement. Similarly, laboratory experiments with winter flounder eggs buried to various depths (i.e., control, < 0.5 mm, and up to 2 mm) indicated a decreased hatch success and delayed hatch with increasing depth; but differences were not statistically significant (Berry *et al.* 2004). The same study also exposed winter flounder eggs to both clean, fine-grained sediment and highly contaminated, fine-grained sediment at various depths from 0.5 mm to 6 mm. The investigators found that eggs buried to depths of 4 mm with clean sediments did not hatch, while eggs buried to depth of 3 mm with contaminated sediments had little or no hatching success (Berry *et al.* 2004). Although there are clearly adverse effects to sessile benthic organisms and life stages due to sedimentation from dredging activities, additional investigations are needed to assess lethal and sublethal thresholds for more species and under different sediment types and quality. In addition, better understanding on the relationship between natural and anthropogenic sources of suspended sediments and population-level effects are needed.

The use of certain types of dredging equipment can result in greatly elevated levels of fine-grained particles in the water column. Mechanical dredging techniques such as clam shell or bucket dredges usually increase suspended sediments more than hydraulic dredge techniques such as hopper or cutterheads, unless the sediment and water mixture (slurry) removed during hydraulic dredging are allowed to overflow from the barge or hopper and into the water column, a technique often used to reduce the number of barge trips required (Wilber and Clarke 2001). Mechanical dredges are most commonly used for smaller projects or in locations requiring maneuverability such as close proximity to docks and piers, or in rocky sediments (Wilber *et al.* 2005), although small hydraulic dredges can be used to minimize suspended sediment impacts on adjacent benthic habitats such as SAV or shellfish beds.

Seasonal or time-of-year (TOY) restrictions to dredging activities are used to constrain the detrimental affects of dredging to a timeframe that minimizes impacts during sensitive periods in the life history of organisms, such as spawning, egg development and migration (Nightingale and Simenstad 2001b; Wilber *et al*. 2005). Segregating dredging impacts by life history stages provides a means for evaluating how different impacts relate to specific organisms and life history strategies (Nightingale and Simenstad 2001b). The application of TOY restrictions should be based upon the geographic location, species and life history stages present, and the nature and scope of the dredging project. Because the employment of TOY restrictions may have some negative effects, such as extending the overall length of time required for dredging and disposal, increasing the impacts on less economically valuable or poorly studied species, and increasing the economic costs of a project, the benefits of TOY restrictions should be evaluated for each individual dredging project (Wilber *et al*. 2005; Nightingale and Simenstad 2001b).

Contaminate Release and Source Exposure

Contaminated sediments are a concern due to the risk of transport of the contaminants and the exposure to aquatic organism and humans through bioaccumulation and biomagnification (Nightingale and Simenstad 2001b). Navigation dredging can create deep channels where currents are reduced and fine sediments may be trapped. Nutrients and contaminants can bind to fine particles such as those that may settle in these deep channels (Newell *et al.* 1998, Messiah *et al.* 1991). Dredging and disposal causes resuspension of the sediments into the water column and the contaminants that may be associated with the sediment particles. The disturbance of bottom sediments during dredging can release heavy metals (e.g., lead, zinc, mercury, cadmium, copper), hydrocarbons (e.g., PAHs), hydrophobic organics (e.g., dioxins), pesticides, pathogens, and nutrients into the water column and allow these substances to become biologically available either in the water column or through trophic transfer (Wilbur and Pentony 1999; USEPA 2000; Nightingale and Simenstad 2001b). The resuspension of contaminated sediments can be reduced by avoiding dredging in areas containing fine sediments. For additional information regarding the affects of contaminants associated with resuspended sediments, refer to the chapter on Chemical Affects: Water Uptake and Discharge Facilities in this report.

Release of Nutrients/Eutrophication

Dredging can degrade water quality through resuspension of sediments and the release of nutrients and other contaminants into the water column. Nutrients and contaminates may adhere to these fine particles (Newell *et al.* 1998; Messieh *et al*. 1991). The resuspension of this material creates turbid conditions and decreases photosynthesis. The combination of decreased photosynthesis and the release of organic material with high biological oxygen demand can result in short-term oxygen depletion to aquatic resources (Nightingale and Simenstad 2001b). Long-term anoxia can occur if highly organic sediments are dredged or discharged into estuaries, particularly in enclosed or confined bodies of water. The loss of SAV is linked to poor water quality from increased turbidity and nutrient loading (Deegan and Buchsbaum 2005; Wilber *et al.* 2005).

Entrainment and Impingement

Entrainment is the direct uptake of aquatic organisms by the suction field created by hydraulic dredges. Benthic infauna are particularly vulnerable to entrainment by dredging, although some mobile epibenthic and demersal species such as shrimp, crabs, and fish can be susceptible to entrainment as well (Nightingale and Simenstad 2001b). Elicit avoidance responses to suction dredge entrainment has been reported for some demersal and pelagic mobile species (Larson and Moehl 1990; McGraw and Armstrong 1990). The susceptibility to entrainment for some pelagic species may be related to the degree of waterway constriction in the area of the dredging, which makes it more difficult for fish to avoid the dredge operation (Larson and Moehl 1990; McGraw and Armstrong 1990).

Altered Tidal, Current and Hydrologic Regimes

Large channel deepening projects can potentially alter ecological relationships through a change in freshwater inflow, tidal circulation, estuarine flushing, and freshwater and saltwater mixing (Nightingale and Simenstad 2001b). Dredging may also modify longshore current patterns by altering the direction or velocity of water flow from adjacent estuaries. These changes in water circulation are often accompanied by changes in the transport of sediments and siltation rates resulting in alteration of local habitats used for spawning and feeding (Messieh *et al.* 1991).

Altered circulation patterns around dredged areas can also lead to changes in sediment composition and deposition, and the stability of the seabed. The deep channels created during navigational dredging may experience reduced current flow that allows the area to become a sink for fine particles as they settle out of the water column or slump from the channel walls (Newell *et al.* 1998). In some cases this may change the sediment composition from sand or shell substrate to a substrate consisting of fine particles which flocculate easily and are subject to resuspension by waves and currents (Messieh *et al.* 1991). This destabilization of the seabed can lead to changes in sedimentation rates and a reduction in benthic resources, such as shellfish beds and SAV (Wilber *et al*. 2005). In addition, changes in substrate type can smother demersal eggs, affect larval settlement, and increase predation on juveniles adapted to more coarse bottoms (Messieh *et al*. 1991; Wilber *et al.* 2005).

Navigational dredging can remove natural benthic habitat features, such as shoals, sand bars and other natural sediment deposits. The removal of such features can alter the water depth, change current direction or velocity, modify sedimentation patterns, alter wave action and create bottom scour or shoreline erosion (Barr 1987). Channel dredging can alter the estuarine hydrology and the mixing zone between fresh and salt water, leading to accelerated upland run-off, lowered freshwater aquifers, and greater saltwater intrusion into aquifers, as well as reduce the buffering capabilities of wetlands and shallow water habitats (Barr 1987; Nightingale and Simenstad 2001b).

Navigational channels that are substantially deeper than surrounding areas can become anoxic or hypoxic as natural mixing is decreased and detrital material settles out of the water column and accumulates in the channels. This concentration of anoxic or hypoxic water can stress nearshore biota when mixing occurs due to a storm event (Allen and Hardy 1980). The potential for anoxic conditions can be reduced in areas that experience strong currents or wave energy, and sediments are more mobile (Barr 1987; Newell *et al*. 1998).

Altered Temperature regimes

Channel and port dredging can alter bottom topography, increase water depths, and change circulation patterns in the dredged area, which may increase stratification of the water column and reduce vertical mixing. This thermal layering of water may create anoxic or hypoxic conditions for benthic habitats. Deepened or new navigation channels may create deep and poorly flushed areas that experience reduced light penetration and water temperatures. Temperature influences biochemical processes and deep channels may create zones of poor productivity that can serve as barriers to migration for benthic and demersal species and effectively fragment estuarine habitats.

Best Management Practices and Best Management Practices for Navigational Dredging

1. Avoid new dredging to the maximum extent practicable. Activities that would likely require dredging (such as placement of piers, docks, marinas, etc.) should, instead, be located in deep water or designed to alleviate the need for maintenance dredging.
2. Reduce the area and volume of material to be dredged to the maximum extent practicable.
3. Ensure that the volumes of dredge material are appropriately considered and that the identified disposal sites are adequate in containing the material. For example, the volume of material removed for the allowable over-depth dredging (usually 2-feet below the authorized or target depth) should be included in the disposal volume calculations.
4. Ensure that areas proposed for dredging are necessary in order to maintain the necessary and authorized target depths of the channel. Recent bathymetric surveys should be reviewed to evaluate the existing depths of the area proposed for dredging. Areas within the proposed dredge area that are at or deeper than the target depths should be avoided, whenever practicable.
5. Identify sources of erosion in the watershed that may be contributing to excessive sedimentation and the need for regular maintenance dredging activities. Implement appropriate management techniques to ensure that actions are taken to curtail those causes.
6. Settling basins that act as sediment traps may be used to prevent accretion of sediments in the navigational channel. This reduces the need for frequent maintenance dredging of the entire channel.
7. The effects of increased boat traffic to an area should be considered when considering a new dredging project or expanding existing channels. Increases in the speed, size and density boat traffic in an area may require increased frequency of maintenance dredging and produce a number of secondary impacts, such as shoreline erosion, sedimentation, and turbidity.
8. The identification of a user group during the planning process will ensure that the dredging project meets the basic needs of the target user without exceeding an appropriate size and scope, or encouraging inappropriate use.
9. Consider time-of-year dredging restrictions, which may reduce or avoid impacts to sensitive life history stages, such as migration, spawning, or egg and young-of-year development. Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
10. Projects that involve dredging intertidal and wetland habitat should be avoided.
11. Dredging should be avoided in areas with submerged aquatic vegetation (SAV), areas which historically supported SAV, and areas which are potential habitat for recolonization by SAV.
12. Due to the spatial and temporal dynamic nature of SAV beds, both historic surveys of the area and pre-dredge surveys should be conducted.
13. Dredging in areas supporting shellfish beds should be avoided.
14. When practicable and feasible, consider beneficial uses for uncontaminated sediments. Priority should be given to beneficial uses of material that contributes to habitat restoration and enhancement, landscape ecology approach, and includes pre- and post-disposal surveys.
15. Avoid beneficial use projects that impose unnatural habitats and features and involve habitat trade-offs (substituting one habitat type for another).

16. Insure that sediments are tested for contaminants and meet or exceed U.S. EPA requirements and standards prior to dredging and disposal.
17. Cumulative impacts should be assessed for current activities in the vicinity of a proposed dredging project, as well as for activities in the past and foreseeable future.
18. Ensure that bankward slopes of the dredged area are slanted to acceptable side slopes (e.g., 3:1 ratio) to ensure that sloughing of the channel side slopes does not occur.
19. Avoid placing pipelines and accessory equipment used in conjunction with dredging operations close to algae beds, eelgrass beds, estuarine/salt marshes, and other high value habitat areas.
20. Silt curtains may be used in some locations to reduce impacts of suspended sediments on adjacent benthic resources.
21. Dredging in fine sediments should be avoided when possible to reduce turbidity plumes and the release of nutrients and contaminates which may bind to fine particles.
22. Environmental assessments for dredging projects should include information on control sites and pre-dredging sampling for comparison and monitoring of impacts.

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OFFSHORE DREDGING AND DISPOSAL ACTIVITIES

Introduction

The following section describes activities associated with offshore dredging and disposal and their potential effects on living marine resources and habitats in the Northeast region of the U.S. For purposes of this discussion, the "offshore" environment is defined as those waters and seabed areas considered to be "estuarine" environments and extending offshore to and occasionally beyond the edge of the continental shelf. While the open waters of Chesapeake Bay and Long Island Sound are considered offshore for this discussion, the coves and embayments within those waters bodies are not. Conversely, Raritan Bay (lower New York Harbor) and similar areas are considered offshore environments. Dredging and disposal activities within riverine habitats have been discussed in the Alteration of Freshwater Systems chapter of this report, and information on dredging within navigation channels can be reviewed in the Marine Transportation chapter of this report.

Offshore Mineral Mining

Introduction

There is an increasing demand for beach nourishment sand and a smaller, but growing, demand for construction and "stable fill" grade aggregates. As the historic landside sources of these materials have been reduced there has been a corresponding move towards mining the continental shelf to meet this demand. It is expected that the shift to offshore mineral extraction will continue and escalate, particularly in areas where glacial movements have relocated the desired material to the continental shelf. Typically, these deposits are not contaminated due to their offshore location and isolation from anthropogenic pollution sources. Beginning in the mid-1970s, the U.S. Geological Service began mapping the nature and extent of the aggregate resources in coastal and nearshore continental shelf waters throughout the northeast beyond the 10-m isobath. Between 1995 and 2005, the Minerals Management Service (MMS), which oversees offshore mineral extractions, regulated the relocation of over 23 million cubic yards of sand from the Outer Continental Shelf (OCS) for 16 sacrificial beach nourishment projects (MMS 2005a). The OCS is defined as an area between the seaward extent of the State's jurisdiction and the seaward extent of Federal jurisdiction. Currently the MMS, in partnership with 14 coastal States, is focusing on collecting and analyzing geologic and environmental information in the OCS in order to study sand deposits suitable for beach nourishment and wetlands protection projects, and to assess the environmental impacts of OCS mining in general (Drucker *et al.* 2004). With the advances in marine mining and "at sea" processing, aggregate extraction can occur in waters in excess of 40 m **(**MMS 2005a**)**.

Mineral extraction is usually conducted with hydraulic dredges by vacuuming or, in some cases, by mechanical dredging with clamshell buckets in shallow water mining sites. Mechanical dredges can have a more severe but localized impact on the seabed and benthic biota, whereas hydraulic dredges may result in less intense but more widespread impact (Pearce 1994). The impacts of offshore mineral mining on living marine resources and their habitats include: 1) the removal of substrates that serve as habitat for fish and invertebrates; 2) creation of (or conversion to) less productive or uninhabitable sites such as anoxic depressions or highly hydrated clay/silt substrates; 3) release of harmful or toxic materials either in association with actual mining, or from incidental or accidental releases from machinery and materials used for mining; 4) burial of productive habitats during beach nourishment or other shoreline stabilization activities; 5) creation of harmful suspended sediment levels; and 6) adverse modification of hydrologic conditions causing alteration of desirable habitats (Pearce 1994; Wilber *et al.* 2003).

In addition, mineral extraction can potentially have secondary and indirect adverse effects on fishery habitat at the mining site and surrounding areas. These impacts can include accidental discharge of mining gear and wastes, and structures built within habitats to assist in mining, processing and transporting materials can eliminate or degrade benthic habitat. These secondary effects can sometimes exceed the initial, direct consequences of the offshore mining (Pearce 1994).

Loss of Benthic Habitat Types

Offshore benthic habitats occurring on or over target aggregates may be adversely affected by mining. The mineral extraction process can disrupt or eliminate existing biological communities within the mining, or borrow, areas for several years following the excavation. Infill of the burrow areas and re-establishment of a stable sediment structure is dependent upon the ability of bottom currents to transport similar sediments from surrounding areas to the mining site (ICES 1992). The principal concern noted by the International Council for the Exploration of the Sea Working Group on the Effects of Extraction of Marine Sediments on Fisheries was dredging in spawning areas of commercial fish species (ICES 1992). Of particular concern to the ICES Working Group are fishery resources with demersal eggs (e.g., Atlantic herring and sand lance). They report that when aggregates are removed, Atlantic herring eggs are taken with them and lost to the stock. Stewart and Arnold (1994) list the impacts on Atlantic herring from offshore mining to include the entrainment of eggs, larvae, and adults, burial of eggs, and effects of the turbidity plume on demersal egg masses. Gravel and coarse sand have been identified as preferred substrate for Atlantic herring eggs on Georges Bank and in coastal waters of the Gulf of Maine (Stevenson and Scott 2005).

Conversion of Substrate/Habitat and Changes in Community Structure

Disposal of residues ("tailings") of the mining process can alter the type, as well as the functions and values, of habitats which can in turn alter the survival and growth of marine organisms. The tailings are often fine-grained and highly hydrated, making them very dissimilar to the natural seafloor, particular in depths where wave energy and currents are capable of winnowing or sorting sediments and relocating them to depositional areas. It has been found that wave forces are affecting habitats in the New York Bight at depths in excess of 22 m (USACE 2005b). In laboratory experiments, benthic dwelling flatfishes (Johnson *et al.* 1998a) and crabs (Johnson *et al.* 1998b) persistently avoided sediments comprised of mine tailings.

Additionally, there can be adverse impacts of aggregate/mineral mining on nearby habitats associated with the removal and disturbance of substrate (Scarrat 1987). Seabed alteration can fragment habitat, reduce habitat availability and disrupt predator/prey interactions, resulting in negative impacts to fish and shellfish populations.

Long-term mining can alter the habitat to such a degree that recovery may be extremely protracted and create habitat of limited value to benthic communities during the entire recovery period (Van Dalfsen *et al.* 2000). For example, construction grade aggregate removal in Long Island Sound, Raritan Bay (lower New York Harbor) and the New Jersey portion of the intercoastal waterway have left borrow pits that are more than twice the depth of the surrounding area. The pits have remained chemically, physically and biologically unstable with limited diversity communities for more than five decades. These pits were used to provide fill material for interstate transportation projects, and have been investigated to assess their environmental impact (Pacheco 1984). Borrow pits in Raritan Bay were found to possess depressed benthic communities and elevated levels of highly hydrated and organically enriched sediments (Pacheco 1984). In one example, aggregate mining operations during the 1950s through the 1970s created a 20-m deep borrow pit in an area of Raritan Bay that, although the mining company was required to refill the pit, remains today as a rapid deposition area filling with fine-grained sediment and organic material emanating from the Hudson River and adjacent continental shelf (Pacheco 1984). The highly hydrated sediments filling the depressions are of limited utility to colonizing benthic organisms (Pacheco 1984).

In offshore mining operation sites the character of the sediment which is exposed, or subsequently accumulates, at the extraction site is important in predicting the composition of the colonizing benthic community (ICES 1992). If the composition and topography of the extraction site resembles that which originally existed, then colonization of it by the same benthic fauna is likely (ICES 1992).

Changes in Sediment Composition

A review of studies conducted in Europe and Great Britain found that infilling and subsequent benthic recovery of borrow areas may take from one to 15 years, depending upon the tide and current strength, sediment characteristics, the stock of colonizing species and their immigration distance (ICES 1992). Typically the re-establishment of the community appears to follow a successional process similar to those on abandoned farmlands. The process has been described by Germano, Rhoads and Lunz (1994). They report that pioneering species (i.e., stage I colonizers) usually do not select any particular habitat, but attempt to survive regardless of where they settle. These species are typically filter feeders relying on the availability of food in the overlying water rather than the seafloor on which they reside. Thus, their relationship to the substrate is somewhat tenuous and their presence is often ephemeral. However, their presence tends to provide some stability to the seafloor, facilitating subsequent immigrations by other species that bioturbate the sediment seeking food and shelter. Their arrival induces further substrate consolidation and compaction. These colonizers are usually deemed to be stage II species. The habitat modification activities of stage I and II species advance substrate stability and consolidation enough for it to support, both physically and nutritionally, the largest community members (i.e., stage III). If environmental stresses are chronic, the expected climax community may never be attained (Germano, Rhoads and Lunz 1994). However, it is this same benthic community instability that gives rise to one of the principal justifications for retaining benthic disturbances; i.e., that the disruption site may become heavily populated by opportunistic (stage I) colonizer species that flourish briefly and provide motile species with an abundance of food during late summer and fall periods (Kenny and Rees 1996).

If the borrow area fails to refill with sediment similar to that which was present prior to mining, the disturbed area may not possess the original physical and chemical conditions and recovery of the community structure may be restricted or fail to become re-established. Dredge pits that have been excavated to depths much greater than the surrounding bottom often have very slow infill rates and can be a sink for sediments finer than those of the surrounding substrate (ICES 1992).

Changes in Bottom Topography and Hydrology

The combination of rapid deposition, anomalous sediment character, and an uneven topography, as compared to the surrounding seafloor, limit recolonization opportunities for harvesting purposes (Wilk and Barr 1994). By altering bottom topography, aggregate mining can reduce localized current strength, resulting in lowered dissolved oxygen concentrations and increased accumulation of fine sediments inside the burrow pits (ICES 1992). One potential benefit of some borrow pits is that they appear to provide refugia for pelagic species such as alewife and scup, as well as demersal species such as tautog and black sea bass during seasonally fluctuating water temperatures (Pacheco 1984). However, it is doubtful these benefits outweigh the persistent adverse affects associated with borrow pits (Palermo *et al.* 1998; Burlas *et al.* 2001). Other consequences of aggregate mining may include alteration of wave and tidal current patterns which could affect coastal erosion (ICES 1992).

Siltation, Sedimentation and Turbidity

Offshore mining can increase the suspended sediment load in the water column, increasing turbidity that can, in turn, adversely affect marine organisms, particularly less motile organisms such as shellfish, sponges, and sea anemones. The duration of the turbidity plume in the water column depends upon the water temperature, salinity, current speed, and the size range of the suspended particles (ICES 1992). And the distance the dredged material is transported from the excavation site will be dependent upon the current strength, storm resuspension, water salinity and temperature, and the grain size of the suspended material (ICES 1992).

The life stages of the affected taxa are an important factor affecting the type and extent of the adverse impacts (Wilber and Clarke 2001). As a general rule, the severity of sedimentation and turbidity effects tends to be greatest for early life stages and for adults of some highly sensitive species (Newcombe and Jensen 1996; Wilber and Clarke 2001). In particular, the eggs and larvae of nonsalmonid estuarine fishes exhibit some of the most sensitive responses to suspended sediment exposures of all the taxa and life history stages for which data are available (Wilber and Clarke 2001). Stewart and Arnold (1994) list the impacts on Atlantic herring from offshore mining to include the effects of the turbidity plume on demersal egg masses.

Impacts to Water Quality

The release of material into the water column during offshore mining operations can degrade water quality if the excavated material is high in organic content or clay. The effects of mixing on the water column are likely to include increased consumption of oxygen by decomposing organic matter and the release of nutrients (ICES 1992). However, mined aggregate material is typically low in organic content and clay and any increase in the biological oxygen demand is thought to be minor and of limited spatial extent (ICES 1992).

Deep borrow pits can become anaerobic during certain times of the year. The dissolved oxygen concentration within these pits can be depressed to a level that adversely affects the ability of fish and invertebrates to utilize the area for spawning, feeding and development (Pacheco 1984).

Release of Contaminants

In general, sand and gravel material extracted in the aggregate mining industry is low in contaminants (ICES 1992; Pearce 1994). These materials are typically “clean” sand and gravel and because of their relatively large particle size, low surface area relative to total bulk, and low surface activity (i.e., low clay or organic materials to interact chemically), there is usually little chemical interaction in the water column (Pearce 1994). However, extraction of material in estuaries or deep channels, where fine material accumulates and is subject to anthropogenic pollution deposition, may release harmful chemicals during dredging and excavation (Pearce 1994).

Sediment Transport from Site

Excavation at an offshore mining site that contains fine material can release suspended sediments into the water column during the excavation, as well as in the sorting or screening process. The distance the dredged material is transported from the excavation site will be dependent upon the current strength, storm resuspension, water salinity and temperature, and the grain size of the suspended material (ICES 1992). Some of the potential effects of redeposition of fines include smothering of demersal fish eggs on spawning grounds and the suffocation of filter-feeding benthos, such as shellfish and anemones (ICES 1992; Pearce 1994).

Noise Impacts

Anthropogenic sources of ocean noise appear to have increased over the past decades, and have been primarily attributed to commercial shipping, offshore gas and oil exploration and drilling, and naval and other sues of sonar (Hildebrand 2004). Offshore mineral mining likely contributes to the overall range of anthropogenic ocean noise, but little information exists regarding specific effects on marine organisms and their habitats, or the importance of offshore mining relative to other sources of anthropogenic noise. The dredging equipment noise generated in offshore mining may be similar to navigation channel dredging in nearshore habitats; however, because of the greater water depths involved in offshore mining, the noise may be propagated for greater distances than in nearshore areas (Hildebrand 2004). Reductions in Atlantic herring catches on the Finnish coast were hypothesized to be due to disturbance to the herring movement patterns by noise and activity associated with sand and gravel mining activities (Stewart and Arnold 1994). Refer to the chapters on Global Affects and Other Impacts and Marine Transportation for additional information on noise impacts.

Conservation Measures and Best Management Practices for Offshore Mineral Mining

1. Avoid mining in areas containing sensitive or unique marine benthic habitats (e.g., spawning and feeding sites, surface deposits of cobble/gravel substrate).
2. Complete a comprehensive characterization of the borrow site and its resources prior to permit completion. Some of the components of a thorough assessment include:
   a. Determine the optimum dimensions of the sand mining pits/areas (e.g., small and deep areas or wide and less deep areas) in terms of minimizing the effects on resources and mining costs.
   b. Prioritize the optimal locations of sand mining in terms of effects on resources and the mining costs.
   c. Assess the sand infill rates of mining pits/areas after completion.
   d. Assess the sediment migration patterns and rates as well as the side slope and adjacent natural seabed stability of the mining pit/areas after completion.
   e. Model and estimate the effect of massive and/or long-term sand mining on the surrounding seabed, shoreface (i.e., inner continental shelf) sand budgets and resources.
   f. Assess the effect of removal (by dredging) of offshore sand banks/shoals on the surrounding natural seabed, adjacent shoreline and the resources that use those habitats.
   g. Assess the effect of massive and/or long-term sand mining on the ecological structure of the seabed.
3. Use site characterization and appropriate modeling to determine the areal extent and depth of extraction that affords expedited and/or complete recovery and re-colonization times.
4. Employ sediment dispersion models to characterize sediment resuspension and dispersion during mining operations. Use model outputs to design mining operations, including "at sea" processing, to limit impacts of suspended sediment and turbidity on fishery resources and minimize the area affected.
5. Require appropriate monitoring to avoid and minimize individual and cumulative impacts of the mining operations.

6. Seasonal restrictions should be used, when appropriate, for avoiding temporary impacts to habitat during species critical life history stages (e.g., spawning, and egg, embryo, and juvenile development). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements. Resource managers should incorporate adequate time for habitat recovery of affected functions and values, to levels required by managed species.

Petroleum Extraction

Introduction

After some intense but unsuccessful petroleum exploration on the northeastern U.S. continental shelf, the attention for commercial quantities of oil and gas have been directed elsewhere. Georges Bank and the continental shelf off New Jersey were thought to contain significant reserves of natural gas and several exploratory wells were drilled to locate and characterize those reserves in the late 1980s and early 1990s. At that time, few commercially viable reserves were found and the focus of petroleum exploration has shifted to other regions. However, this could change in the future considering the escalating market prices and dwindling supplies of petroleum. Should renewed interest in offshore petroleum exploration and extraction in the Northeast region occur, existing regulatory guidance on petroleum exploration and extraction, as well any recent research and development efforts, should be employed to insure that marine resource impacts can be avoided, minimized and compensated for these types of activity.

Petroleum extraction has impacts similar to mineral mining but, usually, with significantly less of an impact footprint (excluding spills). However, there is more risk and occurrence of adverse impacts associated with equipment operation, process related wastes and handling of byproducts (e.g., drill cuttings and spent drilling mud) which can disrupt and destroy pelagic and benthic habitats (Malins 1977**;** Wilk and Barr 1994). Potential releases of oil and petroleum byproducts into the marine environment may also occur as a result of production well blow-outs and spills.

Drilling muds are used to provide pressure and lubrication for the drill bit and to carry drill cuttings (crushed rock produced by the drill bit) back to the surface. Drilling muds and their additives are complex and variable mixtures of fluids, fine-grained solids, and chemicals (MMS 2005b). Some of the possible impacts associated with petroleum extraction include the dispersion of soluble and colloidal pollutants, as well as the alteration of turbidity levels and benthic substrates. Many of these impacts can be mitigated by on-site re-processing and by transferring substances deemed inappropriate for unrestricted openwater disposal to landside disposal.

For more information on petroleum-related impacts and conservation recommendations for petroleum exploration, production, and transportation refer to the Energy-Related Activities chapter of this report.

Offshore Dredge Material Disposal

Introduction

Disposal of dredged material is regulated under the Clean Water Act (CWA) and the Marine Protection, Research and Sanctuaries Act (MPRSA), also known as the Ocean Dumping Act (33 U.S.C. § 1251 and 1401 *et seq.*). The differences in the two Acts are found in the necessity and type(s) of sediment testing required by each. Generally, ccean dumping under the MPRSA only requires biological testing if the sediments are determined to not be "clean" (i.e., contaminated). The CWA does not require biological testing. However, the U.S. Environmental Protection Agency

(U.S. EPA) and the U.S. Army Corps of Engineers (U.S. ACE) are involved in discussions intended to meld the testing and evaluation protocols described in regulations and the Ocean Dumping ("Greenbook") and Inland (CWA) Testing Manuals.

Offshore disposal sites are identified and designated by the U.S. EPA using a combination of the MPRSA and National Environmental Policy Act (NEPA) criteria. However, the permitted use of designated disposal sites under these laws is not associated with the designation of the sites. To be eligible to use an offshore (i.e., federal waters) disposal site for dredged materials, project proponents must demonstrate: 1) that there are no reasonable and practical alternative disposal options available and; 2) the sediments are compatible with natural sediments at the disposal site and are not likely to disrupt or degrade natural habitats and/or biotic communities (USEPA 2005a). Contaminated dredged material cannot be discharged into sites managed under the MPRSA (USEPA 2005a).

Burial/Disturbance of Benthic Habitat

Studies using sidescan sonar and bottom video have been used to distinguish natural sediment character and evidence of past dumping of mud and boulders on sand bottom (Buchholtz ten Brink *et al.* 1996). These studies have indicated that not only have dumped materials disturbed and altered benthic habitats, but that in some cases (such as on Stellwagon Basin) the material dumped in the past was scattered far from the intended target areas (Buchholtz ten Brink *et al.* 1996). The discharge of dredged material disturbs benthic and pelagic communities during and after disposal. The duration and persistence of those impacts to the water column and seafloor are related to the grain size and specific gravity of the dredge spoil. Impacts to benthic communities are identified and assessed in the site designation documents (Battelle 2003; URI 2003), which may include benthic communities being buried and smothered and the physicochemical environment in which they reside being altered.

Conversion of Substrate/Habitat and Changes in Sediment Composition

Dumping dredged materials results in varying degrees of change in the physical, chemical, and biological characteristics of the substrate. The discharges can adversely affect infauna, benthic and epi-benthic organisms at and adjacent to the disposal site by burying immobile organisms or forcing motile organisms to migrate from the area. Those organisms with digging capabilities may be able to extricate themselves from the placed sediment. However, seasonal constraints on dredging and disposal not withstanding, it is assumed that there is a cyclical and localized depopulation of benthic organisms at a disposal site. Plants and benthic infauna present prior to a discharge are unlikely to recolonize if the composition of the deposited material is significantly different (NEFMC 1998). Altered sediment composition at the disposal site may reduce the availability of infaunal prey species, leading to reduced habitat quality (Wilber *et al.* 2005). However, Rhoades and Germano (1982, 1986) and Germano, Rhoads and Lunz (1994) note that disruption of re-colonization at a disposal site often leads to massive occurrences of opportunistic species that are then heavily predated by more desirable (managed) species. This plethora of prey event resulting from disturbing the community structure increases local productivity on the seafloor.

Siltation, Sedimentation, and Turbibity

Increased suspended sediment released during the discharge process and the associated increase in turbidity may hinder or disrupt activities in the pelagic zone (i.e., predator–prey relationships and photosynthesis rates). It has been estimated that less than 5 percent of the material in each disposal vessel is unaccounted for during and after the disposal activity (Bohlen *et al.* 1996), but the specific volume is influenced by both mechanical and sediment characteristics.

The discharge of dredged material usually results in elevated levels of fine-grained mineral particles, usually smaller than sand (i.e., silt/clay), and organic particles being introduced into the water column (i.e., suspended sediment plumes). The suspended particulates reduce light penetration; lower the rate of photosynthesis and the primary productivity of an aquatic area. Typically, the suspended materials are dispersed and diluted to levels approaching ambient within one to four hours of the release (Bohlen *et al.* 1996). In the plume field, living marine resources may experience either reduced or enhanced feeding ability as a result of the disruption of water clarity, depending upon the predator-prey relationships and the type(s) of avoidance/feeding methodologies used by the species. For instance, flounder and bluefish are sight feeders and avoid areas with reduced water clarity resulting from suspended sediment such as might be found at a dredging or disposal site (Packer *et al.* 1999). Conversely, recent deposits of sediment at dumpsites have been reported to act as an attractant for other species of fish and crustaceans such as winter flounder and American lobster even though winnowing of fines from the excavation site or deposit mound was ongoing at the site (SAIC 2001).

Generally, the severity of the effects of suspended sediments on aquatic organisms increases as a function of the sediment concentration and the duration of exposure (Newcombe and Jensen 1996). Some of the effects of suspended sediments on marine organisms can include altered foraging patterns and success (Breitburg 1988), gill abrasion and reduced respiratory functions, and death (Wilber and Clark 2001). The sensitivity of species to suspended sediments is highly variable, and dependent upon the nature of the sediment and the life history stage of the species. Mortality due to suspended sediments for estuarine species have been reported from less than 1000 mg/L for 24 hours (highly sensitive species) to greater than 10,000 mg/L for 24 hours (tolerant species) (Wilber and Clark 2001). The eggs and larvae stages of marine and estuarine fish exhibit some of the most sensitive responses to suspended sediment exposures of all the taxa and life history stages studied (Wilber and Clark 2001). Impacts that have been identified for demersal eggs of fish due to sedimentation and suspended sediments include delayed hatching and decreased hatching success (Wilber and Clark 2001; Berry *et al.* 2004). The development of larvae may be delayed or altered after exposure of elevated suspended sediments, and increased mortality rates in the larvae of some species, such as striped bass and American shad, has been reported with exposure of suspended sediment concentrations less than or equal to 500 mg/L for 3 to 4 days (Wilber and Clark 2001).

The affects of sedimentation on benthic organisms can include smothering and decrease gas exchange, toxicity from exposure to anaerobic sediments, reduced light intensity, and physical abrasion (Wilber *et al.* 2005). Mobile benthic species that require coarse substrates, such as gravel or cobble (e.g., American lobster) may be forced to seek alternate habitat that is less optimal or compete with other species or individuals for suitable habitat (Wilber *et al.* 2005). Messieh *et al.* (1981) investigated sedimentation impacts on Atlantic herring in laboratory experiments and found increased mortality in herring eggs, early hatching and shorter hatching lengths, and reduced feeding success in herring larvae leading to stunted growth and increased mortality.

Although there is generally a consensus among scientists and resource managers that elevated suspended sediments and sedimentation on benthic habitat due to dredging and disposal of dredge spoils result in adverse impacts to marine organisms, the specific effects on biological communities needs to be better quantified. Additional research is needed to investigate dose-response models for at scales appropriate for dredging and disposal, and for appropriate species and life history stages (Wilber *et al.* 2005).

Release of Contaminants

Dredge material suspended in the water column can react with the dissolved oxygen in the water and result in localized depression of the oxygen level. However, research has indicated that reductions in dissolved oxygen levels during offshore sediment disposal is not appreciable or persistent in the general sediment classes found in waters of the Northeast region (USACE 1982; Fredette and French 2004; USEPA 2004). In certain situations, trace levels of toxic metals and organics, pathogens, and viruses adsorbed or adhered to fine-grained particulates in the dredged material may become biologically available to organisms either in the water column or through food chain processes. Some of these pollutants and their concentrations are evaluated during sediment testing required under the MPRSA and CWA.

Changes in Bottom Topography, Altered Hydrological Regimes, and Altered Current Patterns

A concern often raised is the stability of dredge spoil sediments placed on the seafloor. Because ocean disposal sites are typically located in low current areas with water depths in excess of the active erosion zone, the material is generally contained within the disposal site. However, before 1985, dredged material sites were occasionally located in water depths insufficient to retain materials placed there (USEPA 1986). For example, the Mud Dump Site, located in the New York Bight Apex Slope area off New York Harbor, contains water depths as shallow as 15 m and the site experienced extensive erosion by a "northeast" storm in October 1992 (USEPA 1997). Reclassified as a remediation Site in 1997, the site is now known as the Historic Area Remediation Site or HARS. Erosion was reported at depths of 26 m and the winnowed sediment included grain sizes up to small cobble. Fortunately, much of the sediment was relocated into deeper portions of the site westward of the erosion field (USEPA 1997). More comprehensive evaluation protocols have been put into place since 1985 to prevent dredged or fill material discharged at authorized sites from modifying current patterns and water circulation by obstructing the flow, changing the direction or velocity of water flow and circulation, or otherwise significantly altering the dimensions of a water body.

The U.S. ACE utilizes more than twenty selected or designated offshore dredged material disposal sites in the Northeast region of the U.S. Several of these sites have been used because they are dispersive in nature. These sites are used, normally, to put littoral material back into the nearshore drift pattern. The containment sites have an average size of 1.15 square nautical miles in size (USACE 2005a). By law and regulation, the significant adverse effects of dredged material disposal activities must be contained within the designated or selected disposal site and even those impacts must not degrade the area's overall ecological health. There is some dispersion of fine-grained sediments and contaminants outside the sites. Each site is required to have and be managed under a Dredged Material Monitoring and Management Plan that assesses the health and wellbeing of the site and surrounding environment. Monitoring of disposal sites is a part of these plans, which is designed to insure that any degradation of resources or alteration in seafloor characteristics are identified and would illicit actions by permitting agencies (USEPA 2004).

Release of Nutrients/Eutrophication

Nutrient overenrichment, or eutrophication, is one of the major causes of habitat decline associated with human activities (Deegan and Buchsbaum 2005). There are point sources of nutrients, such as sewage treatment plant outfalls, and non-point sources such as urban storm water runoff, agricultural runoff, and atmospheric deposition, which have been discussed in other chapters of this report. Elevated levels of nutrients have undesirable effects, including 1) increased incidence, extent, and persistence of blooms of noxious or toxic species of phytoplankton; 2) increased frequency, severity, spatial extent, and persistence of hypoxia, 3) alterations in the dominant phytoplankton species, which can reduce the nutritional and biochemical nature of primary productivity; and increased turbidity levels of surface waters, leading to reductions in submerged aquatic vegetation (O'Reilly 1994). Offshore disposal of sediments with a high organic content and nutrient level is currently not permitted under the testing criteria established in the MPRSA and CWA regulations. However, prior to these stricter regulations instituted in the 1980's, the discharge of sewage sludge was permitted for decades in nearshore and offshore waters of many urbanized centers of the northeastern U.S. coast (Barr and Wilk 1994).

Conservation Measures and Best Management Practices for Dredge Material Disposal

1. Ensure that all options for disposal of dredged materials at sea are comprehensively assessed. The consideration of upland alternatives for dredged material disposal sites must be evaluated before offshore sites are considered.
2. Ensure that adequate sediment characterizations are completed and available for developing informed decisions.
3. Ensure that adequate resource assessments are completed and available during project evaluation.
4. Employ sediment dispersion models to characterize sediment resuspension and dispersion during operations. Use model outputs to design disposal operations, including measures to avoid and minimize impacts from suspended sediment and turbidity on living marine resources. Sediment dispersion models should be field verified to various sediment and hydraulic conditions to ensure they have been calibrated appropriately to predict sediment transport and dispersion.
5. Consider "beneficial uses" of dredged material, as appropriate.
6. Ensure that the site evaluation criteria developed for selection or designation of dredged material disposal sites have been invoked and evaluated, as appropriate.
7. Avoid dredged material disposal activities in areas containing sensitive or unique marine benthic habitats (e.g., spawning and feeding sites, surface deposits of cobble/gravel substrate).
8. Employ all practicable methods for limiting the loss of sediment from the activity. Consider closed or "environmental" buckets, when appropriate.
9. Sequential dredging may be used to avoid dredging activity during specific time periods in particularly environmentally sensitive areas of large navigation channel dredging projects. This can avoid turbidity and sedimentation, bottom disruption, and noise in sensitive areas used by fishery resources during spawning, migration, and egg development.
10. Require appropriate monitoring to avoid and minimize individual and cumulative impacts of the disposal operations.
11. Seasonal restrictions should be used, when appropriate, for avoiding temporary impacts to habitat during critical life history stages (e.g., spawning, egg and embryo development, and juvenile growth). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements. Resource managers should incorporate adequate time for habitat recovery of affected functions and values to levels required by managed species.

Fish Waste Disposal

Introduction

Fish waste or material resulting from industrial fish processing operations from either wild stocks or aquaculture consists of particles of flesh, skin, bones entrails, shells or process water (i.e., liquid “stickwater” or “gurry”). The organic components of fish waste have a high biological oxygen demand and, if not managed properly, can pose environmental and health problems. Generally, the solid wastes make up 30 to 40 percent of total production, depending on the species processed (IMO 2005a). Most fish wastes degrade rapidly in warm weather and can cause aesthetic problems and strong odors as a result of bacterial decomposition if not stored properly or disposed of quickly. Because these waste streams are generally required to be pre-treated and fully processed on-site, disposed at a suitable upland site, or sent through municipal sewage treatment, at sea disposal is no longer widely employed in the northeast U.S. However, these materials are sometimes discharged at sea, when appropriate.

Permitting of at sea disposal should be coordinated with appropriate federal and state agencies. Processors should contact the U.S. EPA to determine whether federal permits are necessary for the activity. In order to determine if a federal permit applies, the U.S. EPA must determine if the material constitutes an environmental risk or is a traditional and acceptable "fish waste" disposal defined under Section 102(d) of the Ocean Dumping Act, 33 U.S.C. Part 1412(d) and the regulations promulgated at 40 C.F.R. Part 220. Generally, permits are not required for the transportation or the ocean disposal of fish waste unless disposal is proposed in harbors or other protected and enclosed waters, and the location is deemed by the U.S. EPA as potentially endangering human health, the marine environment or ecological systems. If an environmental or human health risk is determined, the applicant may be required to submit an assessment of the disposal area and potential impacts to marine resources and follow disposal guidelines consistent with the provisions of the London Convention 1972 (IMO 2005a). Permits required for ocean disposal of fish wastes define the discharge rate of the fluids, residual tissue and hard part pieces using a dispersion model. Inputs to the model include discharge flow rate, tissue dimensions, mixing rates, local current patterns and the specific gravity of the solids (USEPA 2005b). The U.S. EPA may also consult with applicable federal and state regulatory and resource agencies, and regional fisheries council(s), to identify any areas of concern with respect to the disposal area and activity. Persons wishing to dispose of fish wastes in the ocean may be required to submit specific dilution modeling in support of the proposed disposal and participate in monitoring to verify the results of the modeling (USEPA 2005b).

Bivalve shells, when brought ashore and processed, are not allowed to be returned to the ocean for the purpose of waste disposal. Reuse of the shells as “cultch” in oyster farming operations is a standard, traditional fishing practice in the Northeast U.S. and does not require permitting but, prior to disposal the shells may be required to meet water quality criteria, principally regarding residual tissue volume.

The guidelines established by the London Convention 1972 places emphasis on progressively reducing the need to use the sea for dumping of wastes. Implementation of these guidelines and the regulations promulgated by U.S. EPA for the disposal of fish wastes includes consideration of potential waste management options that reduce or avoid fish waste to the disposal stream. For example, applications for disposal should consider reprocessing to fishmeal, composting, production of silage (i.e. food for domestic animals/aquaculture) and use in biochemical industry products, and use as fertilizer in land farming and reduction of liquid wastes by evaporation (IMO 2005a).

Introduction of Pathogens

Ocean disposal of fish wastes has the potential to introduce pathogens to the marine ecosystem that could infect fish and shellfish. In particular, aquaculture operations that raise non-native species or those that provide food to animals derived from non-indigenous sources could introduce disease vectors to native species (IMO 2005a). However, the disposal guideline provisions implemented as part of the Ocean Dumping Act is designed to insure wide dispersion of the gurry and limited accumulation of soft parts waste on the sea floor. Models developed to predict the effects of authorized discharges of fish wastes were designed to avoid the accumulation of biodegradable materials on the seafloor and introduction of pathogens.

Release of Nutrients/Eutrophication

The organic components of fish wastes have a high biological oxygen demand (BOD) and, if not managed properly, could result in nutrient over-enrichment and reductions in the dissolved oxygen. In ocean disposal, these affects may be seen with mounding of wastes, subsequent increases in BOD and contamination with bacteria associated with partly degraded organic wastes (IMO 2005a). However, disposal guidelines require dump-site selection criteria that maximizes waste dispersion and consumption of the wastes by marine organisms.

Release of Biosolids

Generally, the solid wastes generated by fish waste disposal comprises approximately 30 to 40 percent of total production, depending upon the species processed (IMO 2005a). Biosolid waste at fish disposal sites could result in nutrient over-enrichment and reduced dissolved oxygen concentration. However, the disposal guideline provisions implemented as part of the Ocean Dumping Act requires wide dispersion of the gurry and limited accumulation of soft parts waste on the sea floor.

Alteration of Benthic Habitat

Ocean disposal of fish wastes that fail to meet permit conditions and guidelines have the potential to degrade fishery habitat by adversely affecting the productivity and ecological functions of the benthic community. Concentration and mounding of wastes can increase the BOD and reduce dissolved oxygen concentration of an area that could result in reductions in the ability to support small consumer organisms such zooplankton and amphipods, which affect species at higher trophic levels that depend upon these consumers for food. However, disposal guidelines requires dump-site selection criteria that maximizes waste dispersion and consumption of the wastes by marine organisms, and disposal monitoring that insures permit conditions are met (USEPA 2005b). In addition, guidelines and permit review also must consider chemical contamination of the marine environment from the waste disposal. For example, the potential presence of chemicals used in aquaculture and fish wastes subjected to chemical treatment must be assessed prior to disposal (IMO 2005a).

Behavioral Effects

The presence of biodegradable tissue in the water column has the potential to alter the behavior of organisms in various ways, such as causing an attractant source for scavengers. This could alter the diet of individuals and interfere with trophic-level energy dynamics and community structure. The discharge of process water and biosolid wastes should be monitored carefully to insure conditions within state and federal permits are met.

Conservation Measures and Best Management Practices for Disposal of Fish Wastes

1. The practical availability of alternative methods of disposal to re-use, recycle, or treat the waste should be considered as a comparative risk assessment involving both ocean dumping and alternatives.
2. Organic materials should be ground to sizes where they will be consumed or degraded in the water column dispersion field during and subsequent to their discharge. The intent should be to avoid water quality degradation and tissue deposition and accumulation on the seafloor.
3. Ensure that the waste will be rendered biologically inert during their residence time in the water column and avoid adverse effects on water quality, including reductions in dissolved oxygen concentrations and nutrient over-enrichment.
4. Require monitoring of the waste plume during and after discharge to verify model outputs and advance the knowledge regarding the practice of at sea disposal of fish processing wastes.

Vessel Disposal

Introduction

When vessels are no longer needed, there are several options for their disposition, including re-use of the vessel or parts of the vessel, recycling or scrapping, creating artificial reefs and disposal on land or sea (USEPA 2006). This section discusses the potential habitat and marine fisheries impacts associated with disposal at sea.

The disposal of vessels in the open ocean is regulated by the U.S. EPA under section 102(a) of the Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act), and under 40CFR § 229.3 of the U.S. EPA regulations. In part, these regulations require that 1) vessels sink to the bottom rapidly and permanently, and that marine navigation is not otherwise impaired by the sunk vessel; 2) all vessels shall be disposed of in depths of at least 1,000 fathoms (6,000 feet) and at least 50 nautical miles from land, and; 3) before sinking, appropriate measures shall be taken to remove to the maximum extent practicable all materials which may degrade the marine environment, including emptying of all fuel tanks and lines so that they are essentially free of petroleum, and removing from the hulls other pollutants and all readily detachable material capable of creating debris or contributing to chemical pollution.

The U.S. EPA and U.S. Maritime Administration have developed national guidance, including criteria and best management practices for the disposal of ships at sea when the vessel(s) are intended for creation or addition to artificial reefs (USEPA 2006). Vessels disposed of to create artificial reefs are generally designed and intended to enhance fishery resources, facilitate access and utilization by recreational and commercial fishermen or recreational SCUBA divers. Some vessels may be sunk to provide a combination of these purposes. Vessels prepared for use as artificial reefs should be “environmentally sound” and free from hazardous and potentially polluting materials; 2) resource assessments for the disposal locations have been conducted to avoid adverse impacts to existing benthic habitats and; 3) stability analyses for the sinking and the ship’s ultimate location have been conducted to insure there is minimal expectation of adverse impacts on adjacent benthic habitats. Several guidance documents have been developed for the planning and preparation of vessels as artificial reef material, including the National Artificial Reef Plan (Stone 1985), Coastal Artificial Reef Planning Guide (ASMFC 1998), the Guidelines for Marine Artificial Reef Materials (ASMFC and GSMFC 2004), and National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs (USEPA 2006). These documents should be consulted to insure that conflicts with existing uses of the potential disposal site/artificial reef site are addressed and that materials onboard the vessel do not adversely impact the marine environment. Section 203 of the National Fishing Enhancement Act of 1984 (Title II of PL 98-623,

Appendix C) established that artificial reefs in waters covered under the Act shall AY be sited and constructed, and subsequently monitored and managed in a manner which will: 1) enhance fishery resources to the maximum extent practicable; 2) facilitate access and utilization by U.S. recreational and commercial fishermen; 3) minimize conflicts among competing uses of waters covered under this title and the resources in such waters; 4) minimize environmental risks and risks to personal health and property; and 5) be consistent with generally accepted principles of international law and shall not create any unreasonable obstruction to navigation."

The appropriate siting is vital to the overall success of an artificial reef. Considerations and options for site placement and function in the environmental setting should be carefully weighed to ensure program success. Since placement of a reef involves displacement and disturbance of the existing habitat, and building the reef presumably accrues some benefits that could not exist in the absence of the reef, documentation of these effects should be brought out in the initial steps to justify artificial reef site selection.

The Coastal Artificial Reef Planning Guide (ASMFC 1998) and the National Artificial Reef Plan (Stone 1985) state that when a man-made reef has been constructed, another important phase of reef management begins: monitoring and maintenance. Monitoring provides an assessment of the predicted performance of reefs and assures that reefs meet the general standards established in the Section 203 of the National Fishing Enhancement Act as listed above. It also ensures compliance with the conditions of any authorizing permits. Artificial reef monitoring should be linked with performance objectives, which ensures that NMFS' responsibilities to protect, restore, and manage living marine resources, and to avoid and minimize any adverse effects on these resources is fulfilled.

Release of Contaminants

Ships disposed of at sea, including those intended to create artificial reefs, are often military and commercial vessels which typically contain various materials that, if released into the marine environment, could have adverse effects on the marine environment. Some of the materials of concern include fuels and oil, asbestos, polychlorinated biphenyls (PCBs), paint, debris (e.g., vessel debris, floatables, introduced material), and other materials of environmental concern (e.g., mercury, refrigerants) (USEPA 2006). Depending upon the nature of the contaminant, and the concentration and duration of the release of contaminant(s), adverse effects to marine organisms may be acute or chronic, and either lethal or sublethal. Some contaminants, such as PCBs and mercury, can be persistent and bioaccumulate in the tissues of organism and result in more serious impacts in higher trophic level organisms. The Ocean Dumping Act and the various guidance documents available for offshore disposal of vessels prohibit materials containing contaminants which may impact the marine environment. The guidance documents provide detailed best management practices regarding recommended measures to remove and abate contaminants contained within and as part of a vessel.

Release of Debris

Solids, debris, and floatables are materials that could break free from a vessel during transportation to the disposal site, and during and after sinking. The release of debris can adversely affect the ecological and aesthetic value of the marine environment. Debris released from vessels is generally categorized into vessel debris (material that was once part of the vessel) and clean-up debris (material that was not part of the vessel, but was brought on board the vessel during preparation for disposal).

Some debris released from vessels is not highly degradable and can be persistent in the marine environment for long periods of time, increasing the threat they pose to the environment. Some of the impacts associated with debris includes: 1. Entanglement and/or ingestion, leading to injury, infection, or death of marine animals that may be attracted to, or fail perceive the debris in the water; 2. Alteration of the benthic floral and faunal habitat structure, leading to injury or mortality or indirect impact to other species linked in the benthic food web; 3. Increasing the risk of spills and other environmental impacts resulting from potential danger to vessel navigation (e.g., hull damage, damage to cooling or propulsion systems) (USEPA 2006). The Ocean Dumping Act and the various guidance documents available for offshore disposal of vessels, require all debris to be removed from vessels prior to sinking. The guidance documents provide detailed best management practices regarding recommended measures to remove vessel and clean-up debris.

Conversion of Substrate/Habitat and Changes in Community Structure

Vessels that are sunk for the purpose of discarding obsolete or decommissioned ships, as well as those sunk to create an artificial reef can convert bottom habitat type and alter the ecological balance of marine communities inhabiting the area. For example, placement of vessels over sand bottom can change niche space and predator/prey interactions for species or life history stages utilizing that habitat type. Large structures such as ships tend to attract adult fish and larger predators, which may increase predation rates on smaller and juvenile fish or displace smaller fish and juveniles to other areas (USEPA 2006). Large, manmade structures, such as oil and gas platforms in the Gulf of Mexico, have been shown to effect the distribution of larval and juvenile fish (Lindquist *et al.* 2005). In addition, large structures tend to provide proportionally less shelter for demersal fishes and invertebrates than smaller, lower profile structures and the surfaces of steel hull vessels is a less ideal surface for colonization by epibenthos than rocks or concrete (ASMFC and GSMFC 2004). Certain types of habitat and areas may be more susceptible to physical and chemical impacts from the placement of vessels, particularly those vessels sunk as artificial reefs. Generally, vessels sunk for disposal only are located in deeper water (> 6,000 feet) and very far offshore (> 50 nautical miles from land) and should have minimal impact on sensitive benthic habitat. However, vessels sunk as artificial reefs are usually located in coastal waters that also support or are frequented by marine resources that could be adversely impacted by the placement of the structure. Artificial reefs should not be sited in sensitive areas that contain coral reefs or other reef communities, submerged aquatic vegetation or habitats known to be utilized by endangered or threatened species (USEPA 2006). The Ocean Dumping Act prohibit vessel disposal in areas that may adversely effect the marine environment.

Changes in Bathymetry and Hydrodynamics

The location of a vessel on the ocean bottom will change the bathymetry and can potentially alter the current flow of the disposal area. A proposed disposal site should be assessed as to the effects the vessel disposal and subsequent bathymetry change may have on the hydrodynamics and geomorphology of the immediate and adjacent habitats. For example, even small vessels placed on the bottom can alter currents and create turbulence around the vessel that may scour existing soft substrates and adversely affect adjacent habitats and communities. In addition, the high vertical profile may cause some vessels to be prone to movement and structural damage due to ocean currents and wave surge during storm events. For example, during the category 5, Hurricane Andrew in south Florida during 1992, nearly all steel-hulled vessels sunk as artificial reefs in the area of the storm's path sustained structural damage and a number moved between 100 and 700 m due to the storm surge (ASMFC and GSMFC 2004). The movement of vessels after disposal can impact adjacent habitats and relocate the vessel to areas that could alter the ecological balance of marine communities in the area. In addition, reductions in navigational clearance above vessels, either as a result on the vessel being sunk in the wrong location and in an area too shallow, or due to later movement of the vessel as a result of storm surge or currents, may increase the potential danger to vessel navigation (e.g., hull damage, damage to cooling or propulsion systems) that could cause further damage from oil/fuel spills or groundings (ASMFC and GSMFC 2004). The Ocean Dumping Act and the various guidance documents available for offshore disposal of vessels require stability analysis, assessments of the seabed, including topography and geological characteristics, mean direction and velocity of currents and storm-wave induced bottom currents prior to dumping activities to minimize the risk of alterations to the bathymetry and hydrodynamics of the disposal area and vessel movement (ASMFC and GSMFC 2004; IMO 2005b).

Deployment Impacts

Some risks to the marine environment exist during the deployment (i.e., the sinking) of vessels for disposal or as an artificial reef. Some potential impacts that may occur during deployment include the release of contaminants accidentally left onboard the vessel, damage to adjacent benthic habitats from anchors and cables used to maintain the vessel position as it sinks, impacts to benthic habitats due to a vessel accidentally sinking in an unintended location while being towed or due to movement of the ship after deployment (ASMFC and GSMFC 2004). However, careful planning during the assessment stages and adherence to operational protocols can avoid impacts during deployment.

Conservation Measures and Best Management Practices for Disposal of Vessels

1. Require that a vessel disposal site assessment adequately characterizes the physical and biological environment of the site. In addition to identifying the habitat types and species utilizing the area and targeted for enhancement, ecological investigations should include community settlement and recruitment and predator/prey dynamics, and anticipated changes in competition and niche space as a result of the vessel disposal (USEPA 2006).
2. The assessment should identify the locations of any sensitive marine habitats in the area. Potential vessels disposal sites should generally not be located near any of the following marine resources: coral reefs; significant beds of aquatic vegetation or macroalgae; oyster reefs; scallop, mussel, or clam beds; existing live bottom (i.e., marine areas supporting sponges, sea fans, corals, or other sessile invertebrates generally associated with rock outcrops); and habitats of endangered or threatened species (federal and state listed) (USEPA 2006).
3. A vessel stability analysis should be conducted to insure the vessel is retained in the intended location, including characterization of anticipated weather conditions, tidal dynamics, mean direction and velocity of surface and bottom drifts and storm-wave induced currents, and general wind and wave characteristics (IMO 2005b).
4. Ensure that a thorough inventory and assessment of all potential contaminants on the vessel is completed and that all pre-placement cleaning and inspections are completed thoroughly and effectively.
5. Avoid the use of explosives to the extent possible in sinking vessels under 150 feet in length where alternate methods (e.g., opening seacocks, flooding with pumps, etc.) are feasible (ASMFC and GSMFC 2004).
6. Monitor the disposal operation and the placement site for adherence to permit compliance and performance objectives.

7. For vessels disposed of as artificial reefs, insure that physical and biological monitoring plans are developed, as appropriate, and that monitoring and reporting requirements are met throughout the designed timeframe.

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CHEMICAL EFFECTS: WATER UPTAKE AND DISCHARGE FACILITIES

Introduction

Disposal of various waste materials into rivers, estuaries and marine waters is not a modern phenomenon; this practice has been used as a preferred disposal option virtually since the beginning of human civilization (Ludwig and Gould 1988; Islam and Tanaka 2004). Yet when the full spectrum of emissions from land-based activities are taken into account, the use of coastal waters as a repository for anthropogenic waste has not previously been practiced on as large or intense a global scale as in recent decades (Williams 1996). In the U.S., growing human population densities in coastal communities have manifested a demonstrably adverse effect on aquatic resources. The scientific literature is replete with evidence of inorganic and organic pollutant accumulation in coastal waters due to anthropogenic effluents (Ragsdale and Thorhaug 1980; Tessier *et al.* 1984; Phelps *et al.* 1985; Long *et al.* 1995; Pastor *et al.* 1996; Smith *et al.* 1996; Chapman and Wang 2001; Hare *et al.* 2001; O'Connor 2002; Robinet and Fenteun 2002; Wurl and Obbard 2004). The federal Clean Water Act (CWA), enacted in 1972 to address many of these issues, has eliminated certain types of disposal activities and otherwise induced improvements to the Nation's surface water quality. Nonetheless, despite reductions in pollution from municipal and industrial point sources more than one-third of the river miles, lake acres, and estuary square miles suffer some degree of impairment (Ribaudo *et al.* 1999). To the extent that it may alter natural processes and natural resource communities, unabated degradation of the aquatic environment caused by a wide spectrum of human activities poses consequences for fishery resources and their habitats.

Contaminants enter our waterways through two generic vectors: point- and non-point sources. Pollutants of non-point source origin tend to enter aquatic systems as relatively diffuse contaminant streams primarily from atmospheric and terrestrial sources (see Coastal Development chapter of this report for discussions on non-point source pollution). In contrast, point-source pollution generally is introduced via some type of pipe, culvert, or similar outfall structure. These discharge facilities typically are associated with domestic or industrial activities, or in conjunction with collected runoff from roadways and other developed portions of the coastal landscape. Waste streams from sewage treatment facilities and watershed runoff in many urbanized portions of the northeast U.S. are first intermingled, and then subsequently released, into aquatic habitats via combined sewer overflows (CSOs). Such point discharges collectively introduce a cocktail of inorganic and organic contaminants into aquatic habitats, where they may become available to living marine resources. While dissolved contaminants tend to be distributed fairly homogeneously (Flegal *et al.* 1991), pollutants originating from many localized sources eventually may become concentrated in sediments or tissues of relatively sessile organisms (O’Connor and Huggett 1988).

While all pollutants can become toxic at high enough levels, there are a number of compounds that are toxic at relatively low levels. The U.S. Environmental Protection Agency (U.S. EPA) has identified and designated these compounds as “priority pollutants”. Some of these “priority pollutants” include: 1) Metals, such as cadmium, copper, chromium, lead, mercury, nickel, and zinc, that arise from industrial operations, mining, transportation, and agriculture use; 2) Organic compounds, such as pesticides, PCBs, solvents, petroleum hydrocarbons, organometallic compounds, phenols, formaldehyde, and biochemical methylation of metals in aquatic sediments; 3) Dissolved gases, such as chlorine and ammonium; and 4) Anions, such as cyanides, fluorides, sulfides, and sulphates and 5) Acides and alkalis (USEPA 2003a).

Determining the eventual effect and fate of naturally occurring and synthetic contaminants in coastal environments and biota is a highly dynamic proposition that requires interdisciplinary evaluation. It is essential that all processes sensitive to pollutants be identified and that investigators realize that the resulting adverse effects may be manifested at the biochemical level in organisms (Luoma 1996), and in a manner particular to the species or life stage exposed. Pollutant exposure can inhibit: 1) basic detoxification mechanisms, like production of metallothioneins or antioxidant enzymes; 2) the ability to resist diseases; 3) the ability of individuals or populations to counteract pollutant-induced metabolic stress; 4) reproductive processes including gamete development and embryonic viability; 5) growth and successful development through early life stages; 6) normal processes including feeding rate, respiration, osmoregulation; and 7) overall Darwinian fitness (Capuzzo and Sassner 1977; Widdows *et al.* 1990; Nelson *et al.* 1991; Stiles *et al.* 1991; Luoma 1996; Thurberg and Gould 2005).

The nature and extent of a pollutant's dispersal in our waterways are collectively dependent on a variety of factors including site-specific ecological conditions, the physical state in which the contaminant is introduced into the aquatic environment, and the inherent chemical properties of the substance in question. Soluble or miscible substances typically enter waterways in an aqueous phase and eventually become adsorbed onto organic and inorganic particles (Wu *et al.* 2005); however, contaminants may enter aquatic systems as either particle-borne suspensions or as solutes (Bishop 1984; Turner and Millward 2002). Dilution and settling out from such effluent streams initially are dictated by physical factors (e.g., the presence of significant currents or perhaps a strong thermocline or pycnocline) which predominantly influence the spatial extent of contaminant dispersal. In particular, turbulent mixing, or diffusion, disperses contaminant patches in coastal waters resulting in larger, comparatively diluted contaminant distributions further away from the initial point source (Bishop 1984). Biological activity and geochemical processes subsequently intercede, and typically result in contaminant partitioning between the aqueous and particulate phases (Turner and Millward 2002).

While physical dispersion, biological activity and other ecological factors clearly have important roles regarding the distribution of contaminants in aquatic habitats, contaminant partitioning is largely governed by certain ambient environmental conditions, notably salinity, pH, and the physical nature of local sediments (Turekian 1978; McElroy *et al.* 1989; Turner and Millward 2002; Leppard and Droppo 2003; Wu *et al.* 2005). Highly reactive suspended particles typically serve as important carriers of aquatic contaminants and largely are responsible for their bioavailability, transport and ecological fate as they become dispersed in receiving waters (Turner and Millward 2002). In addition, hyporheic (i.e., the saturated zone under a river or stream, comprising substrate with the interstices filled with water) exchange between overlying water and groundwater can alter salinity, dissolved oxygen concentration and other water chemistry aspects in ways that can influence the affinity of local sediment types for particular contaminants or otherwise affect contaminant behavior (Ren and Packman 2002).

Amendments to the CWA include important provisions to address acute or chronic water pollution emanating from discharge pipes and outfalls under the National Pollutant Discharge Elimination System (NPDES) program. Until the late 1980s, the NPDES program traditionally focused efforts on controlling industrial and municipal sewage discharges but has since expanded its purview to include storm water management (USEPA 1996). While the NPDES program has led to ecological improvements in waters of the U.S., point sources continue to introduce pollutants into the aquatic environment, albeit at reduced levels. Nonetheless, studies demonstrate that particle-associated contaminants collected in coastal depositional areas are preserved in chronological strata or horizons (Huntley *et al.* 1995; Chillrud *et al.* 2003). Consequently, historically deposited contaminants may be encountered when installing new outfalls or coastal infrastructure, especially near urbanized areas. Regardless of whether these pollutants were deposited recently or decades ago, dredging incidental to construction and related activities that enhance their potential biological availability can have adverse ecological implications.

The environmental dynamics of point source wastes is complex, and involves a variety of physical, chemical and biological processes simultaneously acting on the introduced suite of contaminants and their surrounding habitat. Because of the many competing variables involved, it is difficult to predict the ultimate fate and effects of anthropogenic wastes with great precision; however, local habitat characteristics in combination with the relative solubility, degree of hydrophobicity (i.e., tending to repel and not absorb water), and chemical reactivity of the introduced substances are important determining factors at the most basic level of analysis.

To minimize redundancy, all recommended conservation measures and best management practices for sewage discharge facilities, industrial discharge facilities, and combined sewer overflows have been included at the end of this chapter.

Sewage Discharge Facilities

Introduction

Sewage treatment plants introduce a host of contaminants into our waterways primarily through discharge of fluid effluents comprising a mixture of processed "black water" (sewage) and "gray water" (all other domestic and industrial wastewater). Such municipal effluents begin as a complex mixture of human waste, suspended solids, debris and a variety of chemicals collectively derived from domestic and industrial sources. These contaminants include an array of suspended and dissolved substances, representing both inorganic and organic chemical species (Grady *et al.* 1998; Epstein 2002). The U.S. EPA regulations focus on four priority classes of wastewater contaminants: metals, other trace elements and cyanide; petroleum hydrocarbons and other volatile organic compounds; semi-volatile organic compounds; as well as pesticides and polychlorinated biphenyls (PCBs) (USEPA 1984).

Coastal communities rely on municipal wastewater treatment to contend with potential human health issues related to sewage and also to protect surface and ground water quality. Municipal processing facilities typically receive raw wastewater from both domestic and industrial sources, and are designed to produce a liquid effluent of suitable quality that can be returned to natural surface waters without endangering humans or producing adverse aquatic effects (Grady *et al.* 1998; Epstein 2002). As it is currently practiced in the U.S., wastewater treatment entails subjecting domestic and industrial effluents to a series of physical, chemical or even biological processes designed to address or manipulate different aspects of contamination.

Primary treatment, also known as "screen and grit", is only marginally effective at addressing sewage contaminants and simply entails bulk removal of solids from the wastewater by sedimentation and filtration. Sometimes total suspended solids are further reduced in the initial effluent treatment phase by implementing another level of primary treatment, which entails using chemicals to induce coagulation and flocculation of smaller particles (Parnell 2003). The resulting bio-solids must be disposed, and their final disposition could entail composting with subsequent use in agricultural applications, placement in a landfill, disposal at sea, or even incineration (Werther and Ogada 1999). Removal and appropriate disposal of sewage present in a solid phase is an important step in addressing human health and aesthetic issues surrounding sewage management because it removes visible substances that otherwise would accumulate in the aquatic environment at or near the discharge point. Unfortunately, primary treatment of municipal wastewater alone often fails to meet overall environmental goals of supporting important water-dependent uses like fishery resource production and recreational uses featuring primary contact with the water. As a consequence, coastal communities in the northeast region typically process their wastewater through one or more additional treatment levels beyond bulk solids removal to address the environmental challenges of their sewage effluents more effectively.

Following bulk sludge removal, sewage treatment plants typically pass the highly organically-enriched water emerging from primary treatment through a second process that is intended to address biological oxygen demand (BOD), an indirect measure of the concentration of biologically degradable material present in organic wastes that reflects the amount of oxygen necessary to break down those substances in a set time interval. Such secondary treatment involves removal of much of the remaining organic material by introducing aerobic microorganisms under oxygen-enriched conditions (Parnell 2003). The bacteria subsequently are removed by chlorination before the secondarily-treated effluent is released into local surface waters or the secondarily treated wastewater is directed to another part of the sewage treatment plant for additional processing. Where practiced, such effluent-polishing or advanced treatment measures use any of several techniques to remove inorganic nitrogenous or phosphorous salts to reduce the final effluent's potential to cause excessive nutrient enrichment of the receiving waters (Epstein 2002; Parnell 2003).

Due to the large expense of tertiary sewage treatment, the public sector does not implement it as a uniform municipal wastewater treatment policy. Consequently, while secondary treatment is the standard operating procedure for municipal wastewater treatment in the northeast U.S., natural resource managers cannot assume that advanced treatment is available to meet desired environmental goals. Recent point source management policy decisions by Boston, Massachusetts area communities are a case in point. Rather than implementing more costly advanced treatment during system upgrades, these communities chose to address local municipal wastewater challenges by implementing primary and secondary treatment combined with source reduction of certain contaminants and offshore diversion of outfalls to encourage enhanced effluent dilution (Moore *et al.* 2005). Despite the added expense of implementing them, both secondary and advanced treatment processes are important potential habitat protection measures, particularly because they mitigate oxygen depletion events, eutrophication and related phenomena that can result in adverse ecological conditions.

Release of Nutrients and Eutrophication

Particularly under lesser levels of treatment, municipal sewage facilities discharge large volumes of nutrient-enriched effluent. While some level of readily available nutrients are essential to sustain healthy aquatic habitats and ecological productivity, excess concentrations result in eutrophication of coastal habitats. Elevated nitrogen and phosphorous concentrations in municipal wastewater effluents can cause pervasive ecological responses including: exaggerated phytoplankton and macroalgal populations; initiating harmful algal blooms (Anderson *et al.* 2002); adversely affecting physiology, growth and survival of certain ecologically important aquatic plants (Touchette and Burkholder 2000); reducing water transparency with accompanying adverse effects to submerged and emergent vascular plants, or otherwise disrupting the normal ecological balance among vascular plants and algae (Levinton 1982; Cloern 2001); hypoxic or anoxic events that may cause significant fish and invertebrate mortalities; disturbances to normal denitrification processes; and concomitantly decreasing local populations of fishery resources and forage species (USEPA 1994). Sewage outfalls may become an attraction nuisance in that they may at least initially attract fish around the point of discharge until hypoxia, toxin production and algal bloom development render the aquatic area less productive (Islam and Tanaka 2004).

For additional information on the mechanisms involved in denitrification of organic and inorganic compounds, Korom's (1992) review of denitrification in natural aquifers is a concise and informative compilation of heterotrophic and autrophic denitrifiers.

<u>Release of Contaminants</u>
Municipal treatment facilities discharge large volumes of effluent into the aquatic environment. The waste stream typically contains a complex mixture of domestic and industrial wastes that contain predominantly natural and synthetic organic substances, heavy metals and trace elements, as well as pathogens (Islam and Tanaka 2004). Some of these substances, such as volatile organic compounds, may have a relatively short residence time in the system and other, more persistent substances such as synthetic organometallic compounds, may linger for decades after having become associated with the substrate or becoming concentrated in local biota. Such pollution has been associated with mortality, malformation, abnormal chromosome division, and higher frequencies of mitotic abnormality in adult fish from polluted areas compared with those from less polluted regions of the northwest Atlantic (Longwell *et al.* 1992).

Heavy metals have been shown to produce a number of toxic effects to marine fish species, including skeletal deformities in Atlantic cod such as compression of the spine and jaw deformities from cadmium exposure (Lang and Dethlefsen 1987); larval developmental deformities in haddock from copper exposure (Bodammer 1981); and reduced viable hatch rates in winter flounder embryos and increased larval mortality from silver exposure (Klein-MacPhee *et al.* 1984).

Laboratory experiments with pesticides have shown a positive relationship between malformation and survival of embryos and larvae of Atlantic cod and concentration of DDT and its breakdown product DDE (Dethlefsen 1976, cited in Langton *et al*. 1994). The proportion of fin erosion in winter flounder collected on contaminated sediments was found to be greater in fish sampled with higher concentrations of PCBs in muscle, liver, and brain tissues than fish collected in reference sites (Sherwood 1982). Studies conducted in the harbor of New Haven, CT, found high occurrences of liver lesions, blood cell abnormalities, liver DNA damage, and liver neoplasms in winter flounder with high concentrations of organic compounds, heavy metals, and PCB in their gonads (Gronlund *et al.* 1991).

For almost a century, sewage sludge (the solids that settle during sewage treatment) was disposed of at sea. In the northeastern U.S. a number of designated offshore sewage sludge dumpsites existed, including one in Boston Harbor and sites in the New York Bight and the Middle Atlantic Bight (Barr and Wilk 1994). Not surprisingly, sediments sampled in the vicinity of sewage sludge dumpsites have contained higher levels of contaminants (e.g., PCBs, PAHs, chlorinated pesticides, and heavy metals) than control sites (Barr and Wilk 1994). Sewage sludge has been demonstrated to have adverse effects on aquatic organisms. For example, early life stages of Atlantic herring have shown a series of developmental abnormalities, including premature hatching accompanied by reduced viability of emerging fry; poor larval survival; smothering or incapacitation of larvae by particle flocs; and fin damage (Urho 1989; Costello and Gamble 1992). The Ocean Dumping Ban Act of 1988 prohibited sewage sludge and industrial wastes from being dumped at sea after December 31, 1991. This law is an amendment to the Marine Protection, Research, and Sanctuaries Act of 1972, which regulates the dumping of wastes into ocean waters.

In addition to these diverse contaminant classes, wastewater facilities also discharge a host of synthetic hormones or other substances that could disrupt normal endocrine function in aquatic vertebrates, as well as zoonotic viruses, bacteria and fungi that may be present in raw human sewage. Heavy metals have also been implicated in disrupting endocrine secretions of marine organisms, potentially disrupting natural biotic processes (Brodeur *et al.* 1997). In addition, heavy metals may move upward through trophic levels and accumulate in fish (i.e., bioaccumulation) at levels which can eventually cause health problems in human consumers. However, the long-term effect of endocrine-disrupting substances on aquatic life is not well understood and demands serious attention by the scientific and resource policy communities.

While modern sewage treatment facilities undeniably reduce the noxious materials present in raw wastewater, and some substances typical of processed effluents have their own inherent toxic effects, it also is important to recognize that secondary and advanced treatment can alter the chemistry of ordinarily benign materials in ways that initiate or enhance their toxicity. In particular, normally non-hazardous organic compounds present in wastewater potentially can be rendered toxic when raw municipal effluent is chlorinated in the sewage treatment process (NRC 1980; Epstein 2002). Other contaminants may become toxic to humans or many different aquatic resource taxa when these substances are methylated (addition of a $-CH_4$ group) or otherwise after having been chemically transformed into a harmful, biologically available molecular form.

The behavior and effects of trace chemicals in aquatic systems largely depends on the speciation and physical state of the pollutants in question. A detailed description concerning contaminant partitioning and bioavailability is beyond the scope of this technical discussion. However, Gustafsson and Gschwend (1997) offer an excellent review of the matter in terms of how dissolved, colloidal and settling particle phases affect trace chemical fates and cycling in aquatic environments. While the observations provided by these Massachusetts Institute of Technology researchers pertain specifically to cycling of compounds in natural waters, the generic properties they discuss also would apply in the context of substances in treated wastewater since they are subject to the same physical and chemical forces. In addition, Tchobanoglous *et al.* (2002) may be consulted for an authoritative technical review of the environmental engineering aspects of wastewater treatment.

Logically, exposure to potentially mutagenic or teratogenic pollutants and resulting declines in viability at any life stage reduces the likelihood of maturation and eventual recruitment to adulthood or a targeted fishery. The aqueous and sedimentary geochemistry and physiological effects of contaminants on aquatic biota literature should be consulted to determine the fate of persistent compounds in local sediments and associated pore-water and the extent of acute or chronic toxic effects on affected aquatic biota (Varanasi 1989; Allen 1996; Langmuir 1996; Stumm and Morgan 1996; Tessier and Turner 1996; Paquin *et al.* 2003).

Alteration of Water Alkalinity

Municipal sewage effluent can alter the alkalinity of riverine receiving waters. Acidification of riverine habitats has been linked to the disruption of reproduction, development and growth of anadromous fish (USFWS and NMFS 1999; Moring 2005). For example, osmoregulatory problems in Atlantic salmon smolts have been related to habitats with low pH (Staurnes *et al.* 1996). In estuarine waters, low pH has been shown to cause cellular changes in the muscle tissues of Atlantic herring which may lead to a reduction in the swimming ability (Bahgat *et al.* 1989).

Impacts to Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) requires relatively clear water in order to allow adequate light transmittance for metabolism and growth. Sewage effluent containing high concentrations of nutrients can lead to severely eutrophic conditions, reduced dissolved oxygen and light levels, which can reduce or eliminate SAV beds (Goldsborough 1997). Examples of large scale SAV declines have been seen throughout the eastern coastal states, most notably in Chesapeake Bay where overall abundance has been reduced by 90 percent during the 1960's and 1970's (Goldsborough 1997). Although a modest recovery of the historic SAV distribution has been seen in Chesapeake Bay over the past few decades, reduced light penetration in the water column from nutrient enrichment and sedimentation continues to impede substantial restoration. Primary sources of nutrients into Chesapeake Bay include fertilizers from farms, sewage treatment plant effluent, and acid rain (Goldsborough 1997). Short and Burdick (1996) correlated eelgrass losses in Waquoit Bay, Massachusetts, with anthropogenic nutrient loading primarily as a result of increased number of septic systems from housing developments in the watershed.

Eutrophication can alter the physical structure of SAV by decreasing the shoot density and blade stature, decreasing the size and depths of beds, and by stimulating excessive growth of macroalgae (Short *et al.* 1993). An epidemic of eelgrass wasting disease wiped out most eelgrass beds along the east coast during the 1930s, and although some of the historic distribution of eelgrass has recovered, eutrophication may increase the susceptibility of eelgrass to wasting disease (Deegan and Buchsbaum 2005).

Reduced Dissolved Oxygen

The decline and loss of fishery habitat due to low dissolved oxygen is one of the most severe problems associated with eutrophication in coastal waters ((Deegan and Buchsbaum 2005). The effect of constant and diurnally fluctuating levels of dissolved oxygen has been shown to reduce the growth of young-of-the-year winter flounder, *Pseudopleuronectes americanus* (Bejda *et al.* 1992). High nutrient loads into aquatic habitats can cause hypoxic or anoxic conditions, resulting in fish kills in rivers and estuaries (USEPA 2003b; Deegan and Buchsbaum 2005), and potentially alter long-term community dynamics (NRC 2000; Castro *et al.* 2003). Highly eutrophic conditions have been reported in a number of estuarine and coastal systems in the northeastern U.S., including Boston Harbor, Long Island Sound, and Chesapeake Bay (Bricker *et al.* 1999). For the southern portions of the Northeast coast, O'Reilly (1994) described chronic hypoxia, or low dissolved oxygen, as a result of coastal eutrophication in several aquatic systems (i.e., Narragansett Bay to Chesapeake Bay). He reported episodic low dissolved oxygen conditions in some of the northern portions of the Northeast coast, such as in Boston Bay/Charles River and the freshwater portion of the Merrimack River (O'Reilly 1994). Areas particularly vulnerable to hypoxia are those that have restricted water circulation, such as coastal ponds, subtidal basins, and salt marsh creeks (Deegan and Buchsbaum 2005). While any system can become overwhelmed by unabated nutrient inputs or nutrient enrichment, the effects of these generic types of pollution, when experienced in temperate regions, may be especially significant in the summer. This is primarily a result of stratification of the water column and higher water temperatures and metabolic rates during summer months (Deegan and Buchsbaum 2005).

Siltation, Sedimentation and Turbidity

Municipal sewage outfalls, especially those that release untreated effluent from storm drains, can release suspended sediments into the water column and the adjacent benthic habitat. Increased suspended particles within aquatic habitat can cause elevated turbidity levels, reduced light transmittance, and sedimentation of benthic habitat which may lead to the loss of SAV, shellfish beds and other productive fishery habitats. Other affects from elevated suspended particles include respiration disruption of fishes, reduction in filtering efficiencies and respiration of invertebrates, reduction of egg buoyancy, disruption of ichthyoplankton development, reduction of growth and survival of filter feeders, and decreased foraging efficiency of sight-feeders (Messieh *et al.* 1991; Barr 1993).

Introduction of Pathogens

Fish diseases and shellfish poisoning (e.g., paralytic, amnesic, and neurotoxic) may be linked to the release of municipal sewage wastes in coastal waters. There is evidence that nutrient overenrichment has led to increased incidence, extent, and persistence of blooms and noxious or toxic species of phytoplankton; increased frequency, severity, spatial extent, and persistence of hypoxia; alterations in the dominant phytoplankton species and size compositions; and greatly increased turbidity of surface waters from plankton algae (O'Reilly 1994). Microorganisms entering aquatic habitats in sewage effluents do pose some level of biological risk since they have been shown to infect marine mammals (Oliveri 1982; Bossart *et al.* 1990; Islam and Tanaka 2004). The degree to which anthropogenically-derived microbes may affect fish, shellfish and other aquatic taxa remains an important research topic; however, some recently published observations concerning groundfish populations near the Boston sewage outfall into Massachusetts Bay are encouraging that appropriate management practices may address at least part of this risk (Moore *et al.* 2005). See also the chapter on Introduced/Nuisance Species and Aquaculture for more information on harmful algal blooms and introduction of pathogens.

Introduction of Harmful Algal Blooms

Sewage treatment facilities releasing effluent with a high BOD that may enter estuarine and coastal habitats have been associated with harmful algal bloom events, which can deplete the oxygen in the water during bacterial degradation of algal tissue, and result in hypoxic or anoxic "dead zones" and large-scale fish kills (Deegan and Buchsbaum 2005). Algal blooms may also contain species of phytoplankton such as dinoflagellates that produce toxins. Toxic algal blooms, such as red tides, can decimate large numbers of fish, contaminate shellfish species, and cause health problems in humans. Shellfish sequester toxins from the algae and become dangerous to consume. Toxic algal blooms could increase in the future due to the fact that many coastal and estuarine areas are currently moderately to severely eutrophic (Goldburg and Triplett 1997). Heavily developed watersheds tend to have reduced stormwater storage capacity, and the high flow velocity and pulse of contaminants from freshwater systems can have long-term, cumulative impacts to estuarine and marine ecosystems. There is evidence that heavily developed watersheds with various sources of nutrient input lead to increased incidence, extent, and persistence of blooms and noxious or toxic species of phytoplankton; increased frequency, severity, spatial extent, and persistence of hypoxia; alterations in the dominant phytoplankton species and size compositions; and greatly increased turbidity of surface waters from plankton algae (O'Reilly 1994).

Impacts to Benthic Habitat

As discussed above, treated sewage effluent containing high concentrations of nutrients can lead to severely eutrophic conditions that can reduce or eliminate SAV beds (Goldsborough 1997). In addition, municipal sewage outfalls can release suspended sediments into the water column and the adjacent benthic habitat. Increased suspended particles within aquatic habitat can cause elevated turbidity levels, reduced light transmittance, which may lead to the reduction or loss of SAV, shellfish beds and other productive benthic habitats.

Changes in Species Composition

Treated sewage effluent can contain, at various concentrations, nutrients, toxic chemicals, and pathogens that can affect the health, survival, and reproduction of aquatic organisms. These effects may lead to alterations in the composition of species inhabiting coastal aquatic habitats, and can result in community and trophic level changes (Kennish 1998). For example, highly eutrophic water bodies have been found to contain exaggerated phytoplankton and macroalgal populations that can lead to harmful algal blooms (Anderson *et al.* 2002). Sewage treatment facilities may initially attract fish around the point of discharge until hypoxia, toxin production and algal bloom development render the aquatic area less productive (Islam and Tanaka 2004). Reduced light penetration in the water column from nutrient enrichment and sedimentation has been shown to contribute to the loss of eelgrass beds in coastal estuaries in Southern Massachusetts, Long Island Sound, and the Chesapeake Bay (Goldsborough 1997; Deegan and Buchsbaum 2005).

Contaminant Bioaccumulation and Biomagnification

Sewage discharges can contain heavy metals that are known to be toxic to marine organisms. Not surprisingly, the bays and estuaries of highly industrialized urban areas in northeastern U.S. coastal areas such as Boston Harbor, MA, Portsmouth, NH, Newark Bay, NJ and Western Long Island Sound, NY, have shown relatively high heavy metal burdens in sampled sediments (Larsen 1992; Kennish 1998). While industrial outfalls are responsible for heavy metal contamination in some areas, sewage has been identified as one of the primary sources. For example, although lead contamination in coastal sediments can originate from a variety of sources, sewage is believed to be the primary source of silver contamination (Buchholtz ten Brink *et al.* 1996). Heavy metals may move upward through trophic levels and accumulate in fish and some invertebrates (bioaccumulation) at levels which can eventually cause health problems in human consumers (NEFMC 1998; Kennish 1998). Other chemicals are known to bioaccumulate and biomagnify in the ecosystem, including pesticides (e.g., DDT) and PCBs (Kennish 1998). Although some pesticide and PCB contaminants may enter the wastewater stream, they are generally associated with agricultural and industrial point source and non-point source pollution.

Release of Pharmaceuticals

Concerns have been emerging over the past few years regarding the continual exposure of aquatic organisms to the complex spectrum of pharmaceuticals and active ingredients in personal care products (PPCPs), which can persist in treated effluent from sewage facilities. Excluding antibiotics and steroids, over 50 distinct PPCPs or metabolites have been identified in sewage treatment effluent (USEPA 1999a). From the limited studies, concentrations in natural surface waters have been found to range from parts per thousand to parts per billion; however, most of these compounds have no associated aquatic toxicity data, are extremely persistent and are introduced to the environment in very high quantities (USEPA 1999a). Although growing evidence on this topic suggests further investigation is warranted, population level effects on aquatic organisms from PPCPs are inconclusive.

Endocrine Disruptors

Another recent topic of concern involves a group of chemicals, called "endocrine disruptors", which interfere with the endocrine system of aquatic organisms. Growing concerns have mounted in response to the effects of endocrine-disrupting chemicals on humans, fish and wildlife (Kavlock *et al.* 1996; Kavlock and Ankley 1996). These chemicals act as "environmental hormones" that may mimic the function of the sex hormones androgen and estrogen (Thurberg and Gould 2005). Adverse effects include reduced or altered reproductive functions, which could result in population-level impacts. Some of the chemical shown to be estrogenic include PCB congeners, dieldrin, DDT, phthalates and alkylphenols (Thurberg and Gould 2005), which have had or still have applications in agriculture and may be present in irrigation water. Heavy metals have also been implicated in disrupting endocrine secretions of marine organisms, potentially disrupting natural biotic processes (Brodeur *et al.* 1997).

In summary, the chemical implications of sewage treatment plant effluents vary as a function of the effort taken to remove organic and inorganic contaminants collected by the wastewater treatment plant. Further complicating matters, while secondary treatment is the minimal acceptable standard treatment process in the northeast U.S., inadequately treated or even raw wastewater containing human sewage and attendant debris routinely passes into the aquatic environment from municipal processing plant outfalls when the flow and/or storage demands exceed design specifications. Such releases are commonly experienced when older sewer systems are inundated, particularly in conjunction with storm events (Shapley 2005). Accordingly, the types of treatment processes implemented, how effectively the wastewater treatment infrastructure is operating, and the salinity of the receiving waters (to the extent that it influences contaminant chemistry) are critical variables when considering the chemical implications of releasing treated wastewater into the aquatic environment.

Maintenance Activities Associated with Sewage Discharge Facilities

Maintenance activities associated with sewage treatment plants typically involve periodic application of chemicals to treat piping for colonization of biofouling organisms. Efforts to control fouling communities can produce larger field or even chronic disturbances that could adversely affect the aquatic environment. Under some circumstances, chemical treatments are not necessary and fouling communities may be removed mechanically using hot water under pressure. When this type of procedure is implemented, most of the direct impacts are physical. Although the use of pressurized, hot freshwater to mechanically remove fouling organisms may temporarily alter salinity and solute loads, some localized indirect thermodynamic effects that alter ambient chemistry could also occur in the dispersal plume until ambient temperature is restored. In addition, differences in the chemical composition of the source and receiving waters would be expected to have at least a minimal effect, particularly when chlorinated water is used to facilitate the removal of fouling organism and when there is a significant difference in salinity between cleaning and receiving waters. Perhaps more typically, colonization of fouling communities is controlled through periodic use of anti-fouling paints, coatings or other treatments. When conducted inappropriately, periodic applications of these substances can have chronic and potentially harmful effects in the aquatic environment.

Fortunately, application of biocides in aquatic systems is regulated under the Clean Water Act, which includes provisions to protect fishes and many invertebrate species to the extent practicable. Since local salinity ranges and diffusion rates at the outfall are important considerations in terms of eventual dispersion and relative toxicity of outfall maintenance materials, these and similar site-specific considerations often dictate which products may be used safely at a given project site. It is vital that only products designed and federally approved for use in and near aquatic habitats are deliberately allowed to enter U.S. waterways under any circumstances.

In general, the most deleterious effects of sewage outfall maintenance probably revolve around fouling community control measures. That is because the underlying intent of such practices is to remove a large variety of plant, animal and even bacterial populations from inhabiting the area surrounding the outfall. Biocide applications control undesirable organisms by chemical or biological means (Knight and Cooke 2002). Whether removed chemically or mechanically, the loss of these organisms at least initially may result in other forms of local ecological disturbance, such as reduced productivity and diminished prey and cover (Meffe and Carroll 1997). While outfall maintenance events individually result in an acute chemical impact to the environment and biota, it is important also to consider the cumulative effects of repeated applications over a project's maintenance cycle. Especially when undertaken regularly, the maintenance of outfall structures can create a chronic cycle of disturbance on resident biota, particularly sessile organisms.

Individual biocides and other contaminants released during outfall maintenance operations may have direct effects on local aquatic biota or they may act in an additive, synergistic or antagonistic manner in concert with ambient physical and chemical habitat conditions. Such exposure to organic and inorganic pollutants may result in a spectrum of lethal and sublethal effects that may be discerned at every level of biological organization (Thurberg and Gould 2005). Wide distribution of contaminants, such as biocides and related outfall maintenance substances, can be facilitated through bioaccumulation in motile aquatic organisms that are capable of dispersing between riverine, estuarine and marine habitats (Mearns *et al.* 1991). The pollutant-induced effects these substances engender are not limited to biochemical or physiological responses, as they may also disrupt a variety of complex behaviors which may be essential for maintaining fitness and survival (Atchison *et al.* 1987; Blaxter and Hallers-Tjabbes 1992; Kasumyan 2001; Scott and Sloman 2004).

In addition to measures to control fouling organisms in wastewater treatment facilities, maintenance activities also involve repairs and enhancements of structures associated with the facilities infrastructure. Because they typically are undertaken on a relatively small scale, physical repairs of existing infrastructure usually produce impacts of lesser intensity and on a more limited spatial scale than those created during initial installation. In contrast, application of anti-fouling coatings or related treatments not only discourages settlement by aquatic organisms on the treated surface, but also releases biocide into the aquatic environment (Richardson 1997; Terlizzi *et al.* 2001). Depending on the individual case, such releases can range from very limited to extensive plumes, as measured by the volume of material emitted and the distance broadcast away from the point source the substance may be detected in the water column.

Collectively, such releases degrade local water quality. Fortunately, chemical effects of sewage outfall maintenance in lotic coastal systems generally would be expected to dissipate relatively quickly due to dispersion by river flow or tidal action. For health and aesthetic reasons, municipal sewage outfalls should not be sited in quiescent waters. In addition, government-established protocols for biological control agents approved for applications in subaqueous discharges generally are applied in isolation within a capped pipe and subsequently released after sufficient time has passed for the biocide properties to have abated or more rarely after the bulk of the treating solution is siphoned off and dealt with offsite. Typically, such biocide solutions are designed to decompose into relatively benign constituent forms within hours, and when used properly, are thought not to pose a significant risk to non-target organisms (Diderich 2002).

As is the case for initial outfall installation impacts a variety of chemical and biological factors determine the extent to which the polluting substance affects the water column, sediments, and biota and the distance it migrates from the point source. Among them, salinity and carbonate alkalinity (HCO_3^- and CO_3^{-2} content) are especially important because of their respective roles in mediating chemical reactions in solution and in conferring the buffering capacity provided by marine and estuarine waters. Carbonate alkalinity, or water hardness, is an especially important property in riverine systems because the ambient carbonate concentrations regulate acid-base chemistry and other water quality parameters, which are thought to be important factors in the recovery of depleted salmonid populations in Maine (Johnson and Kahl 2005). While salmonids are particularly sensitive to degraded water quality, poor water quality is known to affect a wide variety of aquatic organisms (Tessier *et al.* 1984; Scott and Sloman 2004; Moore *et al.* 2005; Thurberg and Gould 2005).

Construction Impacts Associated with Sewage Discharge Facilities

The construction of municipal wastewater outfalls can have chemical effects that result from a number of activities, including releasing suspended sediments and associated pore-water in the construction zone; releasing drill mud or cuttings from a directional drilling operation; discharging substances from mechanized equipment (e.g., incidental discharges of hydrocarbons or hydraulic fluid); and introducing leachate from fresh and curing concrete, antifouling paints and other construction materials. Contaminants initially reside in aquatic systems in either a dissolved phase in the water column or in a particulate phase when they have adsorbed onto sediments or other solids. Pollutants present in biologically-available forms subsequently become assimilated by aquatic biota and become biomagnified as they are taken up in successive trophic strata (Levinton 1982; Sigel and Sigel 2001).

While plume and sedimentation effects incidental to outfall construction do not always result in a readily observable ecological response, they commonly produce a range of direct and indirect effects to living aquatic resources and their habitats. Not all of the ecological implications of sediment resuspension and transport result in adverse effects to aquatic organisms (Blaber and Blaber 1980). These effects vary a great deal depending on which life history stages are affected (Wilber and Clarke 2001). As a general rule, however, the severity of adverse chemical effects tends to be greatest for early life stages and for adults of some highly sensitive species (Newcombe and Jensen 1996). In particular, predictive models of dose-response relationships corroborate that the eggs and larvae of nonsalmonid estuarine fishes exhibit some of the most sensitive responses to suspended sediment exposures of all the taxa and life history stages for which data are available (Wilber and Clarke 2001). Mitigative measures that limit the nature and extent of chemical impacts arising from outfall installation typically can, and should, be undertaken to avoid and minimize adverse construction effects.

From the standpoint of water quality, most chemical effects associated with outfall construction should be relatively acute and transitory. Adverse water quality impacts arising from outfall installation generally arise as a consequence of: 1) substances that have adsorbed onto resuspended particles; 2) pollutants that have dissolved or leached into the water column; or 3) contaminants that have been released directly by construction equipment. These pollutants may include substances that lead to nutrient-enrichment; they may be chemically reduced; they may exhibit acidic or caustic properties; they may contain organometallic complexes or a variety of other natural or synthetic compounds; they may be hydrophobic or hydrophilic; or they otherwise may exhibit a diverse spectrum of chemical properties that affect their relative toxicity and dispersal in the water column.

While a variety of physical, chemical and biological factors come into play, the area into which such water quality impacts extends (or plume) largely is dependent on the duration of time particles and solutes are held in the water column and the distance they are transported from the construction site. For obvious reasons, grain size and ambient sediment structure characteristics have an important bearing on dispersal. As benthic material is disturbed during outfall installation and site preparation, resuspended particulate matter would settle predominantly in the immediate project vicinity. Remaining waterborne fractions subsequently would be transported over a distance and direction that are related to the grain size of disturbed sediments, the velocity of local water currents and local wave action (Neumann and Pierson 1966). Contaminants mobilized in and subsequently deposited by the dispersal plume generated by construction activities are subject to complex biogeochemical processes that ultimately dictate their fate and ecological effects. For example, hydrogen sulfide released with pore-water from disturbed sediments depletes dissolved oxygen and results in locally hypoxic or anoxic conditions in the water column until the area engulfed within the dispersal plume becomes re-oxygenated.

While important, it is essential to recognize that local sediment characteristics alone do not determine contaminant introduction or resuspension during outfall installation. The type of construction equipment used to build an outfall structure also has an important influence on the dispersion of disturbed bottom material. For traditional clamshell dredging, Tavolaro (1984) estimates a 2 percent loss of material through sediment resuspension at the dredge site. It is reasonable to conclude that similar losses would accrue when clamshells are used to install outfall pipes for sewage treatment facilities. In the same way, dredging methods that purposely fluidize sediments to facilitate their removal (e.g., hydraulic dredges, water jets) could result in even greater dispersion of resuspended sediment, especially when local waters are not quiescent or in situations where unfiltered return flow to the waterway is permitted. Since fine depositional sediments tend to have greater contaminant loads than coarser sediments typical of higher energy areas, the chemical consequences of resuspending fine sediments during outfall installation are potentially greater since they are more likely to be associated with pollutants.

Likewise, water quality implications of outfall construction are not limited to sediment resuspension or releasing pore-water that contains hydrogen sulfide. Secondary vectors of chemical contamination during outfall installation include substances introduced into aquatic habitats by construction equipment and materials. Mechanized construction equipment may inadvertently or incidentally release a broad spectrum of chemicals, fuels and lubricants into the waterway. Similarly, until the building material has completely cured or has leached out soluble contaminant fractions, subaqueous applications of wet concrete or grout, treated timber products, paints, and other construction materials would all potentially introduce pollutants into the surrounding water.

The chemical implications of constructing municipal outfalls to local substrates ultimately depends on whether (and to what extent) contaminants are released and become associated with, and accumulate in, sediments and surrounding pore-water. While sediment particles naturally exhibit cycles of exchange between the water column and bottom substrate materials (Turner and Millward 2002), dredging or outfall installation can be expected to disturb much deeper sediment horizons in a short period of time than would be expected from storms or in all but the most highly erosion prone coastal areas. As construction equipment disrupts sediment horizons at the project site, some fraction of the benthic substrate becomes resuspended into the water column (Tavolaro 1984).

Outfall construction for sewage treatment facilities can create measurable adverse impacts within the disturbed footprint, including the disruption of ambient sediment stratigraphy, cohesiveness, and geochemistry. These effects have geochemical consequences that may be particularly significant when construction activities are located in depositional or nutrient-enriched areas, and where local sediments tend to be fine-grained and contain at least moderate levels of pollution. Regardless of the nature and concentration of substances adsorbed onto the sediment or sequestered in the pore-water, salinity may significantly affect local aqueous conditions and sedimentary geochemistry, and resulting ecological effects.

While it is critical to consider the impacts of outfall construction on physical habitat features, implications for resident and transitory biota also should be taken into account. Excavation and relocation of sediments, which may be performed incidental to outfall installation, would produce a sediment plume and create sedimentation effects that could result in detrimental effects on aquatic resources present in the affected area (Newcombe and Jensen 1996; Wilber and Clarke 2001; Berry *et al.* 2003; Wilber *et al.* 2005). Direct and indirect impacts related to the removal of benthic material can elicit a variety of responses from aquatic biota (Wilber and Clarke 2001) which have been addressed elsewhere in this report.

While many potential construction impacts clearly are physical in nature, the chemical effects are complex and may have important implications for biota present in the affected area. In addition to the physicochemical considerations already discussed above, the life history and ecological strategies characteristic of different species also are important considerations in assessing the potential chemical impacts of outfall installation. For instance, while highly motile adult and juvenile life stages of most fishes could flee when construction is ongoing, egg and larval stages as well as non-motile benthic organisms could not escape contaminant exposure. While some species like the sessile life stages of American oyster (*Crassostrea virginica*) have adapted to withstand some acute habitat disturbances (Galtsoff 1964; Levinton 1982), most benthic and slow-moving species would not be able to escape contaminant exposure and instead would exhibit adaptive physiological and biochemical responses to counter any pollutants present.

Contaminants released during outfall installation activities may have direct effects on local aquatic biota or they may act in an additive, synergistic or antagonistic manner in concert with ambient physical and chemical habitat conditions. Such exposure to organic and inorganic pollutants may result in a spectrum of lethal and sublethal effects that can be discerned at the organismal, tissue, cellular and sub-cellular levels of biological organization (Thurberg and Gould 2005). Wide distribution of contaminants can be facilitated through bioaccumulation in motile aquatic organisms that are capable of dispersing between riverine, estuarine and marine habitats (Mearns *et al.* 1991).

Importantly, pollutant-induced effects are not limited to biochemical or physiological responses. Environmental pollutants such as metals, pesticides and other organic compounds also have been shown to disrupt a variety of complex fish behaviors, some of which may be essential for maintaining fitness and survival (Atchison *et al.* 1987; Blaxter and Hallers-Tjabbes 1992; Kasumyan 2001; Scott and Sloman 2004). In particular, Kasumyan (2001) provided an excellent review of how chemical pollutants interfere with normal fish foraging behavior and chemoreception physiology, while Scott and Sloman (2004) have focused on the ways metals and organic pollutants have been shown to induce behavioral and physiological effects on fresh water and marine fishes.

Industrial Discharge Facilities

Introduction

Industrial wastewater facilities face many of the same engineering and environmental challenges as municipal sewage treatment plants. Industrial discharge facilities produce a wide variety of trace elements, and organic and inorganic compounds. In the industrialized portions of the northeast U.S., such facilities include a variety of chemical plants, refineries, paper mills, defense factories, energy generating facilities, electroplating firms, mining operations and many other high intensity industrial uses that generate large volumes of wastewater. In many situations, the sanitary and industrial process streams are intermingled and processed at the industrial facility's own treatment plant, requiring that the eventual effluent is treated to address water quality concerns from a fairly broad spectrum of contaminants. While the procedures involved are similar to those implemented at municipal treatment facilities, the specific levels and methods of wastewater treatment at industrial treatment plants vary considerably. While a detailed description of industrial wastewater engineering is well beyond the scope of this technical discussion, readers interested in specific technical information may consult portions of Tchobanoglous and Stensel (2002) or Perry (1997) for more information.

Like sewage plant outfalls, industrial discharge structures are point sources for a variety of environmental contaminants, particularly heavy metals and other trace elements; nutrients; and persistent organic compounds such as pesticides and organochlorides. These substances tend to adhere to solid particles within the waste stream, become adsorbed onto finer sediment fractions once dispersed into coastal waters, and subsequently accumulate in depositional areas. Together with microbial action, local salinity and other properties of the riverine, estuarine or marine receiving waters may alter the chemistry of these contaminant-particle complexes in ways that render them more toxic than their parent compounds. Upon entering the food chain, such contaminants tend to accumulate in benthic organisms at higher concentrations than in surrounding waters (Stein *et al.* 1995) and may results in various physiological, biochemical or behavioral effects (Scott and Sloman 2004; Thurberg and Gould 2005).

Release of Heavy Metals

Industrial discharge structures can release large volumes of effluent containing a variety of potentially harmful substances into the aquatic environment. Heavy metals and other trace elements are common byproducts of industrial processes, and as a consequence are anticipated to be components of typical industrial waste streams that may enter the aquatic environment (Kennish 1998). Heavy metals may be grouped into transitional metals and metalloids. Transitional metals, such as copper, cobalt, iron and manganese, are essential for metabolic function of organisms at low concentrations but may be toxic at high concentrations. Metalloids, such as arsenic, cadmium, lead, mercury, and tin, are generally not required for metabolic function and may be toxic at low concentrations (Kennish 1998). Heavy metals are known to produce skeletal deformities and various developmental abnormalities in marine fish (Bodammer 1981; Klein-MacPhee *et al.* 1984; Lang and Dethlefsen 1987). The early life history stages of fish can be quite susceptible to the toxic impacts associated with heavy metals (Gould *et al.* 1994).

Release of Organic Compounds

A variety of synthetic organic compounds are released by industrial facilities and find their way into aquatic environments and can be taken up by resident biota. These compounds are some of the most persistent, ubiquitous, and toxic pollutants known to occur in marine ecosystems (Kennish 1998). Organochlorines, such as DDT, chlordane, and PCBs are some of the most highly toxic, persistent and well documented and studied synthetic organic compounds. Others include dioxins and dibenzofurans that are associated with pulp and paper mills and wood treatment plants, and have been shown to be carcinogenic and capable of interfering with the development of early development stages of organisms (Kennish 1998). Longwell *et al.* (1992) determined that dozens of different organic contaminants alone were present in ripe winter flounder eggs (*Pseudopleuronectes americanus*). Such accumulation can reduce egg quality and disrupt ontogenic development in ways that significantly depress survival of young (Islam and Tanaka 2004). Organic contaminants, such as PCBs, have been shown to induce external lesions (Stork 1983) and fin erosion (Sherwood 1982); and reduced reproductive success (Nelson *et al.* 1991) in marine fishes. In addition, suspicion is mounting that exposure to even very low levels of such persistent xenobiotic (i.e., foreign) compounds may disrupt normal endocrine function and lead to reproductive dysfunction such as reduced fertility, hatch rate and offspring viability in a variety of vertebrates.

Release of Petroleum Products
Oil, characterized as petroleum and any derivatives, consists of thousands of chemical compounds and can be a major stressor on inshore fish habitats (Wilk and Barr 1994; Kennish 1998). Industrial wastewater, as well as combined wastewater from municipal and storm water drains, contribute to the release of oil into coastal waters. Petroleum hydrocarbons can adsorb readily to particulate matter in the water column and accumulate in bottom sediments, where they may be taken up by benthic organisms (Kennish 1998). Water soluble compounds, such as benzene, toluene, and xylene, can be toxic to meroplankton, ichthyoplankton, and other pelagic life stages exposed to them in the water column (Kennish 1998). Short-term impacts include interference with the reproduction, development, growth and behavior (e.g. spawning, feeding) of fishes, especially early life-history stages (Gould *et al.* 1994). Oil has been demonstrated to disrupt the growth of vegetation in estuarine habitats (Lin and Mendelssohn 1996). Although oil is toxic to all marine organisms at high concentrations, certain species are more sensitive than others. In general, the early life stages (eggs and larvae) are most sensitive, juveniles are less sensitive, and adults least so (Rice *et al.* 2000).

Alteration of Water Alkalinity
A major point of departure when comparing municipal sanitary treatment outfall and industrial plant effluents concerns the ability of some industrial discharges to affect carbonate alkalinity, or buffering capacity, of receiving waters. Both riverine and estuarine strata are particularly susceptible to point source acidification because their low buffering capacity can be quickly overwhelmed by acid discharges; however, even marine habitats can be significantly and adversely affected when continual influx of acidified liquid wastewater outstrips the natural buffering capability of seawater. In riverine systems, it has been postulated that locally reduced pH may be linked to impaired Atlantic salmon recovery (Johnson and Kahl 2005) and osmoregulatory problems (NRC 2004). Oulasvirta (1990) reported periodic massive mortalities of Atlantic herring eggs from effluent containing sulfuric acid and various other metals released at a titanium-dioxide plant in the Gulf of Bothnia, Finland. Low pH in estuarine waters may lead to cellular changes in muscle tissues, which could reduce swimming ability in herring (Bahgat *et al.* 1989). A variety of industrial operations, ranging from mining and metal production to certain industrial manufacturing activities, is known to release acid effluents that may have adverse effects on fish, shellfish and

their habitat. Collectively, such detrimental impacts can hinder the survival and sustainability of fishery resources and their prey. Point source pollution from industrial sources are currently regulated by the states or the U.S. EPA through the NPDES permit program, which generally does not allow discharges of low pH water into estuaries and coastal waters of the U.S.

Release of Nutrients and other Organic Wastes

Industrial facilities that process animal or plant by-products can release effluent with high BOD which may have deleterious affects to receiving waters. Wood processing facilities, paper and pulp mills, and animal tissue rendering plants, can release nutrients, reduced sulfur and organic compounds, and other contaminants through wastewater outfall pipes. For example, wood processing plants and pulp mills release effluents with tannins and lignin products containing high organic loads and BOD into aquatic habitats (USFWS and NMFS 1999). The release of these contaminants in mill effluent can reduce dissolved oxygen in the receiving waters. According to the U.S. EPA, however, all pulp and nearly all paper mills in the U.S. have chemical recovery systems in place and primary and secondary wastewater treatment systems installed to remove particulates and BOD (USEPA 2002).

Construction Impacts of Industrial Discharge Facilities

The chemical impacts associated with constructing an industrial discharge are similar to those described for sewage treatment outfalls. Generally, such discharges predominantly entail suspending sediments and releasing pore-water in the construction zone; releasing drill mud or cuttings from horizontal directional drilling equipment; incidental discharges of fuels, lubricants and other substances from mechanized construction equipment; and leachates from construction materials. Since the substances encountered and circumstances of exposure would be the same regardless of the type of outfall being installed, the preceding discussion of sewage discharge facilities construction should be reviewed for details regarding the impacts to the water column, sediment and aquatic biota from the construction of industrial discharge facilities.

Maintenance Impacts of Industrial Discharge Facilities

The chemical impacts of maintaining industrial discharge facilities are similar to those described for sewage treatment facilities. Generally, the impacts of performing structural repairs are expected to be similar to those experienced during initial outfall installation, but on a lesser scope and magnitude. Impacts associated with the removal and treatment of fouling communities would be similar to those described for the maintenance activities of sewage treatment facilities. The appropriate subsections for sewage facilities maintenance should be reviewed for details on the implications of outfall construction on the water column, sediment and aquatic biota.

Combined Sewer Overflows

The discussion of point source discharges would be incomplete without mention of CSOs, which are ubiquitous in urban and even suburban areas in New England and the Mid-Atlantic region. For a variety of reasons, many of these municipalities operate wastewater collection systems comprised of “separate” and “combined” sewers. “Separate” sewers tend to be newer or replacement installations that have distinct piping components for stormwater and sanitary sewers. Under storm or other high runoff conditions, the separate sewer system allows excess volumes of storm water to bypass sewage treatment facilities and discharge directly into the receiving water body and constrains all sanitary waste to processing at the wastewater treatment plant. This prevents the excess volume of watershed runoff from overwhelming the operating capacity of the treatment facilities. Older systems tend to be “combined” sewer systems that commingle watershed runoff and sanitary waste streams. Typical CSOs do not discharge effluent under dry conditions, but may permit unprocessed sewage under high runoff events to enter the receiving waters completely or partially untreated. This occurs when large volumes of storm water and sewage overwhelm the treatment plant, and untreated sewage is discharged prematurely.

There is no precise estimate on the number of CSOs that exist, or how much untreated sewage is discharged from them each year. However, 828 separate NPDES permits were issued by the U.S. EPA in 2004. There were a total 9,348 authorized discharges from CSOs nationally in 2004, with approximately one half located in the northeastern U.S. and the remaining half in the Great Lakes region (USEPA 2002; USEPA 2004).

The chemical implications of CSOs are that they are potential sources of very large amounts of untreated nutrients and contaminating chemicals that degrade both the aesthetic and ecological conditions of affected habitats. In addition to the adverse effects mentioned for the other outfall types, CSOs can be important point sources for pesticides, herbicides, fertilizers and other substances commonly applied to terrestrial habitats, ranging from rural farmland and suburban yards or golf courses to highly urbanized centers. In addition, they are sources of terrestrial particulates, and may be a secondary source of atmospherically-deposited pollutants that have settled anywhere in the local watershed. While impacts associated with non-point sources are discussed elsewhere in this report, the sanitary sewer component of CSO effluents can be construed as an extension of the preceding discussions for municipal and industrial outfalls. The net effect of permitting untreated domestic wastewater to enter the receiving waterway is to diminish the effectiveness of wastewater treatment elsewhere. In so doing, CSOs contribute to increased pollution levels and related natural resource impairments. It is not possible to measure the resulting habitat damage and accompanying aquatic resource degradation in isolation from non-point pollution. However, it is important that resource managers consider the eventuality that CSO discharges can and will occur and account for the added pollutant loads they generate when setting permissible local effluent limits or establishing priorities for replacing outmoded urban infrastructure.

<u>Conservation Measures and Best Management Practices for Sewage and Industrial Discharge Facilities and CSOs</u> (adapted from Hanson *et al.* 2003)

1. Locate discharge points in coastal waters well away from shellfish beds, submerged aquatic vegetation, reefs, fish spawning grounds and similar fragile and productive habitats.
2. Determine benthic productivity by sampling prior to any construction activity related to installation of new or modified facilities. Implement all appropriate best management practices to maintain habitat quality during construction including any seasonal restrictions, use of cofferdams, working in the dry at low tide, etc., as is necessary and practicable.
3. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
4. Before finalizing outfall design, appropriate modeling studies for plume effects and other parameters of concern should be developed in cooperation with the involved resource agencies. Any appropriate recommendations that involved agencies develop as a consequence of the study results should be incorporated in the construction plans and operation plan for these facilities as enforceable permit conditions.

5. Institute all appropriate source control measures and/or elevate the treatment level to reduce the polluting substances in all effluents to the extent practicable. Ensure that discharge facilities obtain and adhere to NPDES program permits, as appropriate.
6. Ensure that maximum permissible discharges are appropriate for the given project setting and specify any and all operation procedures, performance standards, or best management practices that must be observed to address all reasonable foreseeable contingencies over the life of the project. Consider implementing an adaptive management plan that includes representatives from appropriate agencies to participate in future consultations for administering the management plan.
7. Use best available technologies to treat discharges to the maximal effective and practicable extent, including measures that reduce discharges of biocides and other toxic substances.
8. Precautions should be taken to mitigate the ecological damage arising from outfall maintenance activities. Facility maintenance plans should include measures such as: a) insuring biocides selected for a particular application should be specifically designed for its intended use; b) no more than the minimal effective dose is applied, and; c) instructions for use in aquatic applications and ultimate disposal are followed closely.
9. Use land treatment and upland disposal or storage for any sludge or other remaining wastes after wastewater processing is concluded. Use of vegetated wetlands as biofilters and pollutant assimilators for large-scale discharges should be limited only to circumstances where other less damaging alternatives are not available and the overall environmental suitability of such an action has been demonstrated.
10. Avoid locating pipelines and treatment facilities in wetlands and streams. Do not site discharges near eroding waterfronts, or where receiving waters cannot reasonably assimilate the amount of anticipated discharge.
11. Ensure that the design capacity for all facilities will address present and reasonably foreseeable need and the best available technologies are implemented.
12. Encourage communities to reduce the volume of pollutants entering CSOs and reduce the number of CSO overflows during storm water runoff producing events. The U.S. EPA provides recommended BMPs for communities (USEPA 1999b), including: a) reduce and manage solid wastes streams; b) encourage waste reduction and recycling; c) reduce commercial and industrial pollution; d) regular program of street cleaning; e) maintenance of catch basins; f) water conservation; g) reduce unnecessary fertilizer and pesticide applications and; h) sediment and erosion control.

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PHYSICAL AFFECTS: WATER INTAKE AND DISCHARGE FACILITIES

Introduction

Water intake and discharge facilities are typically municipal or industrial operations that use water for some processing purpose and/or release effluent water into the aquatic environment. Increased water diversion is associated with human population growth and development (Gregory and Bisson 1997). Some examples of facilities that use and discharge water include fossil-fuel and nuclear power plants, sewage treatment facilities, industrial manufacturing facilities, and domestic and agricultural water supplies. The construction and operation of water intake and discharge facilities can have a wide range of physical effects on the aquatic environment including changes in the substrate and sediments, water quality and quantity, habitat quality and hydrology. Most facilities that use water depend upon freshwater, or water with very low salinity, for their needs. Reductions in the quality and quantity of freshwater to bays and estuaries have led to serious damage to estuaries in the Northeast U.S. region and worldwide (Deegan and Buchsbaum 2005). This chapter discusses the physical impacts associated with water discharge and intake facilities. Refer to the chapter on Chemical Affects: Water Intake and Discharge Facilities for information on chemical impacts.

Discharge Facilities

Introduction

Although there are a number of potential impacts to aquatic resources from point-source discharges, it is important to be aware that not all point-source discharge results in adverse impacts to aquatic organisms or their habitats. Most point-source discharges are regulated by the U.S Environmental Protection Agency (U.S. EPA) under the National Pollution Discharge Elimination System (NPDES), and the effects on receiving waters are generally considered under this permitting program. As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly into surface waters. In most cases, the NPDES permit program is administered by authorized states.

Point source discharges may modify habitat by creating adverse impacts to sensitive areas such as freshwater, estuarine, and marine wetlands, emergent marshes and submerged aquatic vegetation beds and shellfish beds. Extreme discharge velocities of effluent may also cause scouring at the discharge point as well as entrain particulates and thereby create turbidity plumes.

Habitat Conversion and Exclusion

The discharge of effluent from point sources can also cause numerous habitat impacts resulting from the changes in sediments, salinities, temperatures and current patterns. These can include the conversion and loss of habitat as the salinities of estuarine areas decrease due to the inflow of large quantities of freshwater, or as areas become more saline through the discharge of effluent from desalinization plants. Temperature changes, increased turbidity and the release of contaminants can also result in the reduced use of an area by marine and estuarine species and their prey, and impede the migration of some diadromous fishes. Outfall pipes and their discharges may alter the structure of the habitats that serve as juvenile development habitat, such as eelgrass beds (Williams and Thom 2001). Power plants, for example, release large volumes of water at higher than ambient temperatures, and the area surrounding the discharge pipes may not support a healthy, productive community due to physical and chemical alterations of the habitat (Wilber and Pentony 1999).

As mentioned above, the accumulation of sediments at an outfall may alter the composition and abundance of infaunal or epibenthic invertebrate communities (Ferraro *et al*. 1991). These accumulated sediments can smother sessile organisms or force mobile animals to migrate from the area. If sediment characteristics are changed drastically at the discharge location, the benthic community composition may be altered permanently. This can lead to reductions in the biological productivity of the habitat at the discharge site for some aquatic resources as their prey species and important habitat types, such as aquatic vegetation, are no longer present. Outfall pipes can act as goins and interrupt sand transport, cause scour around the structures, and convert native sand habitat to larger course sediment or bedrock (Williams and Thom 2001). This can affect the spawning success of diadromous and estuarine species, many of which serve as prey species for other commercially or recreationally important species.

Alteration of Sediment Composition

As discussed above, outfall pipes and their discharges may alter the composition of sediments that serve as juvenile development habitat through scouring or deposition of dissimilar sediments (Williams and Thom 2001). Outfalls that typically release water at low velocities may result in a deposition of fine grained, silt-laden sediments, which may increase the need to dredge to remove sediment buildup. Conversely, outfalls that release water at higher velocities may scour sediments in the vicinity of the outfall and convert the substrate to course sediments or bedrock (Williams and Thom 2001). This can lead to a change in the community composition because many benthic organisms are sensitive to grain size. The chronic accumulation of sediments can also bury benthic organisms that serve as prey and limit an area's suitability as forage habitat.

Substrate and Sediment Scouring

The discharge of effluent from point sources can result in a variety of benthic habitat and water quality impacts relating to scouring of substrate and sediments at the discharge point. Changes to the substrate from scouring may impact benthic invertebrate and shellfish community, as well as submerged aquatic vegetation, such as eelgrass (Williams and Thom 2001).

Turbidity and Sedimentation Effects

Turbidity plumes of suspended particulates caused by the discharge of effluent, the scouring of the substrate at the discharge point, and even the repeated maintenance dredging of the discharge area, can reduce light penetration and lower the rate of photosynthesis and the primary productivity of an aquatic area while elevated turbidity persists. Fish and invertebrates in the immediate area may suffer a wide range of adverse effects, including avoidance and abandonment of the area, reduced feeding ability and growth, impaired respiration, a reduction in egg hatching success, and resistance to disease if high levels of suspended particulates persist (Newcombe and MacDonald 1991; Newcombe and Jensen 1996; Wilber and Clarke 2001). Auld and Schubel (1978) reported reduced egg hatching success in white perch and striped bass at suspended sediment concentrations of 1,000 mg/L. They also found reduced survival of striped bass and yellow perch larvae at concentrations greater than 500 mg/L and for American shad at concentrations greater than 100 mg per liter (Auld and Schubel 1978). Short-term effects associated with an increase in suspended particles may include high turbidity, reduced light, and sedimentation, which may lead to the loss of benthic structure and disrupt overall productivity if elevated levels persist (USFWS and NMFS 1999; Newcombe and Jensen 1996). Other problems associated with suspended solids include reduced water transport rates and filtering efficiency of fishes and invertebrates, and decreased foraging efficiency of sight feeders (Messieh *et al.* 1991; Wilber and Clarke 2001). Breitburg (1988) found the predation rates of striped bass larvae on copepods to decrease by 40 percent when exposed to high turbidity conditions in the laboratory. In riverine habitats, Atlantic salmon fry and parr find refuge within interstitial spaces provided by gravel and cobble that can be potentially clogged by sediments, subsequently decreasing survivorship (USFWS and NMFS 1999).

Increased Need for Dredging

The release of sediment from water discharge facilities, as well as increased turbidity and sedimentation resulting from high velocity outfall structures, can lead to a build-up of sediments. Over time this may increase the need to dredge around the intake facilities in order to prevent the sediments from negatively affecting the operations of the facility or interfere with vessel navigation. Dredging can cause direct mortality of the benthic organisms within the area to be dredged, as well as create turbidity plumes of suspended particulates that can reduce light penetration, interfere with respiration and the ability of site-feeders to capture prey, impede the migration of anadromous fishes, and affect the growth and reproduction of filter feeding organisms (Wilber and Clarke 2001). For more detailed discussion on the impacts of dredging, refer to the chapters on Marine Transportation and Offshore Dredging and Disposal Activities.

Reduced Dissolved Oxygen

The contents of the suspended material can react with the dissolved oxygen in the water and result in oxygen depletion, or bury submerged aquatic vegetation and benthos. Reduced dissolved oxygen can cause direct mortality of aquatic organisms or result in sub-acute effects such as reduced growth and reproductive success. Bejda *et al.* (1992) found that the growth of juvenile winter flounder was significantly reduced when dissolved oxygen levels were maintained at 2.2 mg/L or varied diurnally between 2.5 and 6.4 mg/L for periods of 11 weeks.

Alteration of Temperature Regimes

Sources of thermal pollution from water discharge facilities include industrial and power plants. Temperature changes due to the release of cooling water from power plants can cause unfavorable conditions for some species while attracting others. Altered temperature regimes have the ability to affect the distribution, growth rates, survival, migration patterns, egg maturation and incubation success, competitive ability, and resistance to parasites, diseases, and pollutants of aquatic organisms (USEPA 2003). Elevated water temperature can alter the normal migration patterns of some species or result in thermal stress and mortality in individuals should the discharges cease during colder months of the year. Thermal effluents in inshore habitat can cause severe problems by directly altering the benthic community or killing marine organisms, especially larval fish. Temperature influences biochemical processes of the environment and the behavior (e.g., migration) and physiology (e.g., metabolism) of marine organisms (Blaxter 1969). Investigations to determine the thermal tolerances of larvae of Atlantic herring, smooth flounder, and rainbow smelt suggests that these species can tolerate elevated temperatures for short durations which are near the upper limits of cooling systems of most normally operating nuclear power plants (Barker *et al.* 1981). However, a number of factors affected the survival of larvae, including the salinity the individuals were acclimated to and the age of the larvae.

Long-term thermal discharge may change natural community dynamics. For example, elevated water temperature has been identified as a potential factor contributing to harmful algae blooms (ICES 1991), which can lead to rapid growth of phytoplankton populations and subsequent oxygen depletion, sometime resulting in fish kills. Some evidence indicates that elevated water temperatures in freshwater streams and rivers in the northeastern U.S. due to anthropogenic impacts may be responsible for increased algal growth, which has been suggested as a possible factor in the diminished stocks of rainbow smelt (Moring 2005).

Alteration of Salinity Regimes

The discharge of water with elevated salinity levels from desalination plants may be a potential source of impacts to fishery resources. Waste brine is either discharged directly to the ocean or passed through sewage treatment plants. Although some studies have found desalination plant effluent to not produce toxic effects in marine organisms (Bay and Greenstein 1994), there may be indirect effects of elevated salinity on estuarine and marine communities, such as forcing juvenile fish into areas that could increase their chances of being preyed upon by other species. Conversely, treated freshwater effluent from municipal wastewater plants can produce localized reductions in salinity and could subject juvenile fish to conditions of less than optimal salinity for growth and development (Hanson *et al.* 2003).

Changes in Local Current Patterns

In addition to changes in temperature and salinities, local current patterns can be altered by outfall discharges or by the structures themselves. These changes can be related to changes in the rate of sedimentation around the outfall, the volume of water discharged, and the size and location of the structures.

Release of Radioactive Wastes

Both natural and man-made sources of radionuclides exist in the environment (ICES 1991). Potential sources of man-made radioactive wastes include non-point sources, such as storm water runoff and atmospheric sources (e.g., coal-burning power plants) and point sources, such as industrial facilities (e.g., uranium mining and milling fuel lubrication) and nuclear power plant discharges (ICES 1991; NEFMC 1998). Fish exposed to radioactive wastes can accumulate radioisotopes in tissues, causing toxicity to other marine organisms and consumers (ICES 1991). The identification of radioactive wastes from industrial and nuclear power plant discharges were a focus of concern during the 1980's (ICES 1991). However, most studies since then have found trends of decreasing releases of artificial radionuclides from industrial and nuclear power plant discharges and reduced tissue-burdens in sampled fish and shellfish to levels similar to naturally occurring radionuclides (ICES 1991).

Ballast Water Discharges

Commercial cargo-carrying and recreational vessels are the primary type of vector that transports marine life around the world, some of which become exotic, invasive species that can alter the structure and function of aquatic ecosystems (Valiela 1995; Carlton 2001; Niimi 2004). Ballast water discharges, occurring when ships take on additional cargo while at a port, are one of the largest pathways for the introduction and spread of aquatic nuisance species (ANS). The introduction of ANS can have wide reaching impacts to the aquatic ecosystem, economics and human health. Many ANS species are transported and released in ballast in their larval stages, becoming bottom-dwelling as adults, and include sea anemones, marine worms, barnacles, crabs, snails, clams, mussels, bryozoans, sea squirts, and seaweeds (Carlton 2001). In addition, some species are transported and released as adults, including diatoms, dinoflagellates, copepods, and jellyfish (Carlton 2001). Invasive, exotic species can displace native species and increase competition with native species, and can potentially alter nutrient cycling and energy flow leading to cascading and unpredictable ecological effects (Carlton 2001). Additional discussion of the effects of introduced species can be found in the chapters on Introduced Species, Aquaculture, and Other Biological Threats and Marine Transportation.

Behavioral Effects

Discharge facility effluents have the potential to alter the behavior of riverine, estuarine, and marine species by changing the chemical and physical attributes of the habitat and water column in the vicinity of the outfall. These include attractions to the increase in flow velocity and altered temperature regimes at the discharge point and changes in predator/prey interactions. Changes in temperature regimes can artificially attract species and alter their normal seasonal migration behavior, resulting in cold shock and mortality of fishes when ambient temperatures are colder and the flow of heated water is ceased during a facility shutdown (Pilati 1976). Shorelines physically altered with outfall structures may also disrupt the migratory patterns and pathways of fish and invertebrates (Williams and Thom 2001).

Physiological Effects

Point-source discharges can cause a wide range of physiological effects on aquatic resources including both lethal and sub-lethal effects. Alteration of temperature, salinity and dissolved oxygen concentration regimes have been shown to effect the normal physiology of marine organisms and can retard or accelerate egg and larval development and time of hatching (Blaxter 1969). Fish subjected to abnormally cold or hot temperatures from water discharges will either leave the affected area or acclimate to the change if it is within the species' thermal tolerance zone (Pilati 1976). However, a sudden change in ambient temperature can cause thermal shock and result in death to the fish; or the thermal shock may debilitate a fish and make it susceptible to predation (Pilati 1976). Temperature plays an important role in determining the survival and fitness of coldwater species, such as Atlantic salmon, and can affect the normal growth and development of eggs and fry (Blaxter 1969; Spence *et al.* 1996).

Water intake and outfall facilities can also have widespread chemical effects on aquatic organisms. These effects are discussed in the Chemical Effects: Water Discharge Facilities chapter.

Construction Related Impacts

Impacts to aquatic habitats can result from construction-related activities (e.g., dewatering, dredging) as well as routine operation and maintenance activities for water discharge facilities. Generally, these impacts are similar in nature to both water intake and outfall structures and facilities. There is a broad range of impacts associated with these activities depending on the specific design and needs of the system. For example, dredging activities associated with construction of pipelines, bulkheads and seawalls, and buildings for a facility can cause turbidity and sedimentation in nearby waters, degraded water quality, noise, and substrate alterations. Filling of the aquatic habitat may also be needed for the construction of the facilities. Excavation of sediments in subtidal and intertidal habitats during construction may have at least short-term impacts, but the recovery of the aquatic habitat for spawning and egg deposition is uncertain (Williams and Thom 2001). Many of these impacts can be reduced or eliminated through the use of various techniques, procedures, or technologies such as careful siting of the facility, timing restrictions on in-water work, the use of directional drilling for the installation of pipelines. Some impacts may not be fully eliminated except by eliminating the activity itself.

Turbidity plume and sedimentation effects incidental to facility construction commonly produce a range of direct and indirect effects to living aquatic resources and their habitats. However, not all of the ecological implications of sediment resuspension and transport result in adverse effects to aquatic organisms (Blaber and Blaber 1980). The life history and ecological strategies characteristic of different species also are important considerations in assessing potential physical impacts from facility installation. For instance, while highly motile adult and juvenile life stages of most fishes could flee when construction is ongoing, egg and larval stages as well as non-motile benthic organisms will likely not be able to avoid impacts. As a general rule, the severity of adverse effects tends to be greatest for early life stages and for adults of some highly sensitive species (Newcombe and Jensen 1996). The eggs and larvae of nonsalmonid estuarine fishes exhibit some of the most sensitive responses to suspended sediment exposures of all the taxa and life history stages for which data are available (Wilber and Clarke 2001). Reductions in the hatching success of white perch and striped bass eggs were reported at suspended sediment concentrations of 1,000 mg/L, and the survival of striped bass and yellow perch larvae were reduced at concentrations greater than 500 mg/L and for American shad larvae at concentrations greater than 100 mg/L (Auld and Schubel 1978). Nelson and Wheeler (1997) found reduced hatching success for winter flounder eggs exposed to suspended sediment concentrations as low as 75 mg/L. While some species like the sessile life stages of American oyster (*Crassostrea virginica*) have adapted to withstand some acute habitat disturbances such as sedimentation and turbidity (Galtsoff 1964; Levinton 1982), most benthic and slow-moving species would not be able to escape exposure and instead would exhibit adaptive physiological and biochemical responses to counter adverse effects to water quality.

The area effected by water quality impacts from the construction of a water discharge facility is largely is dependent on the nature of the resuspended sediments, the duration the sediments are held in the water column, and the factors contributing to the transport of the sediments from the site. As benthic material is disturbed during facility installation and site preparation, resuspended particulate matter settles predominantly in the immediate vicinity of the project. Remaining waterborne fractions subsequently would be transported from the site and dispersed according to the grain size of disturbed sediments, the velocity of local water currents and local wave action (Neumann and Pierson 1966).

The construction of water discharge facilities can create adverse impacts within the immediate vicinity of the construction, including disrupting ambient sediment stratigraphy, cohesiveness, and geochemistry. These effects have geochemical consequences that may be particularly significant when construction activities are located in depositional or nutrient-enriched areas and where local sediments tend to be fine-grained. While important, it is essential to recognize that local sediment composition is not the only factor which affects resuspension during water intake facilities installation. The type of construction equipment used to build an outfall structure also has an important influence on the dispersion of dredge material. For traditional clamshell dredging, Tavolaro (1984) estimates a 2 percent loss of material through sediment resuspension at the dredge site. Dredge equipment that fluidize sediments to facilitate their removal (e.g., hydraulic dredges or water jets) could result in a greater dispersion of resuspended sediment, especially when local waters are not quiescent or in situations where unfiltered return flow to the waterway is permitted. While sediment particles naturally exhibit cycles of exchange between the water column and materials comprising the bottom substrate (Turner and Millward 2002), mechanized equipment used to remove sediments can reasonably be expected to disturb much deeper sediment horizons in a short period of time than would be expected from storms or in all but the most highly erosion prone coastal areas.

Additional discussions of the effects of dredging, dredged material disposal, and coastal development can be found in the Marine Transportation, Coastal Development, and Offshore Dredging and Disposal chapters.

Conservation Measures and Best Management Practices for Discharge Facilities (adapted from Hanson *et al.* 2003)

1. A thorough environmental assessment of proposed site locations for water discharge facilities should be conducted prior to granting any regulatory permits. The assessments should include detailed investigations on the utilization of the aquatic environment by resident and transient species, including the migratory pathways of marine and diadromous fishes. Physical and chemical parameters of the proposed site should be included, such as sediment and substrate characteristics, hydrological dynamics of tides and currents, and temperature and salinity regimes.
2. Outfall design (e.g., modeling concentrations within the predicted plume or likely extent of deposition within the zone of influence) should be developed using site specific, hydrological data with input from appropriate resource and tribal agencies.
3. Selection of appropriate point-source discharge locations should be made using information on the concentrations of living marine resources based upon site specific, biological assessments. Sensitive and highly productive areas and habitats, such as shellfish beds, sea grass beds, hardbottom reefs should be avoided. Reduce potentially high velocities by diffusing effluent to acceptable velocities.
4. Regulate discharge temperatures (both heated and cooled effluent) such that they do not appreciably alter ambient temperatures and cause a change in species assemblages and ecosystem function in the receiving waters. Strategies should be implemented to diffuse the heated effluent.
5. Use land-treatment and upland disposal/storage techniques where possible. Use of vegetated wetlands as natural filters and pollutant assimilators for large-scale discharges should be limited to those instances where other less damaging alternatives are not available and the overall environmental and ecological suitability of such an action has been demonstrated.
6. Avoid siting pipelines and treatment facilities in wetlands and streams. Since pipelines routes and treatment facilities should not necessarily be water-dependent with regard to positioning, the priority should be to avoid their placement in wetlands or other fragile coastal habitats. Avoiding placement of pipelines within streambeds and wetlands will also reduce inadvertent infiltration into conveyance systems and retain natural hydrology of local streams and wetlands.
7. Ensure that all discharge water from outfall structures meet state and federal water quality standards. Whenever feasible, discharge pipes should extend a substantial distance offshore and be buried deep enough to not affect shoreline processes. Buildings and associated structures should be set well back from the shoreline to preclude the need for bank armoring.

Intake Facilities

Introduction

Water intake facilities can be located in riverine, estuarine and marine environments and can include domestic water supply facilities, irrigation systems for agriculture, power plants and industrial process users. In freshwater riverine systems, water withdrawal for commercial and domestic water use supports the needs of homes, farms, and industries that require a constant supply of water. Freshwater is diverted directly from lakes, streams, and rivers by means of pumping facilities or is stored in impoundments or reservoirs. Water withdrawn from estuarine and marine environments may be used to cool coastal power generating stations, as a source of water for agricultural purposes, and more recently, as a source of domestic water through desalinization facilities. In the case of power plants and desalinization plants, the subsequent discharge of water with temperatures higher than ambient levels can also occur.

Water intake structures can interfere or disrupt ecosystem functions in the source waters, as well as downstream water bodies such as estuaries and bays. The regulation of freshwater in rivers for the production of hydropower, domestic and industrial use, and agriculture reduces the volume and alters the timing of freshwater delivery to estuaries (Deegan and Buchsbaum 2005). Long-term water withdrawal may adversely affect fish and shellfish populations by adding another source of mortality to the early life-stage, which affects recruitment and year-class strength (Travnichek *et al.* 1993). Water intake structures can result in adverse impacts to aquatic resources in a number of ways, including: 1) entrainment and impingement of fishes and invertebrates; 2) alteration of natural flow rates and hydroperiod; 3) degradation of shoreline and riparian habitats; and 4) alteration of aquatic community structure and diversity.

Entrainment and Impingement

Entrainment is the voluntary or involuntary movement of aquatic organisms from the parent water body into a surface diversion or through, under or around screens, and results in the loss of the organisms from the population; whereas, impingement is the involuntary contact and entrapment of aquatic organisms on the surface of intake screens caused when the approach velocity exceeds the swimming capability of the organism (Washington Department of Fish and Wildlife 1998). Most water-intake facilities have the potential to cause entrainment and impingement of some aquatic species when they are located in areas that support those organisms. Facilities that are known to entrain and impinge marine animals include power plants, domestic and agricultural water supplies, industrial manufacturing facilities, ballast water intakes and hydraulic dredges. Some of these types of facilities need very large volumes and intake rates of water. For example, conventional 1,000-megawatt fossil fuel and nuclear power plants require cooling water rates of approximately 50 and 75 m^3/s, respectively (Hanson *et al.* 1977). The injury or death of early life history stage fish due to water diversion projects has been identified as a source of fish mortality, and egg and larval stages of aquatic organisms tend to be the most susceptible (Hallock 1977 in NOAA Fisheries 1994; Moazzam and Rizvi 1980; Richkus and McLean 2000). Entrainment can subject these life stages to adverse conditions resulting from the effects of increased heat, antifouling chemicals, physical abrasion, rapid pressure changes, and other detrimental effects. Although some temperate species of fish are able to tolerate exposure to extreme temperatures for short durations (Brawn 1960; Barker *et al.* 1981), fish and invertebrates entrained into industrial and municipal water intake structures experience nearly 100 percent mortality due to the combined stresses associated with altered temperatures, toxic effects of chemical exposure, and mechanical and pressure-related injuries (Enright 1977; Hanson *et al.* 1977; Moazzam and Rizvi 1980; Barker *et al.* 1981; Richkus and McLean 2000).

Both entrainment and impingement of fish and invertebrates in power plant and other water intake structures have immediate as well as future impacts to the riverine, estuarine and marine ecosystems. Not only is fish and invertebrate biomass removed from the aquatic system, but the biomass that would have been produced in the future would not become available to predators (Rago 1984). Water intake structures, such as power plants and industrial facilities, are a source of mortality for managed-fishery species and play a role as one of the factors driving changes in species abundance over time (Richkus and McLean 2000).

Various physical impacts to fish traversing low-head, tidal turbines in the Bay of Fundy, Canada were reported by Dadswell and Rulifson (1994), and included mechanical strikes with turbine blades, shear damage, and pressure- and cavitation-related injuries/mortality. They found between 21 and 46 percent mortality rates for experimentally tagged American shad passing through the turbine. Bell (1991 in NOAA Fisheries 1994) reported fish diverted into power turbines experience up to 40 percent mortality, and as well as injury, disorientation, and delay of migration.

Organisms that are too large to pass through in-plant screening devices instead become stuck or impinged against the screening device or remain in the forebay sections of the system until they are removed by other means (Hanson *et al.* 1977; Langford *et al.* 1978; Helvey 1985; Helvey and Dorn 1987; Moazzam and Rizvi 1980). They cannot escape because the water flow either pushes them against the screen or prevents them from exiting the intake tunnel. This can cause injuries such as bruising or descaling, as well as direct mortality. The extent of physical damage to organisms is directly related to the duration of impingement, techniques for handling impinged fish, and the intake water velocity (Hanson *et al.* 1977). Similar to entrainment, the withdrawal of water can entrap particular species especially when visual acuity is reduced (Helvey 1985) or when the ambient water temperature and the metabolism of individuals are low (Grimes 1975). This condition reduces the suitability of the source waters to provide normal habitat functions necessary for subadult and adult life stages of managed living marine resources and their prey. Increased predation can also occur. Intakes can stress or disorient fish through non-lethal impingement or entrainment in the facility and by creating conditions favoring predators such as larger fish and birds (Hanson *et al.* 1977; NOAA Fisheries 1994).

Ballast Water and Vessel Operations Intake

Vessels take in and release water in order to maintain proper ballast and stability, which is affected by the variable weight of passengers and cargo and sea conditions. In addition, water is used for cooling engine and other systems. While the discharge of ballast water can cause significant impacts on the aquatic environment, particularly through the introduction of invasive species as discussed below, the intake of water for ballast and vessel cooling can also cause entrainment and impingement impacts on aquatic organisms.

Depending upon the size of the vessel, millions of gallons of water and its associated aquatic life, particularly eggs and larvae, can be transferred to the ballast tanks of a ship at a rate of tens of thousands of gallons per minute. For example, large ships, such as those constructed to transport liquefied natural gas (LNG), need to take on ballast water to stabilize the ship during offloading of the LNG. It is estimated that a 200,000-m^3 capacity LNG carrier would withdraw approximately 19.8 million gallons of water over a 10-hour period at an intake rate of 2 million gallons per hour (FERC 2005). The use of water for ballast and vessel cooling at these volumes and rates has the potential to entrain and impinge large numbers of fish eggs and larvae. For example, in the northeast U.S., an offshore LNG degasification facility with a closed-loop system has been proposed near Gloucester, MA, with estimated annual mortality rates due to vessel ballast and cooling water of the eggs and larvae for Atlantic mackerel, pollock, yellowtail flounder, and Atlantic cod of 8.5 million, 7.8 million, 411,000, and 569,000, respectively (USCG 2006). Refer to the chapters on Energy-Related Activities and Marine Transportation for additional information on vessel entrainment and impingement impacts.

Alteration of Hydrological Regimes/Flow Restrictions

Water withdrawals for industrial or municipal water needs can have a number of physical effects to riverine systems, including altering stream velocity, channel depth and width, turbidity, sediment and nutrient transport characteristics, dissolved oxygen concentrations, and seasonal and diel temperature patterns (Christie *et al.* 1993; Fajen and Layzer 1993). These physical changes can have ecological impacts, such as a reduction of riparian vegetation that affects the availability of fish habitat and prey (Christie *et al.* 1993; Fajen and Layzer 1993; Spence *et al.* 1996). For example, the historic natural flow rates of the Ipswich River in Massachusetts have been reduced by 1/10th due to increasing water withdrawals, such as irrigation water during the growing season, power plant cooling water, and potable water for a growing human population (Bowling and Macklin 2003). Approximately one-half of the 45-mile long Ipswich River was reported to have gone completely dry in 1995, 1997, 1999, and 2002, and nearly one-half of the native fish populations have either been extirpated or severely reduced in size (Bowling and Macklin 2003). Many estuarine and diadromous species, such as American eel, striped bass, white perch, Atlantic herring, blue crab, American lobster, Atlantic menhaden, cunner, tomcod, and rainbow smelt, depend upon the development of a counter current flow set up by freshwater discharge to enter estuaries as larvae or early juveniles (Deegan and Buchsbaum 2005). Reductions in the timing and volume of freshwater entering estuaries can reduce this counter current flow and disrupt larval transport (Deegan and Buchsbaum 2005).

Increased Need for Dredging

The alteration of the hydrological regimes and reductions in flow in riverine and estuarine systems due to water intake structures can result in the build-up of sediments and increase the need to dredge around the intake facilities in order to prevent the sediments from negatively affecting the operations of the facility. Dredging can cause direct mortality of the benthic organisms within the area to be dredged, result in turbidity plumes of suspended particulates that can reduce light penetration, interfere with respiration and the ability of site-feeders to capture prey, impede the migration of anadromous fishes, and affect the growth and reproduction of filter feeding organisms. For more detailed discussion on the impacts of dredging, refer to the chapters on Marine Transportation and Offshore Dredging and Disposal Activities.

Habitat Impacts

The construction and operation of water intake facilities can have a broad range of adverse effects on fishery habitats, including the conversion and loss of habitat and the alteration of the community structure resulting from changes in the hydrological regimes, salinities and flow patterns. Large withdrawals of freshwater from riverine systems above the tidal water influence can cause an upstream “relocation” of the salt wedge, altering an area’s suitability for some freshwater species and possibly altering benthic community structure. In addition, reductions in the volume of freshwater entering estuaries can alter vertical and longitudinal habitat structure and disrupt larval transport (Deegan and Buchsbaum 2005). Water withdrawals during certain times of the year, such as the use of irrigation water during the growing season of crops, power plant cooling water used during high energy-demand periods, or for domestic water usage during dry, summer months, can severely impact the ecological health of riverine systems. For example, the water withdrawal from the Ipswich River in Massachusetts increases by two-fold or more during summer months when natural river flows are lowest (Bowling and Macklin 2003). This has led to one-half of the river going completely dry in some years, and caused fish kills and habitat degradation (Bowling and Macklin 2003).

Construction-Related Impacts of Water Intake Facilities

The physical effects of constructing water intake facilities can result from a number of activities, including releasing suspended sediments and associated pore-water in the construction zone, removal of bottom sediments and subsequent suspended sediments, turbidity and alteration of benthic habitats from dredging, releasing drill mud or cuttings from a directional drilling operation, and the loss or conversion of the existing benthic habitat and water column from placement of fill, pipelines, and shoreline stabilization structures (e.g., riprap, headwalls). The impacts are generally similar for both water intake and outfall structures and facilities are similar in nature and have been discussed in more detail in the water discharge facilities section of this chapter.

Conservation Measures and Best Management Practices for Water Intake Facilities (adapted from Hanson *et al.* 2003)

1. Locate facilities that rely on surface waters for cooling of ballast in areas other than estuaries, inlets, heads of submarine canyons, rock reefs or small coastal embayments where important fishery species or their prey concentrate for spawning and migration.
2. Design and operate facilities to create flow conditions that provide for passage, water quality, proper timing of life history stages, and properly functioning channel, floodplain, riparian, and estuarine conditions.
3. Establish adequate instream flow conditions for anadromous fish.
4. Design intake structures to minimize entrainment or impingement. Velocity caps that produce horizontal intake/discharge currents should be employed and intake velocities across the intake screen should generally not exceed 0.5 ft/s.
5. Closed-loop cooling systems should be utilized in facilities requiring water whenever practicable, especially in areas that would impinge and entrain large numbers of fish and invertebrates.
6. Screen water diversions on fish-bearing streams, as needed. In general, 2 mm wedge wire screens are recommended on intake facilities in areas that support anadromous fishes.
7. Incorporate juvenile and adult fish passage facilities on all water diversion projects (e.g., fish bypass systems).
8. Assess existing and potential aquatic vegetation, the volume and depth of the water body, the amount and timing of freshwater inflow, the presence of upland rearing and spawning habitat, and the relative salinity of the water body.
9. Assess the hydrology of the regulated land’s tolerance for increased water exchange. The assessment should account for active management of the water intake facility to allow increased water exchange during critical periods.
10. Install intake pipes and facilities during low flow periods and tidal stage; incorporate appropriate erosion and sediment control BMPs, and have an equipment spill and containment plan and appropriate materials onsite.
11. Monitor facility operations to assess impacts on water temperatures, dissolved oxygen, and other applicable parameters. Adaptive management should be designed to minimize impacts.

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AGRICULTURE AND SILVICULTURE

Croplands, Rangelands, Livestock and Nursery Operations

Introduction

Substantial portions of croplands, rangelands and commercial nursery operations are connected, either directly or indirectly, to coastal waters where point and nonpoint pollution can have an adverse effect on aquatic habitats. According to the U.S. Environmental Protection Agency's (U.S. EPA) 2000 National Water Quality Inventory, agriculture was the most wide spread source of pollution for assessed rivers and lakes (USEPA 2002a). In that report, agriculture was responsible for 18 percent of all river-mile impacts and 14 percent of all lake-acre impacts in the U.S. In addition, 48 percent of all impaired river miles and 41 percent of all impaired lake acres was attributed to agriculture (USEPA 2002a). Impacts to fishery habitat from agricultural and nursery operations can be the result of: 1) nutrient loading; 2) introduction of animal wastes; 3) erosion; 4) introduction of salts; 5) pesticides; and 6) sedimentation (USEPA 2002a).

Release of Nutrients/Eutrophication

Nutrients in agricultural land are found in several different forms and originate from various sources, including: 1) commercial fertilizers containing nitrogen, phosphorus, potassium, secondary nutrients, and micronutrients; 2) manure from animal production facilities; 3) legumes and crop residues; and 4) irrigation water (USEPA 2002a). In addition, agricultural lands are characterized by poorly maintained dirt roads, ditches and drains that transport sediments and nutrients directly into surface waters. In many instances, headwater streams have been replaced by a constructed system of roads, ditches and drains that deliver nutrients directly to surface waters (Larimore and Smith 1963). Worldwide, the production of fertilizers is the largest source of anthropogenic nitrogen mobilization, although atmospheric deposition exceeds fertilizers as the largest non-point source of nitrogen to surface waters in the northeastern U.S. (Howarth *et al.* 2002). Human activity is estimated to have increased nitrogen input to the coastal water of the northeastern U.S., specifically to Chesapeake Bay, by 6- to 8-fold (Howarth *et al.* 2002). Castro *et al.* (2003) estimated that the Mid-Atlantic and southeast regions contained between 24 to 37 percent agricultural lands, with fertilizers and manure applications representing the highest nitrogen sources for those watersheds. The Pamlico-Pungo Sound, North Carolina, Wynah Bay, South Carolina, and Chesapeake Bay estuaries contained the highest percent of nitrogen sources coming from agriculture from these regions (Castro *et al.* 2003). The second leading cause of pollution in streams and rivers in Pennsylvania has been attributed to agriculture, primarily nutrient loading and siltation (Markham 2006).

Nitrogen and phosphorus are the two major nutrients which degrade water quality due to agriculture sources. The main forces controlling nutrient movement from land to water are runoff, soil infiltration, and erosion. Introduction of these nutrients into aquatic systems can promote aquatic plant productivity and decay that lead to cultural eutrophication (Waldichuk 1993). Eutrophication can adversely affect the quality and productivity of fishery habitats in rivers, lakes, estuaries, and near-shore, coastal waters. Eutrophication can cause a number of secondary effects, such as increased turbidity and water temperature, accumulation of dead organic material, decreased dissolved oxygen, and the proliferation of aquatic vegetation. Cultural eutrophication has resulted in widespread damage to the ecology of the Chesapeake Bay, causing nuisance algal blooms, loss of productive shellfish and blue crab habitat, and destruction of submerged aquatic vegetation beds (Duda 1985). Nearly 80 percent of the nutrient loads into Chesapeake Bay can be attributed to nonpoint sources, and agriculture accounted for the majority of those (USEPA 2003b). Agriculture accounts for approximately 40 percent and 48 percent of nitrogen and phosphorus loads, respectively, to the Bay (USEPA 2003b). Chronic eutrophication has severely impacted the historically productive recreational and commercial fisheries of the Chesapeake Bay.

While eutrophication generally causes increased growth of aquatic vegetation, it has been shown to be responsible for wide spread losses of submerged aquatic vegetation in many urbanized estuaries (Deegan and Buchsbaum 2005). By stimulating the growth of macroalgae, eutrophication can alter the physical structure of seagrass meadows such as decreased shoot density, and reductions in the size and depth of beds (Short *et al.* 1993). These alterations can result in the destruction of habitat that is critical for developing juvenile fish and can severely impair biological food chains (Hanson *et al.* 2003).

Groundwater is also susceptible to nutrient contamination in agricultural lands composed of sandy or other coarse-textured soil (USGS 1999). Nitrate, a highly soluble and mobile form of nitrogen, can leach rapidly through the soil profile and accumulate in groundwater, especially in shallow zones (USEPA 2003a). In the eastern U.S., nitrogen contamination of ground water is generally higher in areas that receive excessive applications of agriculture fertilizers and manure, most notably in middle Atlantic states like Delaware, Maryland and Virginia (i.e., Delmarva Peninsula) (USEPA 2003a). When discharged through seeps, drains, or by direct subsurface flow to water bodies, groundwater can be a significant source of nutrients to surface waters (Hanson *et al.* 2003). Phosphorus from agricultural sources, such as manure and fertilizer applications and tillage, can also be a significant contributor to eutrophication in freshwater and estuarine ecosystems. Cultivation of agricultural land greatly increases erosion and with it the export of particle-bound phosphorus.

Livestock waste (manure), including fecal and urinary wastes of livestock and poultry, processing water and the feed, bedding, litter, and soil with which they become intermixed, is reported to be the single largest source of phosphorus contamination in the U.S. (Howarth *et al.* 2002). Because cattle are often allowed to graze in riparian areas, nutrients that are consumed elsewhere are often excreted in riparian zones that can impact adjacent aquatic habitats (Hanson *et al.* 2003). Because grazing processes remove or disturb riparian vegetation and soils, runoff that carries additional organic wastes and nutrients into aquatic habitats is accelerated (Hanson *et al.* 2003). Pollutants contained and processed in rangelands, pastures, or confined animal facilities can be transported by storm water runoff into aquatic environments. These pollutants may include oxygen-demanding substances such as nitrogen and phosphorus; organic solids; salts; bacteria, viruses and other microorganisms; metals; and sediments that increase organic decomposition (USEPA 2003a). Increased nutrient levels due to processed water or manure causes excessive aquatic plant growth and algae. The decomposition of aquatic plants depletes dissolved oxygen in the water, creating anoxic or hypoxic conditions that can lead to fish kills. For example, six individual spills from animal waste lagoons in North Carolina during 1995 totaled almost 30 million gallons; including one spill that involved 22 million gallons of swine waste that was responsible for a fish kill along a 19-mile stretch of the New River (USEPA 2003a). Animal wastes from farms in the U.S. produce nearly 1.5 billion tons of nitrogen and phosphate-laden wastes each year that contribute to nutrient contamination in approximately 27,999 miles of rivers and groundwater (Markham 2006). The release of animal wastes from livestock production facilities have led to reductions in productivity of riverine, estuarine and marine habitats due to eutrophication.

Reduced Dissolved Oxygen

Reduced (hypoxic) or depleted (anoxic) oxygen conditions within coastal water as a result of cultural eutrophication may be one of the most severe problems facing coastal waters in the U.S. (Deegan and Buchsbaum 2005), and agriculture is a major contributing source in some areas. In general, extensive hypoxia has been more chronic in river-estuarine systems in the southern portions of the Northeast coast (i.e., Narragansett Bay to Chesapeake Bay) than in the northern portion (Whitledge 1985; O'Reilly 1994; NOAA 1997). In 2001 approximately 50 percent of the deeper waters of the Chesapeake Bay had reduced dissolved oxygen concentrations (USEPA 2003b)

Low dissolved oxygen conditions tend to occur in bottom waters at night during summer months due to warm temperatures, high metabolic sediment demand and water column stratification (Deegan and Buchsbaum 2005). Hypoxia of coastal waters north of Cape Cod, MA are uncommon, due to strong mixing and flushing characteristics of the estuaries in the northern New England region. However, high nutrient loads into aquatic habitats from livestock and croplands can cause hypoxic or anoxic conditions that can result in fish kills in rivers and estuaries in other areas of the northeast coast (USEPA 2003a; Deegan and Buchsbaum 2005), and potentially alter long-term community dynamics (NRC 2000; Castro *et al.* 2003). Chronically low-dissolved oxygen conditions can lower the growth and survivorship of finfish and shellfish. For example, the effect of constant and diurnally fluctuating levels of dissolved oxygen has been shown to reduce the growth of young-of-the-year winter flounder, *Pseudopleuronectes americanus* (Bejda *et al.* 1992).

Bank and Soil Erosion

Soil erosion in U.S. farmland is estimated to occur seven times as fast as soil formation (Markham 2006). Soil erosion can lead to the transport of fine sediment that may be associated with a wide variety of pollutants from agricultural land into the aquatic environment. The presence of livestock in the riparian zone accelerates sediment transport rates by increasing surface soil erosion (Hanson *et al.* 2003), loss of vegetation due to trampling and increase streambank erosion due to shearing or sloughing (Platts 1991). Increased sedimentation in aquatic systems can increase turbidity and the temperature of the water, reduce light penetration and dissolved oxygen, smother fish spawning areas and food supplies, decrease the growth of submerged aquatic vegetation, clog the filtering capacity of filter feeders, clog and harm the gills of fish, interfere with feeding behaviors of certain species and significantly lower overall biological productivity (Duda 1985; USEPA 2003a). Soil eroded and transported from cropland usually contains a higher percentage of finer and less dense particles, which tend to have a higher affinity for adsorbing pollutants such as insecticides, herbicides, trace metals and nutrients (Duda 1985; USEPA 2003a). One of the consequences of erosional runoff from agricultural land is that it necessitates more frequent dredging of navigational channels (Wilk and Barr 1994; USEPA 2003a), which may result in transportation and disposal of contaminated sediments in areas important to fisheries production and other marine biota (Witman 1996). Deposition of sediments from erosional runoff can also decrease the storage capacity of roadside ditches, streams, rivers, and navigation channels, resulting in more frequent flooding (USEPA 2003a).

Loss and Alteration of Riparian-Wetland Areas

Functioning riparian-wetland areas require stable interactions between geology, soil, water, and vegetation in order to maintain productive riverine ecosystems. When functioning properly riparian-wetland areas can: 1) reduce erosion and improve water quality by dissipating stream energy; 2) filter sediment and runoff from floodplain development; 3) support denitrification of nitrate-contaminated ground water; 4) improve floodwater retention and ground water discharge; 5) develop root masses that stabilize banks from scouring and slumping; 6) develop ponding and channel characteristics necessary to provide habitat for fish, waterfowl and invertebrates; and 7) support biodiversity (USEPA 2003a). Agriculture activities have the potential to degrade riparian habitats. In particular, improper livestock grazing along riparian corridors can eliminate or reduce vegetation due to trampling and increase streambank erosion due to shearing or sloughing (Platts 1991). These effects tend to increase the streambank angle, which increases stream width, decreases stream depth, and alters or eliminates fish habitat (USEPA 2003a). As discussed above, the transport of eroded soil from the streambank to streams and rivers impacts water quality and aquatic habitats. Removing riparian vegetation also increases the amount of solar radiation reaching the stream and can result in higher water temperatures.

Change in Community Structure and Species Composition

Cropland and livestock operations can result in community-level impacts to riverine and estuarine ecosystems. As mentioned above, fertilizers applied to agricultural lands enter streams, rivers, and estuaries through stormwater runoff and groundwater sources (e.g., seeps and subsurface flows) and may result in eutrophication. Eutrophication can cause a number of secondary effects, such as increased turbidity and water temperature, accumulation of dead organic material, decreased dissolved oxygen, and the proliferation of macroalgae. These alterations can in turn result in the destruction of habitat for small or juvenile fish and severely impair biological food chains (Hanson *et al.* 2003). For example, eelgrass beds growing in deeper areas of estuaries tend to be impacted more than shallower areas because those beds are very sensitive to light attenuation due to eutrophication (Deegan and Buchsbaum 2005). Species that depend upon eelgrass beds may be forced into shallower, potentially less desirable habitats. Declines in commercially and recreationally important finfish in Waquoit Bay, Massachusetts, have followed a concomitant decline in eelgrass beds for that area (Deegan and Buchsbaum 2005). Similarly, the eelgrass wasting disease was documented to be responsible for severe declines in bay scallop landings along the east coast in the 1930's (Buchbaum 2005).

Other impacts from agricultural activities such as soil erosion and release of fine sediments, can alter aquatic communities through siltation and alteration of benthic substrates. Waldichuk (1993) identified a number of impacts to Pacific salmon due to activities related to agriculture, such as siltation in spawning, egg incubation and feeding habitats, impaired respiration and abrasion of gills from suspended particles, and failure of egg hatching due to low dissolved oxygen. The cumulative effect from the degradation of riverine habitats can inhibit or preclude restoration efforts of salmon populations to historic ranges by altering the community. Release of nutrients from fertilizers applied to croplands, livestock manure, and erosion of soils can reduce the dissolved oxygen levels in aquatic habitats through storm water runoff. Reduced dissolved oxygen in the water or sediments can change community composition to coastal habitats, particularly in areas with restricted water circulation such as coastal ponds, subtidal basins, and salt marsh creeks (Deegan and Buchsbaum 2005). Chronic hypoxia due to cultural eutrophication can permanently alter the species composition and productivity of these areas.

Altered Temperature Regimes

Increased siltation in shallow aquatic habitats due to erosion from croplands and livestock operations can result in increased water temperature (Duda 1985). In addition to accelerating bank erosion, loss of riparian vegetation due to livestock grazing can increase the amount of solar radiation reaching streams and rivers and resulting in an increase in water temperatures (Moring 2005). Altered temperature regimes have the ability to affect the distribution, growth rates, survival, migration patterns, egg maturation and incubation success, competitive ability, and resistance to parasites, diseases, and pollutants of aquatic organisms (USEPA 2003a). In freshwater habitats of the northeastern U.S., the temperature regimes of cold-water fish such as Atlantic salmon, rainbow smelt and trout, may be exceeded leading to local extirpation of the species. The removal of riparian vegetation can also have the effect of lowering water temperatures during winter, which can increase the formation of ice and delaying the development of incubating fish eggs and alevins (Hanson *et al.* 2003). Some evidence indicates that elevated water temperatures in freshwater streams and rivers in the northeastern U.S. may be responsible for increased algal growth, which has been suggested as a possible factor in the diminished stocks of rainbow smelt (Moring 2005). In the watersheds of eastern Maine, blueberry and cranberry processing plants discharge processing water into rivers important to Atlantic salmon spawning and migration. These facilities are permitted to discharge water at temperatures known to be lethal to both juvenile and adult Atlantic salmon (USFWS and NMFS 1999).

Siltation, Sedimentation and Turbidity

As discussed above, siltation, sedimentation, and turbidity impacts related to agricultural activities are generally a result of soil erosion. Agricultural lands are also characterized by poorly maintained dirt roads, ditches and drains that transport sediments directly into surface waters. Suspended sediments in aquatic environments reduces the availability of sunlight to aquatic plants, covers fish spawning areas and food supply, interferes with filtering capacity of filter feeders, and can clog and harm the gills of fish (USEPA 2003a). For example, the largest source of sediment into Chesapeake Bay is from agriculture. Approximately 63 percent of the over 5 million pounds of sediment delivered each year to tidal waters of the Chesapeake Bay comes from agricultural sources (USEPA 2003b), resulting in devastating impacts to shellfish and submerged aquatic vegetation.

In addition to the affects described in greater detail within the Bank and Soil Erosion subsection above, contaminants such as pesticides, phosphorus, and ammonium are transported with sediment in an adsorbed state, such that they may not be immediately available to aquatic organisms. However, alteration in water quality, such as decreased oxygen concentration or changes in water alkalinity, may cause these chemicals to be released from the sediment (USEPA 2003a). Consequently, the impacts to aquatic organisms associated with siltation and sedimentation may be combined with the affects of pollution originating from the agricultural lands.

Altered Hydrological Regimes

There are both direct and indirect affects of agriculture activities on the hydrology of coastal watersheds. Direct alterations of hydrology occur from water diversion projects used for crop irrigation and livestock operations. Water diverted for agriculture reduces the volume and alters the timing of freshwater delivery to estuaries, which in turn can increase the salinity of coastal marine ecosystems and diminish the supply of sediments and nutrients to coastal systems (Deegan and Buchsbaum 2005). Agriculture activities use large volumes of water for irrigation, accounting for one-third of all U.S. water withdrawals in 2000 and the second largest source of total water use after thermoelectric energy (Markham 2006).

Water withdrawal for agriculture can have adverse affects on anadromous fish, particularly Atlantic salmon, which use rivers in the Gulf of Maine for spawning and migration. Water withdrawals pose a threat to life stages of Atlantic salmon and their habitat in the Machias, Pleasant, and Narraguagus Rivers (USFWS and NMFS 1999). According to this report, freshwater is diverted from eastern

Maine watersheds to irrigate approximately 6,000 acres of blueberry agricultural activities, but that acreage was expected to double by the year 2005 (USFWS and NMFS 1999).

Altered hydrodynamics can affect estuarine circulation, including short-term (diel) and longer term (seasonal or annual) changes (Deegan and Buchsbaum 2005). In addition, counter current flows set up by freshwater discharges into estuaries are important for larvae and juvenile fish recruitment entering those estuaries. Diurnal behavioral adaptations of marine and estuarine species allow larvae and early juveniles to concentrate in estuaries. Reductions in freshwater flows due to increased freshwater withdrawals for irrigation of crops and livestock can disrupt counter current flows and larval transport into estuaries (Deegan and Buchsbaum 2005). The quality and quantity of freshwater flows into estuaries are important in maintaining suitable conditions for spawning, egg, larval, and juvenile development for many estuarine-dependent species.

Indirect affects occur when sediments are transported from agricultural lands due to soil erosion and are deposited in roadside ditches, streams, rivers, and navigation channels, which decrease the capacity of the watershed to attenuate the affects of flooding. The morphology of streams and rivers can be altered due to eroded soil from improper livestock grazing and croplands, changing the stream width and depth and the timing and magnitude of stream flow (USEPA 2003a). In addition, sediment deposited in lakes and navigation channels reduces the storage capacity of those systems and necessitates more frequent dredging (USEPA 2003a).

Entrainment and Impingement

Water diverted and extracted for agriculture use can entrain (i.e., draw into flow system) and impinge (i.e., capture onto filter screens) aquatic organisms. Entrainment and impingement generally affects eggs, larvae, and early juvenile fish and invertebrates that cannot actively avoid the currents created at the water intake opening (ASMFC 1992). Long-term water withdrawal may adversely affect fish and invertebrate populations, as well as their prey, by adding another source of mortality to the early life stage which often determines recruitment and year-class strength (Hanson *et al.* 2003). Refer to the Physical Affects: Water Intake and Discharge Facilities chapter in this report for additional information on entrainment and impingement.

Impaired Fish Passage

Sediments transported from agricultural lands due to soil erosion can change the morphology of streams and rivers. As a result, alteration of stream width and depth and the timing and magnitude of stream flow can impair the ability of anadromous fish to reach upstream spawning habitats. Roads that are constructed to access agriculture lands and for livestock may impede or prohibit migrating fish. For example, culverts constructed under roads to allow for water flow can alter the velocity and volume of water in streams, and inhibit the ability of fish to migrate through the structure (Furniss *et al.* 1991). Additional information on fish passage impairments can be reviewed in the Alterations of Freshwater Systems chapter of this report.

Reduced Soil Infiltration and Soil Compaction

Tillage of croplands aerates the upper soil, but tends to compact fine textured soils just below the depth of tillage, thus altering infiltration. Use of farm machinery on cropland and adjacent roads causes further compaction, reducing infiltration and increasing surface runoff (Hanson *et al.* 2003).

Johnson (1992) and Platts (1991) reviewed studies related to livestock grazing and concluded that heavy grazing nearly always decreases infiltration, reduces vegetative biomass, and increases bare soil. Compaction of rangelands generally increases with grazing intensity, although site-specific soil and vegetative conditions are also important factors in determining the effects of soil compaction (Kauffman and Krueger 1984). Reduced soil infiltration and compaction due to agriculture are two of the factors that accelerate erosion and release of sediments and contaminants in aquatic habitats.

Salts are present in varying amounts in all soils due to the natural weathering process, but agricultural lands that have poor subsurface drainage can lead to high salt concentrations. Likewise, irrigation water, whether from ground or surface water sources has a natural base load of dissolved mineral salts. Irrigation return flows convey the salt to the receiving streams or groundwater reservoirs. If the amount of salt in the return flow is low in comparison to the total stream flow, water quality may not be degraded to the extent that aquatic functions are impaired. However, if the process of water diversion and the return flow of saline drainage water is repeated many times along a stream or river, downstream habitat quality can become progressively degraded (USEPA 2003a). The accumulation of salts, particularly on irrigated croplands, tends to cause soil dispersion, structure breakdown and decreased infiltration (USEPA 2003a). While salts are generally a greater pollutant for freshwater ecosystems than estuarine systems, they may adversely affect anadromous fish that depend upon freshwater systems for crucial portions of their life cycles (USEPA 2003a).

Land-use Change (Post-Agriculture)

When demands for developable land are sufficiently high, the value of land in developed use will exceed its value in agricultural use. In general, conversion of land from agricultural to urban uses is largely irreversible according to the U.S. Department of Agriculture. In the continental U.S., census data from urban areas has shown more than a doubling of agricultural land conversion from 25.5 million acres to 55.9 million acres between 1960 and 1990 (USDA 2005). While impacts on aquatic ecosystems from agriculture may be problematic in some areas, conversion of croplands and rangelands to urban and industrial uses may be more harmful in the long-term. For example, between 1992 and 1997 the state of New York has lost approximately 90,000 acres of prime farmland to residential and commercial development, which was 140 percent faster than in the previous five years (Markham 2006). Refer to the Coastal Development chapter in this report for more information on the impacts of land-use change.

Release of Pesticides, Herbicides, and Fungicides

The term “pesticide” is a collective description of hundreds of chemicals from different sources and different fates in the aquatic environment that have different toxic effects on fish and other aquatic organisms. Agricultural activities are a major non-point source of pesticide and herbicide pollution in coastal ecosystems (Hanson *et al.* 2003). Large quantities of pesticides, perhaps 18 to 20 pounds of pesticide active ingredient per acre, are applied to vegetable crops in coastal areas to control insect and plant pests (Scott *et al.* 1999). Soil eroded and transported from croplands and rangelands usually contains a higher percentage of finer and less dense particles, which tend to have a higher affinity for adsorbing pollutants such as insecticides and herbicides (Duda 1985; U.S. EPA 2003a). In addition, agricultural lands are typically characterized by poorly maintained dirt roads, ditches and drains that transport sediments, nutrients, and pesticides directly into surface waters. In many instances, roads, ditches and drains have replaced headwater streams, and these constructed systems deliver pollutants directly to surface waters (Larimore and Smith 1963). Pesticides are frequently detected in freshwater and estuarine systems that provide fishery habitat. A variety of human activities, such as fire suppression on forested lands, forest site preparation, algae control in lakes and irrigation canals, and various agricultural practices, result in contamination from chemicals used in these activities (Hanson *et al.* 2003).

The most common pesticides include insecticides, herbicides, and fungicides. These are used for pest control on forested lands, agricultural crops, tree farms and nurseries. Pesticides can enter the aquatic environment as single chemicals or complex mixtures. Direct applications, surface runoff, aerial drift, leaching, agricultural return flows, and groundwater intrusions are all examples of transport processes that deliver pesticides to aquatic ecosystems (Hanson *et al.* 2003).

Most studies evaluating pesticides in runoff and streams generally find that concentrations can be relatively high near the application site and soon after application, but are significantly reduced further downstream and with time (USEPA 2003a). However, some pesticides used in the past, such as DDT, are known to persist in the environment for years after application. Chlorinated pesticides, such as DDT, and some of the breakdown products are known to cause malformation and fatality in eggs and larvae, alter respiration, and disrupt central nervous system functions in fish (Gould *et al.* 1994). In addition, pesticides containing organochlorine compounds accumulate and persist in the fatty tissue and livers of fish, and could be a threat to human health for those who consume contaminated fish (Gould *et al.* 1994).

Pesticides may bioaccumulate in organisms by first being adsorbed by sediments and detritus which is ingested by zooplankton, and then eaten by planktivores, which in turn are eaten by fish (ASMFC 1992). For example, the livers of winter flounder (*Pseudopleuronectes americanus*) from Boston and Salem Harbors contained the highest concentrations of DDT found on the east coast of the US and were ranked first and third, respectively, in the country in terms of total pesticides (Larsen 1992). In the Pocomoke River, a tributary of the Chesapeake Bay, agricultural runoff (primarily from poultry farms) was identified as one of the major sources of contaminants (Karuppiah and Gupta 1996). Blueberry and cranberry agriculture is an important land use in eastern Maine watersheds, and involves the use of a number of pesticides, herbicides and fungicides that may cause immediate mortalities to juvenile Atlantic salmon or can have direct effects when chemicals enter rivers (USFWS and NMFS 1999). One study investigating the effects of two different classes of pesticides (organochlorines and organophosphates) in South Carolina estuaries, found significant affects on populations of the dominant macrofauna species, grass shrimp and mummichogs (Scott *et al.* 1999). The study found impacts from pesticide runoff on grass shrimp populations may cause community-level disruptions in estuaries; however, the authors concluded that implementation of integrated pest management, best management practices and retention ponds could significant reduce the levels of non-point source runoff from agriculture (Scott *et al.* 1999).

<u>Endocrine Disruptors</u>

Studies have recently focused on a group of chemicals, called "endocrine disruptors", that when present at extremely low concentrates can interfere with fish endocrine systems. Some of these chemicals act as "environmental hormones" that may mimic the function of the sex hormones androgen and estrogen (Thurberg and Gould 2005). Some of the chemicals shown to be estrogenic include some PCB congeners, dieldrin, DDT, phthalates and alkylphenols (Thurberg and Gould 2005), which have had or still have applications in agriculture. Several studies have found vitellogenin, a yolk precursor protein, in male fish in the North Sea estuaries (Thurberg and Gould 2005). Heavy metals have also been implicated in disrupting endocrine secretions of marine organisms, potentially disrupting natural biotic processes (Brodeur *et al.* 1997). However, the long-term effect of endocrine-disrupting substances on aquatic life is not well understood and demands serious attention by the scientific and resource policy communities.

Introduction of Pathogens

Fish diseases and shellfish poisoning (e.g., paralytic, amnesic, and neurotoxic) may be linked to agricultural runoff. There is evidence that nutrient overenrichment has led to increased incidence, extent, and persistence of blooms and noxious or toxic species of phytoplankton; increased frequency, severity, spatial extent, and persistence of hypoxia; alterations in the dominant phytoplankton species and size compositions; and greatly increased turbidity of surface waters from plankton algae (O'Reilly 1994). See also the chapter on Introduced/Nuisance Species and Aquaculture.

Conservation Measures and Best Management Practices for Croplands, Rangelands, Livestock and Nursery Operations (adapted from Hanson *et al.* 2003)

1. Recommend field and landscape buffers to provide cost-effective protection against the cumulative effects of multiple pollutant discharges associated with agricultural activities, including riparian forests, alley cropping, contour buffer strips, crosswind trap strips, field borders, filter strips, grassed waterways with vegetative filters, herbaceous wind barriers, vegetative barriers, and windbreak/shelterbelts.
2. Protect and restore soil quality with natural controls that affect permeability and water holding capacity, nutrient availability, organic matter content, and biological activity of the soil. Some example of best management practices include cover cropping, crop sequence, sediment basins, contour farming, conservation tillage, crop residue management, grazing management, and the use of low-impact farming equipment.
3. Promote efficient use and appropriate applications of pesticides and irrigated water. Sound agricultural practices include use of integrated pest management, irrigation management and soil testing and appropriate timing of nutrient applications.
4. Encourage protection and restoration of rangelands using practices such as rotational grazing systems or livestock distribution controls, exclusion of livestock from riparian and aquatic areas, livestock-specific erosion controls, reestablishment of vegetation, or extensive brush management correction.
5. Avoid locating new confined animal facilities or expansion of existing facilities near riparian habitat, surface waters, and areas with high leaching potential to surface or groundwater. Ensure that adequate nutrient and wastewater collection facilities are in place.
6. Minimize water withdrawals for irrigation and promote water conservation measures, such as water reuse.
7. Roads for agricultural lands should be sited to avoid sensitive areas such as streams, wetlands, and steep slopes.
8. BMPs should be included for agricultural road construction plans, including erosion control, avoidance of side casting of road materials into streams, and using only native vegetation in stabilization plantings.
9. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Silviculture and Timber Harvest Activities

Introduction

The growth and harvest of forestry products is a major land use type for watersheds along the east coast, particularly in New England, and can have short-term and long-term impacts to riverine habitat (USFWS and NMFS 1999). In Maine, forestry is the dominant land-use type in the watersheds of the Dennys, East Machias, Machias, Pleasant and Narraguagus Rivers (USFWS and NMFS 1999). Timber harvests generally removes the dominant vegetation, converts mature and old-growth upland and riparian forests to tree stands or forests of early seral stage, reduces the permeability of soils, increases sedimentation from surface runoff and mass wasting processes, alters hydrologic regimes and impairs fish passage through inadequate design, construction, and maintenance of stream crossings (Hanson *et al.* 2003). Silviculture practices can also increase water temperatures in streams and rivers, increase impervious surfaces and decrease water retention capacity in watersheds (USFWS and NMFS 1999). These watershed changes may result in inadequate river flows, increase stream bank and streambed erosion, sedimentation and siltation of riparian and stream habitat, increase in the amount of woody debris, and an increase of run-off and associated contaminants (e.g., from herbicides) (Sigman 1985; Hicks *et al.* 1991; Hanson *et al.* 2003). Debris (i.e., wood and silt) is released into the water as a result of timber harvest activities and can smother benthic habitat. Poorly placed or designed road construction can cause erosion, producing additional silt and sediment that can impact stream and riparian habitat. Deforestation can alter or impair natural habitat structures and dynamics of the ecosystem.

Four major categories of silviculture activities that can impact fishery habitat are: 1) construction of logging roads; 2) creation of barriers; 3) removal of streamside vegetation; and 4) impacts to aquatic habitats from pesticide and herbicide treatments.

<u>Alteration and Loss of Vegetation</u>
By removing vegetation, timber harvesting tends to decrease the absorptive capability of the groundcover vegetation. This, in turn, increases surface runoff during periods of high precipitation. These effects can destabilize slopes and increase erosion, and cause sedimentation and debris input to streams (Hanson *et al.* 2003). Reductions in the supply of large woody debris to streams can result when old-growth forests are removed, with resulting loss of habitat complexity that is important for successful salmonid spawning and rearing (Hicks *et al.* 1991; Hanson *et al.* 2003). Removing riparian vegetation increases the amount of solar radiation reaching the stream and can result in higher water temperatures during summer months. A loss of streamside vegetation can also have the effect of reducing water temperatures during the winter months (Beschta *et al.* 1987; Hicks *et al.* 1991).

<u>Bank and Soil Erosion and Altered Hydrological Regimes</u>
Timber harvesting may result in inadequate or excessive surface and stream flows, increased stream bank and streambed erosion, and the loss of complex instream habitats. Clear cutting large areas of forests can alter the hydrologic characteristics of watersheds, such as water temperature, and result in greater seasonal and daily variation in stream discharge and flows (Hicks *et al.* 1991; Hanson *et al.* 2003).

In addition, logging road construction can destabilize slopes and increase erosion and sedimentation. Mass wasting and surface erosion are the two major types of erosion that can occur due to logging road construction. Mass movement of soils, commonly referred to as landslides or debris slides, is associated with timber harvesting and road building on high hazard soils and unstable slopes. The result is increased erosion and sediment deposition in down-slope waterways. Erosion from roadways is most severe when poor construction practices are employed that do not include properly located, designed and installed culverts or when proper ditching is not utilized (Furniss *et al.* 1991).

Siltation, Sedimentation and Turbidity

Sediment deposition in streams due to timber harvesting activities can reduce benthic community production, cause mortality of incubating salmon eggs and alevins, and reduce the amount of habitat available for juvenile salmon (Hicks *et al.* 1991; Hanson *et al.* 2003). Fine sediments deposited in salmon spawning gravel can reduce interstitial water flow, causing reduced dissolved oxygen concentrations, and can physically trap emerging fry in the gravel (Hicks *et al.* 1991). Fine sediments on stream bottoms and in suspension can also reduce primary production and invertebrate abundance, reducing the availability of prey for fish (Hicks *et al.* 1991). Sedimentation in riparian habitat due to logging activities can reduce streamside vegetation that impacts bank stabilization and increases solar radiation reaching the stream. In addition, suspended sediments can alter behavior and feeding efficiencies of salmonids following timber harvesting (Hicks *et al.* 1991). Sawdust and pulp from sawmills and lumber companies can also enter streams and rivers and adversely affect benthic habitats of anadromous fish (Moring 2005).

Impaired Fish Passage

Poorly placed or ill-designed culverts placed as part of road construction can negatively affect access to riverine habitat by fish. Stream crossings (e.g., bridges and culverts) on forest roads are often inadequately designed, installed, and maintained and they frequently result in full or partial barriers to both the upstream and downsteam migration of adult and juvenile fish (Hanson *et al.* 2003). Perched culverts, in which the culvert invert at the downstream end is above the water level of the downstream pool, creates waterfalls that can be physical barriers to migrating fish. Undersized culverts can accelerate stream flows to the point that these structures become velocity barriers for migrating fish, and blocked culverts can result in displacement of the stream from the downstream channel to the roadway or roadside ditch (Hanson *et al.* 2003). Blocked culverts often result from installation of undersized culverts or inadequate maintenance to remove debris. In addition, culverts and bridges deteriorate structurally over time and failure to replace or remove them at the end of their useful life may cause partial or total blockage of fish passage.

Altered Temperature Regimes

Removing streamside vegetation to construct logging access roads or by logging adjacent to streams or rivers increases the amount of solar radiation reaching the water body and can increase water temperatures (Beschta *et al.* 1987; Hicks *et al.* 1991). In studies conducted in Alaska, researchers found that maximum temperatures in logged streams without riparian buffers exceeded that of unlogged streams by up to 5º C, but did not reach lethal temperatures (Meehan *et al.* 1969, cited in Hanson *et al.* 2003). In cold climates, the removal of riparian vegetation can result in lower water temperatures during winter, increasing the formation of ice, and damaging and delaying the development of incubating fish eggs and alevins (Hanson *et al.* 2003). In freshwater habitats of the northeastern U.S., the temperature tolerances of cold-water fish such as Atlantic salmon, rainbow smelt, and trout, may be exceeded leading to local extirpation of the species (USFWS and NMFS 1999). However, increased water temperatures can also increase primary and secondary production, which may lead to greater availability of food for fish (Hicks *et al.* 1991).

Reduced Dissolved Oxygen

Small wood debris and silt due to timber harvesting can smother benthic habitat and reduce dissolved oxygen levels in streams (Hicks *et al.* 1991; Hanson *et al.* 2003). Fine organic material introduced into streams following logging can result in increased oxygen demand and reduced exchange of surface and intergravel water (Hicks *et al.* 1991). While low oxygen conditions may not directly kill salmon embryos and alevins in streams after logging, emergent juveniles may have reduced viability (Hicks *et al.* 1991).

Altered Nutrient Supply

After logging activities, concentrations of plant nutrients in streams and rivers may increase for several years and up to a decade (Hicks *et al.* 1991). Excess nutrients, combined with increased light regimes due to removal of riparian vegetation, can stimulate algal growth; however, the effects of nutrient increases on salmonid populations are not well-understood (Hicks *et al.* 1991).

Release of Pesticides, Herbicides and Fungicides

Riparian vegetation is an important component of rearing habitat for fish, providing shade for maintaining cool water temperatures, food supply, channel stability and structure (Furniss *et al.* 1991), and herbicides that are used to suppress terrestrial vegetation can negatively impact these habitat functions (USFWS and NMFS 1999). In addition, insecticides applied to forests to control pests can interfere with the smoltification process of Atlantic salmon, preventing some fish from successfully making the transition from fresh to salt water. Matacil, one pesticide used in the Maine timber industry, is known to contain an endocrine disrupting chemical (USFWS and NMFS 1999). These chemicals act as "environmental hormones" that may mimic the function of the sex hormones androgen and estrogen (Thurberg and Gould 2005). Refer to the Chemical Effects: Water Discharge Facilities chapter for more information on endocrine disruptors. Other possible affects to Atlantic salmon from pesticides may include altered chemical perception of home stream odor and osmoregulatory ability (USFWS and NMFS 1999).

Conservation Measures and Best Management Practices for Silviculture and Timber Harvest Activities

1. Encourage timber operations to be located as far from aquatic habitats as possible. Buffer zones of 100 ft for first- and second-order streams, and greater than 600 feet for fourth- and fifth-order streams are recommended.
2. Insure that all silviculture and timber operations incorporate conservation plans that include control of non-point source pollution, protecting important habitat through landowner agreements, maintaining riparian corridors, and monitoring and controlling pesticide use.
3. Incorporate watershed analysis into timber and silviculture projects. Attention should be given to the cumulative effects of past, present, and future timber sales within a watershed.
4. Logging roads should be sited to avoid sensitive areas such as streams, wetlands, and steep slopes.
5. BMPs should be included for timber forest road construction plans, including erosion control, avoidance of side casting of road materials into streams, and using only native vegetation in stabilization plantings.
6. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.

Timber and Paper Mill Processing Activities

Introduction

Timber and paper mill processing activities can affect riverine and estuarine habitats through both chemical and physical means. Timber and lumber processing can release sawdust and wood chips in riverine and estuarine environments, where they may impact the water column and benthic habitat of fish and invertebrates. These facilities may also either directly or indirectly release contaminants, such as tannins and lignin products, into aquatic habitats (USFWS and NMFS 1999). Pulp manufacturing converts wood chips or recycled paper products into individual fibers by chemical and/or mechanical means, which are then used to produce various paper products. Paper and pulp mills use and can release a number of chemicals that are toxic to aquatic organism, including chlorine, dioxins, and acids (Mercer *et al.* 1997), although a number of these chemicals have been reduced or eliminated from the effluent stream due to increased regulations regarding their use.

Chemical Contamination Releases

Approximately 80 percent of all U.S. pulp tonnage comes from kraft or sulfate pulping which uses sodium-based alkaline solutions, such as sodium sulfide and sodium hydroxide (USEPA 2002b). Kraft pulping reportedly involves less release of toxic chemicals, compared to other processes such as sulfite pulping (USEPA 2002b). Paper and pulp mills may also release a number of toxic chemicals used in the process of bleaching pulp for printing and wrapping paper products. The bleaching process may use chlorine, sulfur derivatives, dioxins, furans, resin acids, and other chemicals that are known to be toxic to aquatic organisms (Mercer *et al.* 1997). These chemicals have been implicated in various abnormalities in fish, including skin and organ tissue lesions, fin necrosis, gill hyperplasia, elevated detoxifying enzymes, impaired liver functions, skeletal deformities, increased incidence of parasites, disruption of the immune system, presence of tumors, and impaired growth and reproduction (Barker *et al.* 1994; Mercer *et al.* 1997). Due to concern about the release of dioxins and other contaminants, considerable improvements in the bleaching process have reduced or eliminated the use of elemental chlorine. Approximately 96 percent of all bleached pulp production uses chlorine-free bleaching technologies (USEPA 2002b).

An endocrine disrupting chemical, 4-nonylphenol, has been used in pulp and paper mill plants in Maine and has been shown to interfere with smoltification processes and the chemical perception of home range, and osmoregulatory ability in Atlantic salmon (USFWS and NMFS 1999). Other studies have implicated pulp and paper effluents with altered egg production, gonad development, sex steroids, secondary sexual characteristics, and vitellogenin concentration in male fish, considered to be an indicator of estrogenicity (Kovacs *et al.* 2005). A study investigating the prevalence of a microsporan parasite found in winter flounder (*Pseudopleuronectes americanus*) in Newfoundland waters observed infestations in the liver, kidney, spleen, heart and gonads of fish collected downstream from pulp and paper mills, whereas fish collected from pristine sites harbored cysts of the parasite in only the digestive wall (Khan 2004). In addition, flounder with a high prevalence of parasite infections throughout multiple organs were found to have significant impairments to growth, organ mass, reproduction, and survival that were not observed in fish sampled from pristine locations, suggesting a link between those affects and effluent discharged by the pulp and paper mills (Khan 2004).

Entrainment and Impingement

Pulp and paper mills require large amounts of water and energy in the manufacturing process. For example, a bleached kraft pulp mill can utilize 4,000-12,000 gallons of water per ton of pulp produced (USEPA 2002b). Diverting water from stream, rivers, and estuaries for pulp and paper mills can entrain and impinge eggs, larvae and juveniles, and may impact local populations of fish and invertebrates. Information is not available on the potential magnitude of entrainment and impingement impacts from wood, pulp and paper mills. Refer to Physical Effects: Water Intake and Discharge Facilities for more information on entrainment and impingement impacts.

Thermal Discharge

Pulp and paper production involves thermal and chemical processing to convert wood fibers to pulp and/or paper, and may result in the release of effluent water with higher than ambient temperatures. There is a potential for cold-water fish such as Atlantic salmon, rainbow smelt, and trout to be adversely affected by these facilities. However, information is not available on the potential magnitude of thermal discharge impacts from wood, pulp and paper mills.

Reduced Dissolved Oxygen

Pulp and paper mill wastewaters generally contain sulfur compounds with a high biological oxygen demand (BOD), suspended solids, and tannins (USEPA 2002b). The release of these contaminants in mill effluent can reduce dissolved oxygen in the receiving waters. According to the U.S. EPA, however, all kraft pulp mills and nearly all U.S. paper mills have chemical recovery systems in place and primary and secondary wastewater treatment systems installed to remove particulates and BOD (USEPA 2002b).

Conversion of Benthic Substrate

Sawdust and pulp from sawmills and lumber processing facilities can enter streams and rivers, adversely affecting benthic habitats for anadromous fish (Moring 2005). Pulp and paper mill effluent can contain solid particulates and high BOD that can alter the benthic habitat of receiving water bodies. The impacts to benthic habitat from past practices of wood, pulp and paper mills are evident today in some streams and rivers of Maine, including the Penobscot River from Winterport to Bucksport (USFWS and NMFS 1998). Most of the bottom substrate in this stretch of the Penobscot River is covered by bark and sawdust, which substantially reduces the diversity of benthic organisms (USFWS and NMFS 1998). However, chemical recovery systems and wastewater treatment systems should reduce or eliminate most solid wastes from the effluent stream.

Alteration of Light Regimes

Lumber, pulp, and paper mills releasing effluent containing solids, BOD, and tannins can reduce water clarity and alter the light regimes in receiving waters. This can adversely affect primary production and submerged aquatic vegetation in riverine and estuarine habitat where these facilities are located. Information is not available on the potential magnitude of light regime impacts from wood, pulp and paper mills.

Conservation Measures and Best Management Practices for Timber and Paper Mill Processing Activities

1. Ensure that lumber, pulp, and paper mills have adequate chemical recovery systems and wastewater treatment systems installed to reduce or eliminate most toxic chemicals and solid wastes from the effluent stream. Ensure that effluent streams do not elevate the ambient water temperatures of the receiving water bodies.
2. Discourage the construction of new lumber, pulp, and paper mills adjacent to riverine and estuarine waters that contain productive fisheries resources. New facilities should be sited so as to avoid the release of effluents in wetlands and open water habitats.

3. Seasonal restrictions should be used to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods). Recommended seasonal work windows are generally specific to regional or watershed-level environmental conditions and species requirements.
4. Incorporate watershed analysis into new lumber, pulp, and paper mill facilities, with consideration for the cumulative effects of past, present, and future impacts within the watershed.

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INTRODUCED/NUISANCE SPECIES AND AQUACULTURE

Introduced/Nuisance Species

Introduction

Introductions of non-native invasive species into marine and estuarine waters are a significant threat to living marine resources in the United States (Carlton 2001). Non-native species can be released intentionally (i.e., fish stocking and pest control programs), or unintentionally during industrial shipping activities (e.g., ballast water releases), aquaculture operations, recreational boating, biotechnology, or from aquarium discharge (Hanson *et al.* 2003; Niimi 2004). Hundreds of species have been introduced into U.S. waters from overseas and from other regions around North America, including finfish, shellfish, phytoplankton, bacteria, viruses, and pathogens (Drake *et al.* 2005). The rate of introductions has increased exponentially over the past 200 years and it does not appear that this rate will level off in the near future (Carlton 2001).

In New England and the mid-Atlantic region, a number of fish, crabs, bryozoans, mollusks, tunicates, and algae species have been introduced since colonial times (Deegan and Buchsbaum 2005). New introductions continue to occur, such as *Convoluta convoluta*, a small carnivorous flatworm from Europe that has invaded the Gulf of Maine (Byrnes and Witman 2003; Carlton 2001); *Didemnum* sp., an invasive species of tunicate that invaded Georges Bank (Pederson *et al.* 2005); *Hemigrapsus sanguineus,* the Asian shore crab that has invaded Long Island Sound (Carlton 2001); and *Codium fragile tomentosoides,* an invasive algal species from Japan that has invaded the Gulf of Maine (Pederson *et al.* 2005).

Introduced species may thrive best in areas where there has been some level of environmental disturbance (Vitousek *et al.* 1997; USFWS and NMFS 1999; Minchinton and Bertness 2003). For example, in riverine systems alterations in temperature and flow regimes can provide a niche for non-native species to invade and dominate over native species such as salmon (USFWS and NMFS 1999). Invasive species introductions can result in negative impacts to the environment and to society, with millions of dollars being expended for research, control, and management efforts (Carlton 2001).

Introduced species impact the environment in a variety of ways, including: 1) habitat alterations; 2) trophic alterations; 3) gene pool alterations; 4) alterations to communities and competition with native species; 5) introduced diseases; 6) changes in species diversity; 7) alteration in the health of native species; and 8) impacts to water quality. The following is a review of the potential environmental impacts associated with the introduction of non-native aquatic invasive/nuisance species into marine, estuarine, and freshwater ecosystems.

Habitat Alterations

Introduced species can have severe impacts on the quality and quantity of habitat (Deegan and Buchsbaum 2005). Non-native aquatic plant species can infest water bodies, impair water quality, cause anoxic conditions when they die and decompose, and alter predator-prey relationships. Fish may be introduced into an area to graze and biologically control aquatic plant invasions. However, introduced fish may also destroy habitat, which can eliminate nursery areas for native juvenile fishes, accelerate eutrophication, and cause bank erosion (Kohler and Courtenay 1986).

Habitat has been altered by the introduction of many invasive species in New England (Deegan and Buchsbaum 2005). The green crab, *Carcinus maenus*, is an exotic species from Europe that can interfere with restoration efforts to transplant eelgrass (Deegan and Buchsbaum 2005). *Didemnum* sp. is an invasive species of tunicate that has colonized the northern edge of Georges Bank. This filter-feeding organism forms dense mats that encrust the seafloor, which can prevent the settlement of benthic organisms, reduce food availability for juvenile scallops and groundfish, and smother organisms attached to the substrate (e.g., Atlantic sea scallops in spat and juvenile stages) (Pederson *et al.* 2005; Valentine *et al.* 2007), and could have impacts to productive fishing grounds in New England and elsewhere. There is no evidence at this time that the spread of the tunicate on Georges Bank will be held in check by natural processes other than smothering by moving sediments (Valentine *et al.* 2007).

An invasive species of algae from Japan, *Codium fragile tomentosoides*, also referred to as deadman's fingers, has invaded subtidal and intertidal marine habitats in the Gulf of Maine and mid-Atlantic. Deadman's fingers can outcompete native kelp and eelgrass, thus destroying habitat for finfish and shellfish species (Pederson *et al.* 2005). *Phragmites australis*, a non-native marsh grass, has invaded coastal estuaries and can exclude native brackish and salt marsh plant species such as *Spartina alterniflora* from their historic habitat (Burdick *et al.* 2001; Minchinton and Bertness 2003; Deegan and Buchsbaum 2005). *Phragmites* invasions can increase the sedimentation rate in marshes and reduce intertidal habitat available for fish species in New England (Deegan and Buchsbaum 2005).

<u>Trophic Alterations</u>

Introduced species can alter the trophic structure of an ecosystem via increased competition for food sources between native and non-native species (Kohler and Courtenay 1986; Caraco *et al.* 1997; Strayer *et al.* 2004; Deegan and Buchsbaum 2005), as well as through predation by introduced species on native species (Kohler and Courtenay 1986). Increased competition for food sources between invasive and native species has been shown in the Hudson River estuary between the zebra mussel, *Dreissena polymorpha*, and open-water commercial and recreational species such as the American shad and black sea bass (Strayer *et al.* 2004; Deegan and Buchsbaum 2005). Zebra mussels have altered trophic structure in the Hudson River estuary by withdrawing large quantities of phytoplankton and zooplankton from the water column, thus increasing competition with planktivorous fish. Phytoplankton is the basis of the food web and altering the trophic levels at the bottom of the food web could have a detrimental, cascading effect on the aquatic ecosystem. Introductions of the invasive zebra mussel in the Hudson River estuary coincided with a decline in the abundance, a decreased in growth rate, and a shift in the population distribution of commercially and recreationally important species. The invasion of zebra mussels has been associated with large, pervasive alterations in young-of-the-year fish, which can result in interspecies competition and alterations in trophic structure (Strayer *et al.* 2004; Deegan and Buchsbaum 2005).

Predation of native species by non-native species may increase the natural mortality of a species and could also alter the trophic structure (Kohler and Courtenay 1986). Whether the predation is on eggs, young, or full-grown native adult fish species, a decline in native forage species can affect the entire food web (Kohler and Courtenay 1986). For example, *Hemigrapsus sanguineus*, the Asian shore crab, invaded Long Island Sound and has an aggressive predatory behavior and voracious appetite for crustaceans, mussels, young clams, barnacles, periwinkles, polychaetes, macroalgae, and salt marsh grasses. The removal of the forage base by this invasive crab could have a ripple effect throughout the food chain that could restructure communities along the Atlantic coast (Tyrell and Harris 2000; Brousseau and Baglivo 2005).

Gene Pool Alterations

Native species may hybridize with introduced species that have a different genetic makeup (Kohler and Courtenay 1986), thus weakening the genetic integrity of wild populations and decreasing the fitness of wild species via breakup of gene combinations (Goldburg *et al.* 2001). Aquaculture operations have the potential to be a significant source of non-native introductions into North American waters (Goldburg and Triplett 1997; USCOP 2004). Escaped aquaculture species can alter the genetic characteristics of wild populations when native species interbreed with escaped non-native or native aquaculture species (USFWS and NMFS 1999). Refer to the Aquaculture section of this chapter for a more detailed discussion on impacts from aquaculture operations.

In the Gulf of Maine, the wild Atlantic salmon population currently exhibits poor marine survival, a low spawning stock, and is in danger of becoming extinct, which makes the species particularly vulnerable to genetic modification via interbreeding with escaped aquaculture species. Any genetic modification combined with environmental threats such as reduced water levels, parasites and diseases, commercial and recreational fisheries, loss of habitat, poor water quality, and sedimentation may threaten or potentially extirpate the wild salmon stock in the Gulf of Maine (USFWS and NMFS 1999).

Alterations to Communities and Competition with Native Species

Introductions of non-native species may result in alterations to communities and an increase in competition for food and habitat (Deegan and Buchsbaum 2005). Non-native marsh grass introductions can alter habitat conditions, resulting in changes in the fauna of salt marsh habitat. Alterations to communities have been noted in areas in which native marsh cordgrass, *Spartina alterniflora,* habitat has been invaded by the invasive, exotic common reed, *Phragmites australis* (Posey *et al.* 2003). *Phragmites* has been implicated in alteration of the quality of intertidal habitats, including: lower abundance of nekton in *Phragmites* habitat; reduced utilization of this habitat during certain life stages (Weinstein and Balletto 1999; Able and Hagan 2000); decreased density of gastropods, oligochaetes, and midges (Talley and Levin 2001, cited in Posey *et al.* 2003); decreased bird abundance and species richness (Benoit and Askins 1999); and avoidance of *Phragmites* by juvenile fishes (Weis and Weis 2000).

A limited supply of food or viable habitat may induce competition between native and non-native species. Competition may result in the displacement of native species from their habitat or a decline in recruitment, which are factors that can collectively contribute to a decrease in population size (Kohler and Courtenay 1986). Increased competition for food sources between the invasive zebra mussel and native species has occurred in the Hudson River (Strayer *et al.* 2004). Filter-feeding zebra mussels have removed large quantities of phytoplankton and zooplankton from the water column, which has increased competition with planktivorous fish and altered the trophic structure of this ecosystem. Increased competition has resulted in a geographic shift of native species such as the American shad and black sea bass out of the invaded area, a decrease in fish abundance, and a decline in growth rate of commercially and recreationally important species (Strayer *et al.* 2004; Deegan and Buchsbaum 2005).

Introduced Diseases

Introduced aquatic species are often vectors for disease transmittal that represent a significant threat to the integrity and health of native aquatic communities (Kohler and Courtenay 1986). Bacteria, viruses, and parasites may be introduced advertently or inadvertently, and can reduce habitat quality (Hanson *et al.* 2003). Introduced pathogens may be lethal or sublethal to aquatic organisms, and have the potential to impair the health and fitness level of wild fish populations. Sources of introduced pathogens include industrial shipping, recreational boating, dredging activities, sediment disposal, municipal and agricultural runoff, wildlife feces, septic systems, biotechnology labs, aquariums, and by transferring oyster spat to new areas for aquaculture or restoration purposes (ASMFC 1992; Boesch *et al.* 1997).

In the 1940's and 1950's, scientists inadvertently introduced a new disease into eastern U.S. waters when they attempted to restore declining populations of the native oyster (*Crassostrea virginica*) via the introduction of the pacific oyster (*Crassostrea gigas*) (Burreson *et al.* 2000; Rickards and Ticco 2002). *Haplosporidium nelsoni* is a protistan parasite that causes MSX oyster disease, and was present amongst the pacific oysters introduced in east coast waters. MSX spread from Delaware Bay to the Chesapeake Bay and contributed to the decline in the native oyster population. MSX, and another pathogenic disease, Dermo (*Perkinsus marinus*), have collectively decimated the native oyster population remaining along the much of the eastern U.S. coast (Rickards and Ticco 2002).

Parasite and disease introductions into wild fish and shellfish populations can be associated with aquaculture operations. These diseases have the potential to lower the fitness level of native species or contribute to the decline of native populations (USFWS and NMFS 1999). In eastern Maine and New Brunswick, an outbreak of two diseases in both wild and cultured stocks of Atlantic salmon suggests that cultured stocks are acting as reservoirs of diseases and are now passing them on to wild stocks (Moring 2005). In addition to these diseases, sea lice are a flesh-eating parasite that has been passed from farmed salmon to wild salmon while wild salmon migrate through coastal waters. Sea lice also can serve as a host for Infectious Salmon Anemia (ISA), which is a virus that has spread from salmon farms in New Brunswick to salmon farms in Maine (USFWS and NMFS 1999). The ISA virus causes a fatal disease in salmon at aquaculture facilities, and this virus has been detected in wild fish species. ISA appeared in the United States in 2001, is currently moving into southern regions, and represents a significant threat to wild salmon populations (Goldburg *et al.* 2001).

<u>Changes in Species Diversity</u>

Introduced species can rapidly dominate a new area and can cause changes within species communities to such an extent that native species are forced out of the invaded area or undergo a decline in abundance, leading to changes in species diversity (Omori *et al.* 1994). Changes in species diversity have been seen in the Hudson River, in which the invasion of zebra mussels caused localized changes in phytoplankton levels and trophic structure that favored littoral zone species over open-water species. Open-water fishes (e.g., American shad) shifted their populations downriver and suffered declines in abundance and growth rate. Littoral zone species (e.g., sunfishes) prospered with the zebra mussel invasion, as evidenced by their increased abundance and growth rate (Strayer *et al.* 2004).

Alterations in species diversity have been noted in areas in which native *Spartina alterniflora* habitat has been invaded by *Phragmites australis* (Posey *et al.* 2003). *Phragmites* can rapidly colonize a marsh area, thus changing the species of marsh grass present at that site. In addition, *Phragmites* invasions have been shown to change species use patterns and abundance at invaded sites.

Benthic species diversity can be altered due to the introduction of shellfish for aquaculture purposes (Kaiser *et al.* 1998) and for habitat restoration projects. Cultivation of shellfish requires the placement of gravel or crushed shell on the substrate. Seed clams are placed on the substrate in bags, or directly on substrate covered with protective plastic netting. This change in benthic structure can result in a shift in species found at that site (e.g., from a polychaete to a bivalve and nemertean dominated benthic community) (Kaiser *et al.* 1998; Simenstad and Fresh 1995). In addition, changes in species diversity may occur as a result of oyster habitat restoration. Oyster reefs provide habitat for a variety of resident and transient species (Coen *et al.* 1999), so restoration activities that introduce oysters into a new area may result in localized changes in species diversity, as reef-building organisms and fish are attracted to the restoration site.

<u>Alteration in Health of Native Species</u>
The health of native species can be impaired due to exotic invasions and the introduction of new species into an area. A number of factors may contribute to reduced health of native populations, including: 1) competition for food sources may result in a decrease in growth rate and abundance of native species (Strayer *et al.* 2004), or result in the decline of native populations (USFWS and NMFS 1999); 2) aggressive and fast growing non-native predators can reduce the populations of native species (Pederson *et al.* 2005); 3) diseases represent a significant threat to the integrity and health of native aquatic communities, and can decrease the sustainability of the native population (Kohler and Courtenay 1986; Rickards and Ticco 2002; Hanson *et al.* 2003; USFWS and NMFS 1999); and 4) the genetic integrity of native species may be compromised through hybridization with introduced species (Kohler and Courtenay 1986), which can also decrease the fitness of wild species via breakup of gene combinations (Goldburg *et al.* 2001). The factors listed above, combined with potential impact on the habitats of native species, can collectively result in long-term impacts to the health of native species (Burdick *et al.* 2001; Minchinton and Bertness 2003; Deegan and Buchsbaum 2005; Pederson *et al.* 2005).

<u>Impacts to Water Quality</u>
Invasive species can affect water quality in marine, estuarine, and riverine environments because they have the potential to outcompete native species and dominate habitats. For example, non-native aquatic plant species, which may not have natural predators in their new environments, can proliferate within water bodies, impair water quality, and cause anoxic conditions when they die and decompose. Fish species introduced to control noxious weeds can accelerate eutrophication (Kohler and Courtenay 1986)

Introduced non-native algal species from ballast water, recreational boating, dredging activities, and shellfish transfer (e.g., seeding) combined with nutrient overloading may increase the intensity and frequency of algal blooms. An overabundance of algae can degrade water quality when they die and decompose, which depletes oxygen levels in an ecosystem. Oxygen depletion can result in ecological "dead zones," reduced light transmittance in the water column, seagrass and coral habitat degradation, and large-scale fish kills (Deegan and Buchsbaum 2005).

<u>Conservation Measures and Best Management Practices for Introduced/Nuisance Species</u>
1. Exotic species should not be introduced for aquaculture purposes unless a thorough scientific evaluation and risk assessment is performed.
2. Boaters, anglers, aquaculturists, traders, and other potential handlers of introduced species should prevent and discourage accidental or purposeful introduction of exotic species into their local ecosystems.

3. Boaters, anglers, aquaculturists, traders, and other potential handlers of introduced species should avoid introduction of species into waters that may allow for easy movement into other waters.
4. Require vessels brought from other areas over land via trailer to clean any surfaces that may harbor non-native plant or animal species (e.g., propellers, hulls, anchors, fenders, etc.). Bilges should be emptied and cleaned thoroughly using hot water or a mild bleach solution. These activities should be performed in an upland area to prevent introduction of non-native species to aquatic environments during the cleaning process.
5. Natural resource managers should provide outreach materials on the potential impacts resulting from releases of non-native species into the natural environment.
6. Importation of ornamental fishes should be limited to dealers.
7. Only local, native fish should be used for sale as live seafood or bait. Only native organisms should be used for aquaculture or mariculture open-water operations.
8. Natural resource managers should identify areas where invasive plants have become established at an early time in the infestation and pursue efforts to manually remove it.
9. Natural resource managers should identify methods to eradicate invasive species (e.g., reduce the spread of *Phragmites* in coastal marshes by mitigating the effects of tidal restrictions).
10. Treat effluent from public aquaria displays, laboratories, and educational institutes that are using exotic species prior to discharge for the purpose of preventing the introduction of viable animals, plants, reproductive material, pathogens, or parasites into the environment.
11. Facility designers should avoid siting new vessel moorings or launching facilities in areas with invasive species until the species is eradicated or enforceable and dependable mechanisms are available to assure that the species won't spread.
12. Encourage vessels to perform a ballast water exchange in marine waters (in accordance with the U.S. Coast Guard's voluntary regulations) to minimize the possibility of introducing exotic species into estuarine habitats. Ballast water taken on in marine waters will contain fewer organisms and these organisms will be less likely to become invasive in estuarine conditions than species transported from other estuaries.
13. Discourage vessels that have not performed a ballast water exchange from discharging their ballast water into estuarine receiving waters.

Aquaculture

Introduction

Aquaculture is defined as the controlled cultivation and harvest of aquatic organisms, including finfish, shellfish, and aquatic plants (Goldburg *et al.* 2001, 2003). Aquaculture operations are conducted at both land and water facilities. Land-based aquaculture systems include ponds, tanks, raceways, and water flow-through and recirculating systems. Water-based aquaculture systems include netpens, cages, ocean ranching, longline culture, and bottom culture (Goldburg and Triplett 1997).

Aquaculture can provide a number of socio-economic benefits, including food provision, improved nutrition and health, generation of income and employment, diversification of primary production, and foreign exchange earnings through export of high-value products in developing countries (Barg 1992). Aquaculture can also provide environmental benefits by supporting stocking and release of hatchery-reared organisms, countering nutrient and organic enrichment in eutrophic waters from the culture of some mollusk and seaweed species, and prevention and control of aquatic pollution through sustainable aquaculture operations (Barg 1992).

However, freshwater, estuarine, and marine aquaculture operations have the potential to adversely impact the habitat of native fish and shellfish species. The impact of aquaculture facilities varies according to the species cultured, the type of system used, and the location, operation, and siting of structures. Intensive cage and floating netpen systems typically have a greater impact because aquaculture effluent is released directly into the environment. Pond and tank systems are less harmful to the environment because waste products are released in pulses during cleaning and harvesting activities rather than continuously into the environment (Goldburg *et al.* 2001). The relative impact of finfish and shellfish aquaculture differs depending on the foraging behavior of the species. Finfish require the addition of a large amount of feed into the ecosystem, which can result in environmental impacts. Bivalves are filter feeders and typically do not require food additives; however, fecal deposition can result in benthic and pelagic habitat impacts, changes in trophic structure (Kaspar *et al.* 1985; Grant *et al.* 1995), and nutrient and phytoplankton depletion (Dankers and Zuidema 1995).

Typical environmental impacts resulting from aquaculture production include: 1) discharge of organic wastes and contaminants; 2) seafloor impacts; 3) introductions of exotic invasive species; 4) food web impacts; 5) gene pool alterations; 6) impacts to the water column; 7) impacts to water quality; 8) changes in species diversity; 9) sediment deposition; 10) introduction of diseases; 11) habitat replacement or exclusion; and 12) habitat conversion. The following is a review of the potential environmental impacts associated with the cultivation and harvest of aquatic organisms in land- and water-based aquaculture facilities.

Discharge of Organic Wastes

Aquaculture operations can degrade water quality and the benthic environment via the discharge of organic waste and other contaminants (Goldburg *et al.* 2001; USCOP 2004). Organic waste includes uneaten fish food, urine, feces, mucus, and byproducts of respiration, which can have an adverse effect on both benthic and pelagic organisms when released into marine, estuarine, and riverine environments.

Uneaten fish food can contribute a significant amount of nutrients to the ecosystem at aquaculture sites (Kelly 1992; Goldburg and Triplett 1997). Farmed fish are typically fed low-value “forage fish” such as anchovies and menhaden, which are either fed directly to aquaculture species or processed into dry feed pellets. A large percentage of nutrients contained in farmed fish food are lost to the environment through organic waste. As much as 80 percent of total nitrogen and 70 percent of total phosphorus fed to farmed fish may be released into the water column through fish wastes (Goldburg *et al.* 2001).

In New England, the majority of aquaculture operations are located in Maine, with Cobscook Bay being the primary site of finfish aquaculture operations. Recent research in Cobscook Bay and in neighboring waters of New Brunswick, Canada have shown that primary sources of nutrients in the area are coming from both finfish aquaculture operations and from the open ocean (Goldburg *et al.* 2001). Research conducted at an aquaculture facility with 200,000 salmon has revealed that the amount of nitrogen, phosphorus, and feces discharged from the facility are equivalent to that released from untreated sewage produced by 20,000, 25,000, and 65,000 people, respectively (Goldburg *et al.* 2001).

The release of high concentrations of nutrients can negatively affect an aquatic system through eutrophication. Eutrophication of an aquatic system can occur when nutrients, such as nitrogen and phosphorus, are released in high concentrations and over long periods of time. Eutrophication can stimulate the growth of algae and other primary producers (referred to as "algal blooms") (Hopkins *et al.* 1995; Goldburg *et al.* 2001; Deegan and Buchsbaum 2005). Although the effects of eutrophication are not necessarily always adverse, they are often extremely undesirable and include: 1) increased incidence, extent, and persistence of noxious or toxic species of phytoplankton; 2) increased frequency, severity, spatial extent, and persistence of low oxygen conditions; 3) alteration in the dominant phytoplankton species and the nutritional-biochemical "quality" of the phytoplankton community; and 4) increased turbidity of the water column due to the presence of algae blooms (O'Reilly 1994).

Oxygen can be depleted during bacterial degradation of algal tissue, and can result in hypoxic or anoxic "dead zones," reduced water clarity, seagrass and coral habitat degradation, and large-scale fish kills (Deegan and Buchsbaum 2005). Algal blooms may contain species of phytoplankton such as dinoflagellates that can produce toxins and, when populations reach very high densities, can cause toxic algal blooms (e.g., red tides), can kill large numbers of fish, contaminate shellfish species, and cause health problems in humans. The frequency and severity of toxic algal blooms could increase in the future due to the fact that many coastal and estuarine areas are already moderately to severely eutrophic (Goldburg *et al.* 2001; Goldburg and Triplett 1997). Refer to the Coastal Development chapter for more information on eutrophication and harmful algal blooms.

<u>Discharge of Contaminants</u>

In addition to organic waste, chemicals and other contaminants that are discharged as part of the aquaculture process can affect benthic and pelagic organisms (Hopkins *et al.* 1995; Goldburg and Triplett 1997). Chemicals are typically released directly into the water, including antibiotics that fight disease; pesticides that control parasites, algae, and weeds; hormones that initiate spawning; vitamins and minerals to promote fish growth; and anesthetics to ease handling of fish during transport. These chemical agents are readily dispersed into marine, estuarine, and freshwater systems and can be harmful to benthic and pelagic organisms. Few chemicals are legal for use in U.S. aquaculture operations; however, imported seafood may contain residues of harmful chemicals used in countries that permit the use of those chemicals (Hopkins *et al.* 1995; Goldburg *et al.* 2001).

Antibiotics are given to fish and shrimp via injections, baths, and oral treatments (Hopkins *et al.* 1995; Goldburg and Triplett 1997). The most common method of oral administration is the incorporation of drugs into feed pellets, which results in a greater dispersion of antibiotics in the marine environment. Antibiotics, including those toxic to humans, typically bind to sediment particles, may remain in the environment for an extended period of time, can accumulate in farmed and wild fish and shellfish populations, and can harm humans when ingested. Examples of toxins used in the aquaculture industry that are undesirable for human consumption include chloramphenicol, which can trigger circulatory collapse in newborns or harm blood cell production by bone marrow. Betalactam compounds can cause potentially fatal allergic reactions, and another accumulated antibiotic, sulfamethazine, has increased the rate of thyroid tumors in mice and rats (Goldburg and Triplett 1997). The use of antibiotics in aquaculture may also contribute to the development of new bacterial strains that are resistant to the affects of antibiotics used to control them, which could become problematic for humans (Goldburg and Triplett 1997).

Herbicides are chemicals used to control aquatic weeds in freshwater systems, and algicides are herbicides specifically formulated to kill algae that can lower dissolved oxygen levels in ponds when the algae die and decompose. A common ingredient in algicides is copper, which is toxic to aquatic organisms. The aquaculture herbicide 2,4-D is considered to be the least persistent and harmful to aquaculture organisms; however, studies have shown that this chemical may cause non-Hodgkin's lymphoma in humans and lymphatic cancer in dogs. Therefore, herbicides or algicides that are applied in the future must be carefully considered for their toxicity to aquaculture organisms and to humans, as well as their tendency to bioaccumulate in fish and shellfish tissues (Goldburg and Triplett 1997).

Pesticides and insecticides are also commonly used in aquaculture operations and must be carefully monitored for their effects on aquatic organisms, habitat, and on human health. Antifouling compounds such as copper and organic tin compounds were historically used in the aquaculture industry to prevent fouling organisms from attaching to aquaculture structures. These chemicals accumulate in farmed and wild organisms, especially in shellfish species, and the use of organic tin compounds is now banned for use in both Washington and Maine. Aquaculturalists have used the insecticide, Sevin, for 35 years in Wallapa Bay, Washington to control burrowing shrimp that destabilize sediment. Sevin kills other organisms such as the Dungeness crab, so it should be used in moderation to minimize the impacts of the aquaculture industry on other important commercial fisheries (Goldburg and Triplett 1997). For additional information on the release of pesticides, refer to the Agriculture and Silviculture and Coastal Development chapters of this report.

Aquaculture operations not only can cause environmental impacts through the discharge of contaminants and organic wastes, but these operations can also affect the seafloor as a result of the deposition of waste products, the placement of aquaculture structures on the seafloor, and the harvesting of aquaculture species. The following is a description of the environmental impacts of aquaculture operations on seafloor habitat.

<u>Seafloor Impacts</u>

Aquaculture operations can have a wide range of biological, chemical, and physical impacts on seafloor habitat stemming from organic material deposition, shading effects, damage to habitat from aquaculture structures and operations, and harvesting with rakes and dredges (USFWS and NMFS 1999; Goldburg *et al.* 2001). Organic material deposition beneath netpens and cages can smother organisms, change the chemical and biological structure of sediment, alter species biomass and diversity, and reduce oxygen levels. The physical and chemical conditions present at the aquaculture site will influence the degree to which organic waste affects the benthic community. At riverine sites with slower currents and softer sediments, benthic community impacts will be localized; whereas sites with stronger currents and coarser sediments will have widely distributed but less intense benthic community effects downstream of the site.

At both land-based and water-based aquaculture facilities, accumulations of large amounts of carbon and nutrient-rich sediment may produce anaerobic conditions in sediments and cause the release of hydrogen sulfide gas and methane, two gases toxic to fish (Pillay 1992, cited in Goldburg and Triplett 1997). In Maine, seafloor impacts due to sediment deposition at salmon farms include the growth of the bacterial mold *Beggiatoa* sp., which degrades water quality and subsequently lowers species diversity and biomass beneath the pens (Goldburg and Triplett 1997).

Suspended shellfish culture techniques may cause changes in benthic community structure similar to those conditions found under netpens. Filter-feeding shellfish "package" phytoplankton and other food particles into feces and pseudofeces, which are deposited on the seafloor and may cause local changes in benthic community structure (Grant *et al.* 1995; Goldburg and Triplett 1997). In

Kenepuru Sound, New Zealand, a mussel aquaculture site consistently showed a higher organic nitrogen pool than at the reference site, indicating that organic nitrogen was accumulating in the sediments below the mussel farm (Kaspar *et al.* 1985). The benthic community at the mussel farm was comprised of species adaptable to low-oxygen levels that live in fine-textured, organically rich sediments, while the reference site consisted of species that typically reside in highly oxygenated water (Kaspar *et al.* 1985).

Aquaculture structures can have direct impacts on seafloor habitat, including shading of seafloor habitat by netpens and cages (USFWS and NMFS 1999; NEFMC 1998). Shading can impede the growth of submerged aquatic vegetation that provides shelter and nursery habitat to fish and their prey species (Barnhardt *et al.* 1992; Griffin 1997; Deegan and Buchsbaum 2005). Seagrasses and other sensitive benthic habitats may also be impacted by the dumping of shells onto the seafloor for use in shellfish aquaculture operations (Simenstad and Fresh 1995). Shell substratum helps to stabilize the benthos and improve growth and survival of the cultured shellfish species. But the placement of this material on the bottom not only causes a loss in seagrass and other habitat, substrate modification also induces a localized change in benthic community composition (Simenstad and Fresh 1995).

Harvesting practices also have the potential to adversely affect seafloor habitat. Perhaps the most detrimental is the mechanical harvesting of shellfish (e.g., the use of dredges). Polychaete worms and crustaceans may be removed or buried during dredging activities (Newell *et al.* 1998). Mechanical harvesting of shellfish may also adversely affect benthic habitat through direct removal of seagrass and other reef-building organisms (Goldburg and Triplett 1997).

<u>Introductions of Exotic Invasive Species</u>

Aquaculture operations have the potential to be a significant source of non-native introductions into North American waters (Goldburg and Triplett 1997; USCOP 2004). The cultivation of non-native species becomes problematic when fish escape or are intentionally released into the marine environment. Introduced species can reduce biodiversity, alter species composition, compete with native species for food and habitat, prey on native species, inhibit reproduction, modify or destroy habitat, and introduce new parasites or diseases into an ecosystem (Goldburg and Triplett 1997; USFWS and NMFS 1999). Impacts from introduced aquaculture species may result in the displacement or extinction of native species, which is believed to be a contributing factor in the demise of seven endangered or threatened fish species listed under the Endangered Species Act (Goldburg and Triplett 1997).

In Maine, escaped aquaculture salmon can disrupt redds (i.e., spawning nests) of wild salmon, transfer disease or parasites, compete for food and habitat, and interbreed with wild salmon (USFWS and NMFS 1999). Escaped aquaculture salmon represent a significant threat to wild salmon in Maine because even at low levels of escapement, aquaculture salmon can represent a large proportion of the salmon returns in some rivers. Escaped Atlantic salmon have been documented in the St. Croix, Penobscot, East Machias, Dennys, and Narraguagus rivers in Maine. Escapees represented 89 percent and 100 percent of the documented runs for the Dennys River in 1994 and 1997, respectively, and 22 percent of the documented run for the Narraguagus River in 1995 (USFWS and NMFS 1999). In 2000, only 22 wild Atlantic salmon in Maine were documented as returning to spawn in their native rivers; however, total adult returning spawners may have numbered approximately 150 fish (Goldburg *et al.* 2001).

Cultivating a reproductively viable European stock of Atlantic salmon in Maine waters poses a risk to native populations because of escapement and the subsequent interbreeding of genetically divergent populations (USFWS and NMFS 1999). The wild Atlantic salmon population in the Gulf of Maine currently exhibits poor marine survival, low spawning stock size, is particularly vulnerable to genetic modification, and is in danger of becoming extinct. Dilution of the gene pool, when combined with environmental threats such as reduced water levels, parasites and diseases, commercial and recreational fisheries, loss of habitat, poor water quality, and sedimentation, could extirpate the wild salmon stock in the Gulf of Maine (USFWS and NMFS 1999). For additional discussions on this topic, refer to the section in this chapter on Gene Pool Alteration.

Food Web Impacts

Aquaculture operations have the potential to impact food webs via localized nutrient loading from organic waste and by large-scale removals of oceanic fish for dry-pellet fish feed (Goldburg and Triplett 1997). As reviewed in previous sections of this chapter, nutrients in discharged organic waste may affect local populations by changing community structure and biodiversity. These localized changes may have broader implications on higher trophic level organisms. For example, biosedimentation at a mussel aquaculture site had a strong effect on benthic community structure both below and adjacent to mussels grown on rafts (Kaspar *et al.* 1985). Benthic species located beneath and adjacent to mussel rafts included sponges, tunicates, and calcareous polychaete worms, while benthic species at the reference site included bivalve mollusks, brittle stars, crustaceans, and polychaete worms. The shift in benthic community structure at the shellfish aquaculture site may have had implications in higher trophic levels in the ecosystem.

Large-scale removals of anchovy, herring, sardine, jack mackerel, and other pelagic fishes for the production of dry-pellet fish feed has a large impact on the food web (Goldburg and Triplett 1997). Approximately fifteen percent (17 million metric tons) of the world's fish harvest is now used to produce fish feeds. Feeding fish to other fish on a commercial scale is highly energy-inefficient and may have environmental implications and impacts on other species. Higher trophic levels depend on small pelagic fishes for growth and survival, so the net removal of protein can have significant effects on sea birds, mammals, and commercially important fish species (Goldburg and Triplett 1997).

Gene Pool Alterations

Escaped aquaculture species can alter the genetic characteristics of wild populations when native species interbreed with escaped non-native or native aquaculture species or escaped genetically engineered aquaculture species (USFWS and NMFS 1999; Goldburg *et al.* 2001; USCOP 2005). Interbreeding of the wild population with escaped non-native species is problematic, as discussed in the Introduced/Nuisance Species section of this chapter. However, interbreeding of the wild population with escaped, native species may be problematic due to the genetic differences between the escaped native and the wild native populations. Aquaculture operations often breed farmed fish for particular traits, such as smaller fins, aggressive feeding behavior, and larger bodies. Therefore, the genetic makeup of escaped native and wild native fish may be different, and interbreeding may decrease the fitness of wild populations through the breakup of gene combinations and the loss of genetic diversity (Goldburg *et al.* 2001).

Atlantic salmon aquaculture in New England has been established from Cape Cod north to Canada, although most of this activity is clustered at the Maine-New Brunswick border. In 1994, thousands of Atlantic salmon escaped from an aquaculture facility during a storm event, many of which spread into coastal rivers in eastern Maine (Moring 2005). In 2000, a similar storm event in Maine resulted in the escapement of 100,000 salmon from a single farm, which is more than 1,000 times the documented number of native adult Atlantic salmon. Canada is having similar problems with escapees and the interbreeding of wild and farmed salmon populations. In 1998, 82 percent of the young salmon leaving the Magaguadavic River in New Brunswick originated from aquaculture farms (Goldburg *et al.* 2001). Escapees can and do breed with wild populations of Atlantic salmon, which is problematic because interbreeding can alter the genetic makeup of native stocks (Moring 2005).

Escaped genetically engineered aquaculture species may exacerbate the problem of altering the gene pool of native fish stocks. Genetically engineered (i.e., transgenic) species are being developed by inserting genes from other species into the DNA of fish for the purpose of altering performance, improving flesh quality, and amplifying traits such as faster growth, resistance to diseases, and tolerance to freezing temperatures (Goldburg and Triplett 1997; Goldburg *et al.* 2001). For example, genetically engineered Atlantic salmon have an added hormone from chinook salmon that promotes faster growth, which may reduce costs for growers. The Food and Drug Administration has not allowed these fish to be marketed, but if they were, any aquaculture escapees could impair wild Atlantic salmon stocks via competition, predation, and expansion into new regions. Interbreeding could weaken the genetic integrity of wild salmon populations and have long-term, irreversible ecological effects (Goldburg *et al.* 2001).

<u>Impacts to Water Column</u>
Aquaculture may impact the water column via organic and contaminant discharge from land- and water-based aquaculture sites (NEFMC 1998). As discussed in other sections of this chapter, aquaculture discharges include nutrients, toxins, particulate matter, metabolic wastes, antibiotics, herbicides, and pesticides. The water column may become turbid as a result of this discharge, which can degrade overall habitat conditions for fish and shellfish in the area. Discharge may contribute to nutrient loading, which may lead to eutrophic conditions in the water column. Eutrophication often results in oxygen depletion, finfish and shellfish kills, habitat degradation, and harmful algal blooms that may impact human health. For additional information on discharge of nutrients and its subsequent effects on the water column via eutrophication and algal blooms, see the section on the Discharge of Organic Waste and Contaminants of this chapter.

<u>Impacts to Water Quality</u>
Water quality in the vicinity of finfish aquaculture operations may be impaired due to the discharge of organic waste products, subsequent eutrophication of the water column, toxic algal blooms, hypoxic or anoxic zones due to microbial degradation, and the spread of chemical substances such as antibiotics, herbicides, pesticides, hormones, pigments, minerals, and vitamins. The impacts of finfish aquaculture operations on water quality are discussed in previous subsections of the Aquaculture section.

Shellfish aquaculture operations have the potential to improve water quality due to filtration of nutrients and suspended particles from the water column (Newell 1988). However, bivalves may contribute to the turbidity of the pelagic environment via their waste products (Kaspar *et al.* 1985; Grant *et al.* 1995). These waste products are expelled as feces and pseudofeces, which can be suspended into the water column, thus contributing to nutrient loads near aquaculture sites. Nutrient overenrichment often results in oxygen depletion, toxic gas generation, and harmful algal blooms, thus impairing the water quality near shellfish aquaculture sites. Therefore, both finfish and shellfish aquaculture operations have the potential to adversely affect water quality beneath aquaculture structures and in the surrounding environment. For additional information on eutrophication, refer to the chapters on Agriculture and Silviculture, Coastal Development, and Alteration of Freshwater Systems in this report.

Changes in Species Diversity

Species diversity and abundance may change in the vicinity of aquaculture farms as a result of effluent discharges or habitat modifications that alter environmental conditions. Changes in species diversity may occur due to increased organic waste in pelagic and benthic environments, modification to bottom habitat, and the attraction of predators to the farmed species. Accumulated organic waste beneath aquaculture structures may change benthic community structure. In Maine, salmon netpen aquaculture can alter the benthos by shifting microbial and macrofaunal species to those adapted to enriched organic sediments. At one netpen site, epibenthic organisms were more numerous near the pen than at reference sites, suggesting that benthic community structure can be altered by salmon aquaculture in coastal Maine waters (Findlay *et al.* 1995).

Cultivated mussels can alter species diversity via biodeposition. Benthic habitat can shift from communities of bivalve mollusks, brittle stars, crustaceans, and polychaete worms to communities of sponges, tunicates, and calcareous polychaete worms beneath mussel aquaculture sites. The difference between the two sites represent a change in species diversity from those that typically reside in highly oxygenated water to those species adaptable to low-oxygen levels that can live in areas with fine-textured, organically rich sediments (Kaspar *et al.* 1985).

Benthic habitat modification at shellfish aquaculture sites can alter species diversity (Kaiser *et al.* 1998). Cultivation of shellfish requires the placement of gravel or crushed shell on the substrate. Seed clams are placed on the substrate in bags, or directly on substrate covered with protective plastic netting. Benthic structure at shellfish aquaculture sites can therefore shift from polychaete-dominated communities to bivalve and nemertean-dominated communities, which could have repercussions at other trophic levels (Simenstad and Fresh 1995; Kaiser *et al.* 1998).

Open water netpens may alter species diversity by attracting wild fish or other predators to the aquaculture site (Vita *et al.* 2004). Wild benthic and pelagic species are attracted to uneaten pellet feed and other discharged effluent, which can result in impacts to the food web (Vita *et al.* 2004). Predators such as seals, sea lions, and river otters may also be attracted to aquaculture pens to feed on farmed species, which can alter communities in the vicinity of aquaculture sites (Goldburg *et al.* 2001).

Sediment Deposition

The effects of sediment deposition include eutrophication of the water column, toxic algal blooms, hypoxic or anoxic zones due to microbial degradation, and the spread of contaminants such as antibiotics, herbicides, pesticides, hormones, pigments, minerals, and vitamins. The impacts of sediment deposition from discharged organic waste and contaminants on the water column and on the seafloor have been discussed in other sections of this chapter.

Introduction of Diseases

Parasite and disease introductions into wild fish and shellfish populations are generally associated with aquaculture operations, and have the potential to lower the fitness level of native species or contribute to the decline of native populations. Atlantic salmon in New England are susceptible to a variety of parasites and fungal, bacterial, and viral diseases (USFWS and NMFS 1999). Common external freshwater parasites found in Atlantic salmon include the gill maggot, freshwater louse, and leeches. Internal freshwater parasites include flukes, tapeworms, spiny-headed worms, and round worms. Bacterial diseases found in Atlantic salmon include vibriosis, coldwater disease, bacterial kidney disease, enteric redmouth disease, and furunculosis. In New England, the only known disease-related mortality is from furunculosis. Viral diseases include salmon papilloma and infectious pancreatic necrosis. Saprolegnia is the only fungal disease found in Atlantic salmon (USFWS and NMFS 1999).

In eastern Maine and New Brunswick, an outbreak of diseases in both wild and cultured stocks of Atlantic salmon suggests that cultured stocks are acting as reservoirs of diseases that are being transferred to wild stocks (Moring 2005). In addition to these diseases, sea lice are a flesh-eating parasite that has been passed from farmed salmon to wild salmon while the wild salmon migrate through coastal waters. Sea lice can serve as a host for Infectious Salmon Anemia (ISA), which is a virus that has spread from salmon farms in New Brunswick to salmon farms in Maine (USFWS and NMFS 1999). The ISA virus causes a fatal disease in salmon at aquaculture facilities, and this virus has been detected in wild fish species. ISA appeared in the United States in 2001, is currently moving into southern regions, and represents a significant threat to wild salmon (Goldburg *et al.* 2001).

Habitat Replacement/Exclusion

Aquaculture facilities may exclude aquatic organisms from their native habitat through the placement of physical barriers to entry or through changes in environmental conditions at aquaculture sites. Nets, cages, concrete, and other barriers exclude aquatic organisms from entering the space in which the aquaculture structures are placed. By effectively acting as physical barriers for wild populations, these formerly usable areas are no longer available as habitat for fish and shellfish species to carry out their life cycles. Aquaculture facilities may physically exclude wild stocks of fish, such as Atlantic salmon, from reaching critical spawning habitat upstream of the facilities (Goldburg *et al.* 2001).

Changes in environmental conditions at the aquaculture site may also exclude aquatic organisms from their native habitat. Discharge of organic waste and contaminants beneath aquaculture netpens and cages may render pelagic and benthic habitat unusable through nutrient loading and the subsequent effects of eutrophication. Low dissolved oxygen caused by eutrophication may force native species out of their habitat, while harmful algal blooms can cause widespread fish kills or exclude fish from areas affected by the outbreak (Goldburg and Triplett 1997). In the case of large shellfish aquaculture operations, filtering bivalves can also decrease the amount and type of nutrients and phytoplankton available to other species. This reduction in nutrients and phytoplankton can stimulate competition between populations of cultured and native species (Dankers and Zuidema 1995). Nutrient and phytoplankton removal could have a cascade effect on the trophic structure of the ecosystem (NEFMC 1998), which may eventually cause mobile species to relocate to other areas.

Habitat Conversion

Aquaculture operations require the use of space, which results in the conversion of natural aquatic habitat that could have been used by native organisms for spawning, feeding, and growth (Goldburg *et al.* 2001). Approximately 321,000 acres of fresh water habitat and 64,000 acres of salt-water habitat have been converted for use in aquaculture operations in the United States. Shellfish aquaculture can eliminate seagrass beds when shell material is dumped on the seafloor (Simenstad and Fresh 1995). Seagrass beds in the vicinity of shellfish bottom culture operations may be eliminated during harvesting, which may temporarily reduce levels of biodiversity by reducing habitat for other marine species. Habitat conversion also takes place at netpen sites in which sediment deposition causes underlying habitat to become eutrophic. Sensitive benthic habitats beneath the netpens, such as seagrasses, may be eliminated or degraded due to poor water quality conditions, thus converting viable habitat to unusable or less productive seafloor area (Goldburg and Triplett 1997).

Conservation Measures and Best Management Practices for Aquaculture

1. When siting new aquaculture facilities, assess the benthic resources in the area (e.g., SAV), the proximity to wild stocks, migratory corridors, competing uses, hydrographic conditions, and upstream habitat uses.
2. Avoid siting of shellfish cultures in or near submerged aquatic vegetation.
3. Avoid enclosing or impounding tidally influenced wetlands for mariculture purposes.
4. Ensure that aquaculture operations adequately address disease issues to minimize risks to wild stocks.
5. Employ methods to minimize escape from culture facilities to minimize potential genetic impacts and to prevent disruption of natural aquatic communities.
6. Design aquaculture facilities to meet applicable environmental standards for wastewater treatment and sludge control.
7. Locate aquaculture facilities to minimize discharge effects on habitat and locate water intakes to minimize entrainment of native fauna.
8. Evaluate and control the use of chemicals in aquaculture operations.
9. Avoid direct application of carbaryl or other pesticides in water.
10. Use aquaculture gear designed to minimize entanglement of prey species.
11. Exclude exotic species from aquaculture operations until a thorough scientific evaluation and risk assessment is performed.
12. Aquaculture facilities rearing non-native species should be located upland and use closed-water circulation systems.
13. Treat effluent from public aquaria displays, laboratories, and educational institutes that are using exotic species prior to discharge for the purpose of preventing the introduction of viable animals, plants, reproductive material, pathogens, or parasites into the environment.
14. Consider growing several cultured species together, such as finfish, shellfish, algae, and hydroponic vegetables to reduce nutrient and sediment loads on the ecosystem.
15. Develop a monitoring program at the site to evaluate habitat and water quality impacts and the need for corrective measures through adaptive management.

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GLOBAL EFFECTS AND OTHER IMPACTS

Climate Change

Introduction

Sea levels have fluctuated throughout time, rising slowly since the end of the Pleistocene epoch (about 10,000 years before present). Recent human-induced increases in atmospheric concentrations of greenhouse gases are expected to cause much more rapid changes in the earth's climate than have previously been experienced. The burning of fossil fuels and forests and use of aerosol-producing substances emit greenhouse gases such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. Over the next century, global warming is expected to accelerate the rate of sea-level rise by expanding ocean water and melting alpine glaciers (Schneider 1998; IPCC 2001).

The Intergovernmental Panel on Climate Change (IPCC) predicted in its Third Assessment Report (IPCC 2001) the following based on current global climate models:

- By 2100 average surface temperatures will increase by 1.4-5.8° C (2.5-10.4° F) above 1990 levels. The most drastic warming will occur in northern latitudes in the winter.
- Sea level rose 10-20 cm (4-8 inches) in the 20th century and may rise another 9-88 cm (4-35 inches) by 2100.
- Global precipitation is likely to increase, with more precipitation and more intense storms in the mid-high latitudes in the northern hemisphere.

In combination, these factors are projected to result in significant impacts on coastal and marine ecosystems. There are several key drivers of climate change: sea level change; alterations in circulation patterns; changes in frequency and intensity of coastal storms; and increased levels of atmospheric carbon dioxide.

Primary impacts of global climate change that could potentially threaten riverine, estuarine, and marine fishery resources include:

1. Increasing rates of sea-level rise and intensity and frequency of coastal storms and hurricanes will increase threats to shorelines, wetlands, and coastal development;
2. Marine and estuarine productivity will change in response to alterations in the timing and amount of freshwater, nutrients, and sediment delivery;
3. High water temperatures and changes in freshwater delivery will alter estuarine stratification, residence time, and eutrophication and;
4. Increased ocean temperatures are expected to cause poleward shifts in the ranges of many other organisms, including commercial species, and these shifts may have secondary effects on their predators and prey (Scavia 2002).

In many cases these impacts may be intensified by other ecosystem stresses (pollution, harvesting, habitat destruction, invasive species) leading to more significant environmental consequences.

It should be noted that while the general consensus among climate scientists today indicates a current and future warming of the Earth's climate due to emissions of greenhouse gases from anthropogenic sources, the anticipated effects at regional and local levels are less understood. For example, although most climate models predict more precipitation for the New England area, other factors may influence and counter those effects resulting in reductions in precipitation for some geographic areas. Consequently, there are degrees of uncertainty regarding the specific effects to marine organisms and communities and their habitats from climate change. This section attempts to address some of the possible effects to fishery resources in the northeast region of the U.S.

Scientists expect that northeastern North America will experience continued warming trends, as predicted in the 2001 IPCC report. Regional models predict a 3.2-5.1° C (6.0-10.0° F) temperature increase in the next 100 years in New England and eastern Canada (Nedeau 2004). The greatest temperature changes are expected to be in the wintertime and early spring with warm periods expecting to increase in frequency and duration. Climate models also predict an increase in the frequency and intensity of coastal storms.

The following discussion of potential affects of climate change to the marine ecosystem is primarily based on two documents: *Effects of Climate Change on the Gulf of Maine Region* (Gulf of Maine Council on the Environment 2004) and *Coastal and Marine Ecosystems and Global Climate Change: Potential Effects on U.S. Resources* (Kennedy 2002).

Alteration of Hydrological Regimes

A number of computer climate models indicate a slowing of the "overturning" process of ocean waters, known as the thermohaline circulation (THC). This phenomenon appears to be driven by a reduction in the amount of cold and salty and hence, more dense, water sinking into the depths of the ocean. In fact, surface waters of the North Atlantic have been warming in recent decades; parts of the North Atlantic are also becoming less salty (Nedeau 2004). In the North Atlantic, a weakening of the THC is related to wintertime warming and increased freshwater flow into the Arctic and the North Atlantic (Nedeau 2004). An increased weakening of the THC could lead to a complete shut down or southward shift of the warm Gulf Stream, as was experienced during the last glacial period (Nedeau 2004). On a regional level, changes in ocean current circulation patterns may alter temperature regimes, vertical mixing, salinity, dissolved oxygen, nutrient cycles, and larval dispersal of marine organisms in the northeast coastal region. Upwelling and mixing could be affected, ultimately leading to a net reduction in oceanic productivity (Nedeau 2004).

Under most climate-change models, the Gulf of Maine region will see increased annual precipitation and more intense storm events; this will increase river flow, and thus increase the export of nutrients, contaminants, and sediment to our estuaries. However, some climate models predict that drought conditions may become common in other areas, resulting in opposite effects (Nedeau 2004).

The quantity of freshwater discharge (i.e., precipitation) affects salt marshes because river flow and runoff deliver sediments that are critical for a marsh to maintain or increase its elevation. An increase in freshwater discharge could increase the rate of salt marsh accretion. However, a decrease in freshwater discharge could cause some salt marshes to become sediment-starved and ultimately lost as sea levels rise and marshes are drowned. A decrease in freshwater discharge might also cause salinity stress in some salt marshes.

Alterations in Temperature Regimes

Temperature affects nearly every aspect of marine environments, from cellular processes to ecosystem function. The distribution, abundance, metabolism, survival, growth, reproduction, productivity, and diversity of marine organisms will all be affected by temperature changes

(Kennedy 2002; GMCE 2004). For example, cold-adapted species (e.g., Atlantic salmon) may gradually be less able to compete with warm-adapted species if coastal water temperatures increase.

In the northeast Atlantic, studies have found the timing of phytoplankton blooms and the abundance of phytoplankton populations have shifted with water temperatures (Richardson and Schoeman 2004). Phytoplankton tended to become more abundant when cooler regions warmed, probably because higher temperatures boost metabolic rates. Phytoplankton became less common when already warm regions got even warmer, possibly because warm water blocks nutrient-rich deep water from rising to the upper layers where phytoplankton live (Edwards and Richarson 2004). Impacts on the base of the food chain would not only affect fisheries, but entire ecosystems.

The frequency of diseases and pathogens may increase due to climate change. Examples include DERMO, a disease that affects commercially valuable oysters, which exhibits higher infection rates with increased temperature and salinity. Warm, dry periods (e.g., summer drought) may make oysters more susceptible to this disease. The eelgrass wasting disease pathogen (*Labyrinthula zosterae*) has reduced eelgrass beds throughout the east coast in the past and might become more of a problem due to its preference for higher salinity waters and warmer water (both of which are expected in some estuaries because of sea-level rise) (Nedeau 2004).

Changes in Dissolved Oxygen Concentrations

Dissolved oxygen may decline in deep waters, especially if vertical mixing is reduced. If algal productivity increases due to warmer temperatures and increased available carbon dioxide, the increased decomposition of this organic material will use more oxygen in the water. Oftentimes, highly enriched estuaries suffer from deep-water hypoxia (low oxygen) or anoxia (no oxygen). In addition, because warmer water holds less oxygen than colder water, increased water temperatures will reduce the dissolved oxygen in bodies of water than are not well mixed.

Nutrient Loading and Eutrophication

Nutrients exported from a watershed and delivered to estuarine and marine waters may increase if freshwater flow from rivers and stormwater discharge increases. Higher nutrient loads may increase the occurrences of eutrophication, harmful algal blooms, and periods of hypoxia or anoxia, and increase the intensity of turbidity and changes to benthic communities and submerged aquatic vegetation.

Release of Contaminants

If river discharge and overland runoff increases due to climate change, contaminant loading of coastal waters may increase. Contaminants, such as hydrocarbons, heavy metals, organic and inorganic chemicals, sewage, and wastewater materials, are flushed from the watershed and exported to coastal waters, especially if the frequency and intensity of storms and floods are affected. These contaminants may be stored in coastal sediments or taken up directly by biota (e.g., bacteria, plankton, shellfish, or fish) and could ultimately affect fisheries and human health. Sea-level rise would inundate lowland sites near the coast, many of which contain hazardous substances that could leach contaminants into nearshore habitats (Bigford 1991).

Loss of Wetlands and other Fishery Habitat

Sea level rise may affect diurnal tide ranges, causing coastal erosion, increasing salinity in estuaries, and changing the water content of shoreline soils. Accelerated sea-level rise threatens coastal habitats with inundation, erosion, and saltwater intrusion (Scavia *et al.* 2002). Sea-level rise may encroach on salt marshes and coastal wetlands, at which point shorelines will either need to build upward (accrete) to keep pace with rising sea levels, or migrate inland to keep pace with drowning/erosion on the seaward edge. In cases where the upland edge is blocked by steep topography (e.g., bluffs) or human development (e.g., shoreline protection structures) coastal habitat will be lost. Conservative estimates of losses to saline and freshwater wetlands due to sea-level rise range from 47 to 82 percent of the nation's coastal wetlands, or approximately 2.3 million to 5.7 million acres, respectively (Bigford 1991).

Submerged aquatic vegetation may be affected from reduced light levels due to an increase in sedimentation and turbidity, enhanced growth of competing macroalgae, reduction in dissolved oxygen concentration, thermal stress that affects growth rates and basic plant physiology, changes in salinity regimes, and increased susceptibility (and exposure) to diseases and pathogens.

<u>Bank/Soil Erosion</u>
An increase in freshwater discharge, storm frequency and intensity, and sea level rise can lead to increased erosion rates along coastal shorelines. The loss of riparian and salt marsh vegetation from climate change effects could serve as a feedback loop that reduces the ability of wetlands to withstand these perturbations, which may further increase the rate of coastal erosion.

<u>Alteration in Salinity</u>
Vertical mixing in coastal waters is influenced by several factors, including water temperatures and freshwater input, so warmer temperatures may affect the thermal stratification of estuaries (GMCE 2004). If freshwater flow from rivers is reduced or increased, salinities in river and estuaries will be altered which will have profound affects on the distribution and life history requirements of coastal fisheries. For example, increased freshwater input into estuaries would lower salinities in salt marsh habitat which could enhance conditions for invasive exotic plants that prefer low-salinity conditions, such as *Phragmites* or purple loosestrife. Increased freshwater runoff will increase vertical stratification of estuaries and coastal waters, which could have indirect effects on estuarine and coastal ecosystems. For example, upwelling of deep, nutrient-rich seawater could be reduced, leading to reductions in primary productivity in coastal waters. However, rising sea levels could cause estuarine wetlands to be inundated with higher salinity seawater, altering the ecological balance of highly productive fishery habitat.

<u>Alteration in Weather Patterns</u>
The intensity and frequency of coastal storms and hurricanes is predicted to increase due to climate change, which will threaten shorelines and wetlands. The loss of coastal wetland vegetation and increased erosion of shorelines and riparian habitats due to storms could have an adverse effect on the integrity of aquatic habitats. As discussed in other subsections, altered temperature, rainfall, and snowfall may affect the geographic ranges of species or interfere with spawning and migration. Reductions in dissolved oxygen concentrations and salinity are consistent phenomena associated with coastal storms and hurricanes, and most aquatic systems require weeks or months to recover following a storm (Van Dolah and Anderson 1991); however, increased frequency and intensity of storms could lead to chronic disturbances and have adverse consequences on the health and ecology of coastal rivers and estuaries.

<u>Changes in Water Alkalinity</u>
Increased atmospheric carbon dioxide levels may alter the carbonate chemistry of the world's oceans, causing the water to become more acidic (i.e., lowered pH). Increased acidity in oceans and

estuaries could reduce calcium carbonate availability in seawater, which may lower the calcification rates in marine organisms (e.g., mollusks and crustaceans, hard corals). Alterations of water alkalinity could have severe impacts on trophic level and secondary production, which could result in ecosystem-level affects.

Changes in Community Structure

The geographic distributions of species may expand or contract with changing oceanic temperatures, creating new combinations of species that could interact in unpredictable ways. Fish communities are likely to change. For example, the southern range limit of northern species, such as cod, plaice, haddock, and halibut will likely shift north while the northern range limit of southern species, such as butterfish and menhaden, may shift northward (GMCE 2004). Short-lived fish species may show the most rapid demographic responses to temperature changes, resulting in stronger distributional responses to warming (Perry *et al.* 2005). Range shifts could create new competitive interactions between species that had not evolved in sympatry, causing further losses of competitively inferior or poorly adapted species.

Migratory and anadromous fish such as salmon and shad may be affected by climate change because they depend on the timing of seasonal temperature-related events as cues for migration. Ideal river and ocean temperatures may be out of synch as climate changes, making the saltwater-to-freshwater transition difficult for spawning adults, or the freshwater-to-saltwater transition difficult for ocean-bound juveniles. Migration routes, timing of migration, and ocean growth and survival of fish may also be affected by altered sea-surface temperatures (GMCE 2004).

Invasive species may flourish in a changing climate when shifting environmental conditions give certain species a foothold in a community and a competitive advantage over native species. This is especially true for organisms adapted to warmer conditions.

Changes in Ecosystem Structure

Increases in the severity and frequency of coastal storms may cause more damage to salt marshes by eroding the seaward edge, flooding further inland, changing salinity regimes or marsh hydrology, and causing vegetation patterns to change. Healthy salt marshes can buffer upland areas (including human structures) from storm damage, and this ecosystem function will be impaired if marshes are destroyed or degraded.

The loss or degradation of salt marshes will affect critical habitat for many species of wildlife, which may ultimately affect biodiversity, coastal ecosystem productivity, fisheries, and water quality.

Changes in Ocean/Coastal Uses

Commercial fisheries could be impacted by the cumulative effects of climate change, including rising sea levels and water temperatures, and habitat degradation in estuaries, rivers, and coastal wetlands. Approximately 32 percent of species important to fisheries in New England are dependent upon estuaries during some portion of their life histories (Nedeau 2004). Climate change could also affect human health and the use of ocean resources if the frequency and intensity of harmful algal blooms, fish and shellfish diseases, coastal storms, and impacts to coastal wetlands increase. These effects, combined with sea-level rise, may result in a loss and/or inability to utilize coastal resources. Conservative predictions of impacts to fisheries resources from sea-level rise and habitat loss due to climate change would likely dwarf those impacts now attributed to direct human activities, like water quality degradation, coastal development, and dredging (Bigford 1991).

Conservation Measures and Best Management Practices for Climate Change

1. Promote soft shore protection techniques, such as salt marsh restoration and creation, and beach dune restoration, as alternatives to hard-armoring approaches.
2. Manmade, vertical structures such as concrete bulkheads for shoreline stabilization should be considered only as a last resort.
3. Establish setback lines for coastal development and rolling easements based on sea level rise and subsidence projections that include local land movement.
4. Development projects that involve wetland filling and increase impervious surfaces should be avoided.
5. Improve land use practices, such as more efficient nutrient management, and more extensive restoration and protection of riparian zones and wetlands.
7. Encourage renewable, non-greenhouse gas polluting energy projects, whenever practicable and feasible.
8. Local, regional, and federal agencies should consider implications of climate change in their decision-support analysis and documents (e.g., National Environmental Policy Act) regarding permit decisions and funding programs.
9. Encourage communities and states to develop and implement greenhouse gas inventories and reduction initiatives.
10. Encourage the use of energy efficient technologies to be integrated into commercial and residential construction, including renewable energy and energy efficient heating and cooling systems and insulation.
11. Encourage the use of fuel-efficient vehicles and mass transportation systems.

Ocean Noise

Introduction

Sound is the result of energy created by a mechanical action dispersed from a source at a particular velocity and causes two types of actions: an oscillation of pressure in the surrounding environment and an oscillation of particles in the medium (Stocker 2002). Because water is 3500 times denser than air, sound travels five times faster in water (Stocker 2002). The openness of the ocean and relative density of the ocean medium allows for the transmission of sound energy over long distances. Factors that affect density include temperature, salinity, and pressure. These factors are relatively predictable in the open ocean but highly variable in coastal and estuarine waters. As a result of these factors along with water depth and variable nearshore bathymetry, sound attenuates more rapidly with distance in shallow compared to deep water (Rogers and Cox 1988).

Noise in the ocean environment can be categorized as natural and anthropogenic sources. Naturally generated sounds come from wind, waves, ice, seismic activity, tides and currents, and thunder among other sources. Many sea animals use sound in a variety of ways; some use sound passively and others actively. Passive use of sound occurs when the animal does not create the sound that it senses, but responds to environmental and ambient sounds. These uses include detection of predators, location and detection of prey, proximity perception of co-species in schools or colonies, navigation, and perception of changing environmental conditions such as seismic movement, tides and currents. Animals also create sounds to interact with their environment or other animals in it. Such active uses include sonic communication with co-species for breeding and feeding (e.g., toadfish), territorial and social interactions, echolocation (e.g., marine mammals), stunning and apprehending prey, long distance navigation and mapping (e.g., sharks and marine mammals), and the use of sound as a defense against predators (e.g., croakers) (Stocker 2002).

The degree to which an individual fish exposed to sound will be affected is dependent upon a number of variables, including: 1) species of fish, 2) fish size, 3) presence of a swimbladder; 4) physical condition of the fish; 5) peak sound pressure and frequency; 6) shape of the sound wave (rise time); 7) depth of the water; 8) depth of the fish in the water column; 9) amount of air in the water; 10) size and number of waves on the water surface; 11) bottom substrate composition and texture; 12) tidal currents; and 13) presence of predators (Hanson *et al.* 2003).

Anthropogenic sources of noise include commercial shipping, seismic exploration, sonar, acoustic deterrent devices, and industrial activities and construction. The ambient noises in an average shipping channel are a combination of propeller, engine, hull, and navigation noises. In coastal areas the sounds of cargo and tanker traffic are multiplied by complex reflected paths – scattering and reverberating due to littoral geography. These cargo vessels are also accompanied by all other manner of vessels and watercraft: commercial and private fishing boats, pleasure craft, personal watercraft (e.g., jet skis) as well as coastal industrial vessels, public transport ferries, and shipping safety and security services such as tugs boats, pilot boats, U.S. Coast Guard and coastal agency support craft, and of course all varieties of navy ships – from submarines to aircraft carriers. In large part, anthropogenic activities creating ocean noise are concentrated in coastal and nearshore areas. The most pervasive man-made ocean noise is caused by transoceanic shipping traffic (Stocker 2002). The average shipping channel noise level ranges from 70 to 90 dB, which is as much as 45 dB over the natural ocean ambient noise in surface regions (Stocker 2002). Ships generate noise primarily by propeller action, propulsion machinery, and hydraulic flow over the hull (Hildebrand 2004). Considering all of these noises together, noise generated from a large container vessel can exceed 190 dB at the source (Jasny 1999). Refer to the Marine Transportation chapter for additional information on ocean noises generated from vessels.

The loudest noises may be the sounds of marine extraction industries such as oil drilling and mineral mining (Stocker 2002). Seismic exploration uses air guns to create a sound pressure wave that aids in reflection profiling of underlying substrates for oil and gas. The most prevalent sources of these sounds are from "air guns" used to create and read seismic disturbances. These devices generate and direct huge impact noises into the ocean substrate. Offshore oil and gas exploration generally occurs along the continental margins; however, a recent study indicated that air gun activity in these areas propagates into the deep ocean and is a significant component of low frequency noise (Hildebrand 2004). Peak source levels of air guns typically range between 250 and 255 dB. Following the exploration stage, drilling, coring and dredging is performed during extraction which also generate loud noises. Acoustic telemetry is also associated with positioning, locating, equipment steering and remotely operated vessel control to support extraction operations (Stocker 2002).

Sonar systems are used for a wide variety of civilian and military operations. Active sonar systems send acoustic energy into the water column and receive reflected and scattered energy. Sonar systems can be classified into low (<1000 Hz), mid (1-20 kHz), and high frequency (>20 kHz). Most vessels have sonar systems for navigation, depth sounding and "fish finding." Some commercial fishing boats also deploy various acoustic aversion devices to keep dolphins, seals and turtles from running afoul of the nets (Stocker 2002).

Because the ocean transfers sound over long distances so effectively, various technologies have been designed to make use of this feature (e.g., long distance communication, mapping, and surveillance). Since the early 1990's, it has been known that extremely loud sounds could be transmitted in the deep-ocean isotherm and could be coherently received throughout the seas. Early research in the use of deep-ocean noise was conducted to map and monitor deep-ocean water temperature regimes. Since the speed of sound in water is dependent on temperature, this characteristic was used to measure the temperature of the deep water throughout the sea. This technology has been used to study long-term trends in deep-ocean water temperature that could give a reliable confirmation of global warming. This program (Acoustic Thermography of Ocean Climates or ATOC) uses receivers stationed throughout the Pacific basin from the Aleutians to Australia. ATOC is a long wavelength, low frequency sound in the 1 Hz to 500 Hz band, and the first pervasive deep-water sound channel transmission, filling an acoustical niche previously only occupied by deep sounding whales and other deep water creatures (Stocker 2002). Concurrent with the development of ATOC, the U.S. Navy and other NATO navies have developed other low frequency communications and surveillance systems. Most notable of these is low frequency active sonar (LFAS) on a mobile platform, or towed array (Stocker 2002). Recently, the use of LFAS for military purposes has received considerable attention and controversy due to the concerns that this technology has resulted in injury and death to marine mammals, particularly threatened and endangered whales. In addition, Fernandez *et al.* (2005) found the occurrence of mass stranding events of beaked whales in the Canary Islands to have a temporal and spatial coincidence with military exercises using mid-frequency sonar. Beaked whales that died after stranding were found to have injuries to tissues consistent with acute decompression-like illness in humans and laboratory animals. Additional monitoring and research will need to be conducted to determine the degree of threat sonar has on marine organisms, particularly marine mammals.

Industrial and construction activities concentrated in nearshore areas contribute to ocean noise. Primary activities include pile driving, dredging, and resource extraction and production activities. Pile driving activities, which typically occur at frequencies below 1000 Hz, have led to mortality in fish (Hastings and Popper 2005). Intensity levels of pile driving have been measured up to 193 dB in certain studies (Hastings and Popper 2005). Refer to the chapter on Coastal Development for additional information on the affects of pile driving.

Underwater blasting using explosives are used for a number of development activities in coastal waters. Blasting is typically used for dredging new navigation channels in areas containing large rock boulders and ledges, decommissioning and removing bridge structures, dams; and construction of new in-water structures such as gas and oil pipelines, bridges, and dams. The potential for injury and mortality to fish from underwater explosives has been well-documented (Hubbs and Rechnitzer 1952; Teleki and Chamberlain 1978; Linton *et al.* 1985; and Keevin *et al.* 1999). Generally, aquatic organisms that possess air cavities (e.g., lungs, swim bladders) are more susceptible to underwater blasts than those without. In addition, smaller fish are more likely to be impacted by the shock wave of underwater blasts than larger fish, and the eggs and embryos tend to be particularly sensitive (Wright 1982). However, fish larvae tend to be less sensitive to blasts than eggs or post-larvae fish, probably because the larvae stages do not yet possess air bladders (Wright 1982). Impacts to fishery habitat from underwater explosives may include sedimentation and turbidity in the water column and benthos, and the release of contaminants (e.g., ammonia) in the water column with the use of certain types of explosives.

Noise generated from anthropogenic sources covers the full frequency of bandwidth used by marine animals (1 Hz to 200 kHz), and most audiograms of fishes indicate a higher sensitivity to sound within the 100 Hz to 2 kHz range (Stocker 2002). Evidence indicates that fish as a group have very complex and diverse relationships with sound and how they perceive it. It should be noted that relatively little direct research has been conducted on the impacts of noise to marine fish. However, some studies and formal observations have been conducted that elucidate general categories of impacts to fish species. Noise impacts to fish can be divided into: 1) physiological; 2) acoustic; 3) behavioral; and 4) cumulative impacts.

Physiological Impacts to Marine Organisms

Increased pressure from high noise levels may have impacts on other non-auditory biological structures such as swim bladders, the brain, eyes, and vascular systems (Hastings and Popper 2005). Any organ that reflects a pressure differential between internal and external conditions may be susceptible to pressure-related impacts. Some of the resulting affects on fish include a rupturing of organs and mortality (Hastings and Popper 2005). Sounds within autonomic response ranges of various organisms may trigger physiological responses that are not environmentally adapted in healthful ways (Stocker 2002).

The lethality of underwater blasts on aquatic organisms is dependent upon the detonation velocity of the explosion; however, a number of other variables may play an important role, including the size, shape, species, and orientation of the organism to the shock wave, and the amount, type of explosive, detonation depth, water depth, and bottom type (Linton *et al.* 1985). Fish with swimbladders are the most susceptible to underwater blasts, owing to the effects of rapid changes in hydrostatic pressures on this gas-filled organ. The kidney, liver, spleen, and sinus venosus are other organs that are typically injured after underwater blasts (Linton *et al.* 1985).

Acoustic Impacts to Marine Organisms

Acoustic impacts include damage to auditory tissue that can lead to hearing loss or threshold shifts in hearing (Jasny 1999; Heathershaw *et al.* 2001; Hastings and Popper 2005). Temporary threshold shifts and permanent threshold shifts may result from exposure to low levels of sound for a relatively long period of time or exposure to high levels of sound for shorter periods. Threshold shifts can impact a fish's ability to carry out its life functions.

Behavioral Impacts to Marine Organisms

While tissue damage would be a significant factor in compromising marine organisms, other effects of anthropogenic noise are more pervasive and potentially more damaging to marine organisms. For example, masking biologically significant sounds by anthropogenic interference could compromise acoustical interactions, from feeding to breeding, to community bonding, to schooling synchronization and all of the more subtle communications between these behaviors. Anthropogenic sounds that falsely trigger these responses may have animals expend energy without results (Stocker 2002). With respect to behavioral impacts on fish, studies here have been limited as well. Clupeid fish, including Atlantic herring are extremely sensitive to noise and schools have been shown to disperse when approached by fishing gear, such as trawls and seines (NOAA Fisheries 2005). Several studies indicate that catch rates of fish have decreased in areas exposed to seismic air gun blasts (Engås *et al*. 1996; Hastings and Popper 2005). These results imply that fish relocate to areas beyond the impact zone. One study indicated that catch rates increased 30-50 km away from the noise source (Hastings and Popper 2005). Several studies have indicated that increased background noise and sudden increases in sound pressure can lead to elevated levels of stress in many fish species (Hastings and Popper 2005). Elevated stress levels can increase a fish's vulnerability to predation and other environmental impacts. New studies are addressing the masking effects by background noise on the ability of fish to understand their surroundings. Because fish apparently rely so heavily on auditory cues to develop an "auditory scene", an increase in ambient background noise can potentially reduce a fish's ability to receive those cues and respond appropriately (Jasny 1999; Scholik and Yan 2002; Hastings and Popper 2005). Furthermore, the auditory threshold shifts of fish exposed to noise may not recover even after termination of the noise exposure (Scholik and Yan 2002).

Cumulative Impacts to Marine Organisms

Few research efforts have focused on the cumulative effects of anthropogenic ocean noise. Subtle and long-term effects on behavior or physiology could result from persistent exposure to certain noise levels leading to an impact on the survival of fish populations (Jasny 1999; Hastings and Popper 2005).

Conservation Measures and Best Management Practices for Ocean Noise

1. Mitigation strategies for noise impacts should consider the frequency, intensity, and duration of exposure, and evaluate possible reductions of each of these three factors. Mitigation strategies for ocean noise are challenged by the fact that a sound source may move in addition to the movement of affected fish in and out of the insonified region.
2. Assess the "acoustic footprint" of a given sound source and develop standoff ranges for various impact levels. Standoff ranges can be calculated using damage risk criteria for species exposure, source levels, sound propagation conditions, and acoustic attenuation models. Development of standoff ranges implies that sound sources be relocated or reduced since the sound receptors (fish) are more difficult to control. Because the potential number of species affected and their location is most likely unknown, development of a generic approach for mitigation using the species with the most sensitive hearing would produce a precautionary approach to reducing impacts on all animals (Heathershaw *et al.* 2001).
3. Recommend an assessment and designation of "acoustic hotspots" that are particularly susceptible to acoustic impacts and reducing sound sources around them. These hotspots may include seasonal areas for particularly susceptible life history activities like spawning or breeding (Jasny 1999).
4. Reducing noise intensity at the source primarily relies on technological solutions. These options include the use of "quiet" technology in marine engines and using bubble curtains for activities such as pile driving.
5. Encourage the use of sound dampening technologies for vessels and port/marine infrastructure to reduce ocean noise impacts to aquatic organisms.
5. When the source level of a sound cannot be reduced, duration should be managed to reduce impacts. Underwater sounds should be avoided during sensitive times of year (e.g., upstream and downstream river migrations, spawning, egg and larvae development).
6. Underwater explosives should be avoided in areas supporting productive fishery habitats. The use of less destructive methods should be encouraged, whenever possible. In some cases, the use of mechanical devices (e.g., ram hoe, clamshell dredge) may reduce impacts associated with rock and ledge removal.
7. Options to mitigating the impacts associated with underwater explosives should be investigated. Avoiding uses during sensitive periods (e.g., upstream and downstream river migrations, spawning, and egg and larvae development) may be one of the most effective means of minimizing impacts to fishery resources. Other methods may include the use of bubble curtains;

stemming (back-filling charge holes with gravel); delayed charges (explosive charges broken down into a series of smaller charges); and the use of repelling charges (small explosive charges used to frighten and drive fish away from the blasting zone) (Keevin 1998).

Atmospheric Deposition

Introduction

Pollutants travel through the atmosphere for distances of up to thousands of miles, often times to be deposited into rivers, estuaries, nearshore and offshore marine environments. Substances such as sulfur dioxide, nitrogen oxide, carbon monoxide, lead, volatile organic compounds, particulate matter and other pollutants are returned to the earth through either wet or dry atmospheric deposition. Wet deposition removes gases and particles in the atmosphere and deposits them to the Earth's surface by means of rain, sleet, snow, and fog. Dry deposition is the process through which particles and gases are deposited in the absence of precipitation. Deposition of nutrients (i.e., nitrogen and phosphorous) and contaminants (e.g., PCBs and mercury) into the aquatic system are of particular concern due to the resulting impacts to fisheries and health-risks to humans.

Atmospheric inputs of nutrients and contaminants differ from riverine inputs in the following ways: 1) riverine inputs are delivered to the coastal seas at their margins, whereas atmospheric inputs can be delivered directly to the surface of the central areas of coastal seas and hence exert an impact in regions less directly affected by riverine inputs; 2) atmospheric delivery occurs at all times, whereas riverine inputs are dominated by seasonal high-flows and coastal water phytoplankton activity is low; 3) atmospheric inputs are capable of episodic, high deposition events associated with natural or manmade phenomena (e.g., volcanic eruptions, forest fires); and 4) atmospheric inputs of nitrogen are chemically different from river inputs in that rivers are dominated by nitrous oxides, phosphorus and silica, while atmospheric inputs include reduced and oxidized nitrogen, but no significant phosphorus or silica (Jickells 1998). While there is little information on the direct effects of atmospheric deposition on marine ecosystems, management strategies must attempt to address these variations in inputs from terrestrial and atmospheric pathways.

Nutrient Loading and Eutrophication

Nutrient pollution is currently the largest pollution problem in the coastal rivers and bays of the U.S. (NRC 2000). Nitrogen inputs to estuaries on the Atlantic and Gulf Coasts of the US are now 2 to 20 times greater than during pre-industrialized times (Castro *et al.* 2003). Sources of nitrogen include emissions from automobiles, as well as urban, industrial, and agricultural sources. Atmospheric deposition is one means of nitrogen input into aquatic systems, with atmospheric inputs delivering 20 to greater than 50 percent of the total input of nitrogen oxide to coastal waters (Paerl 1995). One of the most rapidly increasing means of nutrient loading to both freshwater systems and the coastal zone is via atmospheric pathways (Anderson *et al.* 2002).

Precipitation readily removes most reactive nitrogen compounds, such as ammonia and nitrogen oxides, from the atmosphere. These compounds are subsequently available as nutrients to aquatic and terrestrial ecosystems. Because nitrogen is commonly a growth-limiting nutrient in streams, lakes, and coastal waters, increased concentrations can lead to eutrophication, a process involving excess algae production, followed by depletion of oxygen in bottom waters. Hypoxic and anoxic conditions are created as algae die off and decompose. Harmful algal blooms, commonly known as "red tides," associated with unnatural nutrient levels have been known to stimulate fish disease and kills. In addition, phytoplankton production increases the turbidity of waters and may result in a reduced photic zone and subsequent loss of submerged aquatic vegetation. Anoxic conditions, increased turbidity, and fish mortality may result from increased nitrogen inputs into the aquatic system, potentially altering long-term community dynamics (NRC 2000; Castro *et al.* 2003). Refer to the chapters on Agriculture and Silviculture, Coastal Development, Alteration of Freshwater Systems and Chemical Effects: Water Uptake and Discharge Facilities for further discussion on impacts to fisheries from eutrophication.

The atmospheric component of nitrogen flux into estuaries has often been underestimated, particularly with respect to deposition on the terrestrial landscape with subsequent export downstream to estuaries and coastal waters (Howarth *et al.* 2002). The deposition of nitrogen on land via atmospheric pathways impacts aquatic systems when terrestrial ecosystems become nitrogen saturated. Nitrogen saturation means that the inputs of nitrogen into the soil exceed the uptake ability by plants and soil microorganisms. Under conditions of nitrogen saturation, excess nitrogen leaches into soil water and subsequently into ground and surface waters. This leaching of excess nitrogen from the soils degrades water quality. Such conditions have been known to occur in some forested watersheds in the northeastern U.S., and streams that drain these watersheds have shown increased levels of nitrogen in runoff (Williams *et al.* 1996).

In one study, quantifying nitrogen inputs for 34 estuaries on the Atlantic and Gulf coasts of the U.S., atmospheric deposition was the dominant nitrogen source for three estuaries, and 6 estuaries had atmospheric contributions greater than 30 percent of the total nitrogen inputs (Castro *et al.* 2003). In the northeastern U.S., atmospheric deposition of oxidized nitrogen from fossil-fuel combustion may be the major source of nonpoint input. Evidence suggests a significant movement of nitrogen in the atmosphere from the eastern U.S. to coastal and offshore waters of the North Atlantic Ocean where it is deposited (Holland *et al.* 1999). Nitrogen fluxes in many rivers in the northeastern U.S. have increased 2- to 3-fold or more since 1960, with much of this increase occurring between 1965 and 1988. Most of this increase in nitrogen was attributed to increased atmospheric deposition originating from fossil-fuel combustion onto the landscape (Jaworski *et al.* 1997).

Mercury Loading/Bioaccumulation

Mercury is a hazardous environmental contaminant. Mercury bioaccumulates in the environment, which means it can collect in the tissues of a plant or animal over its lifetime and biomagnifies (i.e., increases in concentration within organisms between successive trophic levels) within the food chain. The impacts of heavy metals such as mercury on fish and people may not be immediately noticeable, but long-term impacts are of concern as contaminants may biomagnify in the ecosystem. Predatory fish often contain high levels of mercury, prompting the U.S. and Canada to issue health advisories against consumption of certain fish species. The U.S. Food and Drug Administration has reported certain species to have typically high methyl mercury concentrations (e.g., shark, swordfish, king mackerel, and tilefish) and these species typically have levels near 1 ppm (USFDA 2004).

One of the most important anthropogenic sources of mercury pollution in aquatic systems is atmospheric deposition (Wang *et al.* 2004). The amount of mercury emitted into the atmosphere through natural and re-emitted sources was estimated between 1500-2500 metric tons/year in the late 20th century (Nriagu 1990). Industrial activities have increased atmospheric mercury levels quite significantly, with modern deposition flux estimated to be 3 to 24 times higher than pre-industrial flux (Bindler 2003). More than half of the total global mercury emissions are from incineration of solid waste, municipal and medical wastes, and combustion of coal and oil (Pirrone *et al.* 1996).

Studies strongly support the theory that atmospheric deposition is an important (sometimes even the predominant) source of mercury contamination in aquatic systems (Wang *et al.* 2004). Mercury exists in the atmosphere predominately in the gaseous form (80 percent), although particulate and aqueous forms also exist (Schroeder *et al.* 1991). Gaseous mercury is highly volatile, remaining in the atmosphere for more than one year, making long-range atmospheric transport a major environmental concern (Wang *et al.* 2004).

Concentrations of mercury in the atmosphere and flux of mercury deposition vary with the seasons, and studies suggest that atmospheric mercury deposition is greatest in summer and least in winter (Mason *et al.* 2000). Different, site-specific factors may influence the transport and transformation of mercury in the atmosphere. Wind influences the direction and distance of deposition from the source, while high moisture content may increase the oxidation of mercury, resulting in the rapid settlement of mercury into terrestrial or aquatic systems. Mercury that is deposited on land can be absorbed by plants through their foliage and ultimately passed into watersheds by litterfall (Wang *et al.* 2004).

Mercury and other metal contaminants are found in the water column and persist in sediments (Buchholtz ten Brink *et al.* 1996). Mercury is toxic in any form according to some scientists, but when absorbed by certain bacteria such as those in marine sediments, it is converted to its most toxic form, methyl mercury. Methyl mercury can cause nerve and developmental damage in humans and animals. Mercury inhibits reproduction and development of aquatic organisms, with the early life-history stages of fish being the most susceptible to the toxic impacts associated with heavy metals (Gould *et al.* 1994). Heavy metals have also been implicated in disrupting endocrine secretions of aquatic organisms, potentially disrupting natural biotic properties (Brodeur *et al.* 1997). Direct mortality of fish and invertebrates by lethal concentrations of metals may occur in some instances. Refer to the Coastal Development and Chemical Effects: Water Uptake and Discharge Facilities chapters for more information on impacts from mercury contamination.

<u>PCBs and Other Contaminants</u>

Polychlorinated biphenyls (PCBs) are a group of organic chemicals which can be odorless or mildly aromatic, and in solid or oily-liquid form. They were formerly used in the U.S. as hydraulic fluids, plasticizers, adhesives, fire retardants, way extenders, de-dusting agents, pesticide extenders, inks, lubricants, cutting oils, in heat transfer systems, and carbonless reproducing paper. Most uses of PCBs were banned by the U.S. Environmental Protection Agency (U.S. EPA) in 1979; however this persistent contaminant continues to enter the atmosphere mainly by cycling from soil to air to soil again. PCBs are also currently released from landfills, incineration of municipal refuse and sewage sludge, and improper (or illegal) disposal of PCB materials, such as waste transformer fluid, to open areas (USEPA 2005a).

PCBs are mixtures of different congeners of chlorobiphenyl. In general, the persistence of PCBs increases with an increase in the degree of chlorination. Mono-, di- and trichlorinated biphenyls biodegrade relatively rapidly, tetrachlorinated biphenyls biodegrade slowly, and higher chlorinated biphenyls are resistant to biodegradation. If released to the atmosphere, PCBs will primarily exist in the vapor-phase, and have a tendency to become associated with the particulate-phase as the degree of chlorination of the PCB increases. Physical removal of PCBs from the atmosphere is accomplished by wet and dry deposition (USEPA 2005b).

Since restrictions were first placed on the use of PCBs in the U.S. during the 1970s, lipid-rich finfish and shellfish has continued to accumulate PCBs, DDTs and chlordane from the environment (Kennish 1998). PCBs are strongly lipophilic and accumulate in fatty tissues including egg masses, affecting the development of fish as well as posing a threat to human health through the consumption of contaminated seafood. Refer to the chapters on Coastal Development and Chemical Effects: Water Uptake and Discharge Facilities for more additional information on PCB contamination.

<u>Alteration to Ocean Alkalinity</u>

The influx of acid to the aquatic environment occurs through the atmospheric precipitation of two predominant acids, sulfuric acid and nitric acid, making up acid rain (i.e., pH less than 5.0). Sulfur dioxide is produced naturally by volcanoes and decomposition of plants, while the main anthropogenic source is combustion, especially from coal-burning power plants. In eastern North America, acid rain is ubiquitous due to the presence of coal-burning power plants (Baird 1995). Other sources of sulfuric acid in the atmosphere include oil refinement, cleaning of natural gas and nonferrous smelting. Affects on biological life depend strongly on soil composition. Granite and quartz have little capacity to neutralize acid, while limestone or chalk can efficiently neutralize acids. Under acidic conditions aluminum is leached from rocks. Both acidity and high concentrations of dissolved aluminum are responsible for decreases in fish populations observed in many acidified water systems (Baird 1995).

The freshwater environment does not have the buffering capacity of marine ecosystems, so acidification has serious implications on riverine habitat. Low pH (below 5.0) has been implicated with osmoregulation problems (Staurnes *et al.* 1996), pathological changes in eggs (Peterson *et al.* 1980; Haines 1981), and reproduction failure in Atlantic salmon (Watt *et al.* 1983). Periodic and long-term discharge of acid into aquatic environment can hinder the survival and sustainability of fisheries by disrupting and degrading important fish and shellfish habitat. Refer to the Coastal Development and Chemical Effects: Water Uptake and Discharge Facilities chapters for additional information on the affects of acidification of aquatic habitats.

<u>Conservation Measures and Best Management Practices for Atmospheric Deposition</u>

1. Install scrubbers for flue-gas desulfurization in electricity generating powerplants, oil refineries, nonferrous smelters, and other point sources of sulfur dioxide emissions.
2. Use integrated, gas-scrubbing systems on municipal waste combustion units.
3. Sulfur dioxide emissions can be reduced by substituting natural gas or low-sulfur coal for high-sulfur coal at power plants.
4. Encourage the use of fuel-efficient vehicles and mass transportation systems.
5. Encourage the separation of batteries from the waste stream to reduce the release of mercury vapors through waste incineration.
6. Lower volatization and/or erosion and resuspension of persistent compounds through remediation at waste sites.

<u>Military/Security Activities</u>

The operations of the U.S. military span the globe and are carried out in coastal, estuarine, and marine habitats. Military operations have the potential to adversely impact fish habitat through training activities conducted on land bases as well as in coastal rivers and the open ocean. Military operations also impact fish habitat and larger ecological communities during wars (Literathy 1993).

Because many military bases and training activities are located in coastal areas and oftentimes directly on shorelines, they can cause impacts similar to those mentioned in other parts of this document (e.g., coastal development, dredging, sewage discharge, road construction, shoreline protection, over-water structures, pile driving, port and marina operations, and vessel operations). In addition to these conventional activities, the military often stockpile and dispose of toxic chemicals on base grounds. Toxic dumping on base grounds has led to the contamination of ground water at Otis Air Base in Cape Cod, Massachusetts (NRDC 2003) and in Vieques, Puerto Rico.

The United States Navy also uses sonar systems that create large amounts of noise in ocean waters. The SURTASS low frequency active sonar produces extremely loud low frequency sound that can be heard at 140 dB from 300 miles away from the source (NRDC 2004). Sixty percent of the U.S. Navy's 294 ships are equipped with mid-frequency sonar devices that can produce noise above 215 dB (NRDC 2002). The intensity of these noises in the water column can cause a variety of impacts to fish, marine mammals, and other marine life that can cause behavior alterations, temporary and permanent impairments to hearing and mortality. Other sources of underwater noise from military activities may include explosive devices and ordnances during training exercises and during wartime. Refer to the Ocean Noise subsection in this chapter for more information on impacts associated with sonar, as well as the Marine Transportation and Coastal Development chapters for information related to blasting impacts.

Natural Disasters and Events

Introduction

Natural events and natural disasters of greatest concern for the northeastern U.S. include hurricanes, floods, and drought. These events may impact water quality, alter or destroy habitat, alter hydrological regimes, and result in changes to biological communities. Natural disasters have the potential to impact fishery resources, such as displacing plankton and fish from preferred habitat, and altering freshwater inputs and sediment patterns. While these effects may not in of themselves pose a threat to coastal ecosystems, they may have additive and synergistic effects when combined with anthropogenic influences such as the release of agricultural and industrial pollutants in storm water.

Water Quality Impacts

Water quality degradation by hurricanes can be exacerbated by human activities. Hurricanes and post-hurricane flooding have been known to result in large freshwater inputs and high concentrations of nutrients into river and estuarine waters, causing reductions in water quality and massive fish kills (Mallin *et al.* 1999). For example, when Hurricane Fran struck North Carolina in the area of Cape Fear River in 1996, the following impacts were reported as a result of the hurricane: 1) Power failures caused the diversion of millions of liters of raw and partially treated human waste into rivers when sewage treatment plants and pump stations were unable to operate; 2) Concentrations of dissolved oxygen decreased for more than three weeks following the hurricane; 3) Ammonium and total phosphorous concentrations were the highest recorded in 27 years of monitoring in Northeast Cape Fear River following the hurricane; 4) Sediment-laden waters flowing into Cape Fear River increased turbidity levels (Mallin *et al.* 1999).

Generally, high rates of flushing and reduced water residence times will inhibit the formation of algal blooms in bays and estuaries. However, the input of large amounts of human and animal waste can greatly increase the biological oxygen demand and lead to hypoxic conditions in aquatic systems. In addition to the diversion of untreated waste from sewage treatment plants during Hurricane Fran, several swine waste lagoons were breached, overtopped, or inundated, discharging large quantities of concentrated organic waste into the aquatic environment (Mallin *et al.* 1999). Other sources of nutrient releases during storms and subsequent flooding events include septic systems on private residences built on river and coastal floodplains.

Natural disasters, such as hurricanes, may also put vessels (e.g., oil tankers) and coastal industrial facilities (e.g., LNG facilities, nuclear power plants) at risk of damage and contaminant spills. Tanker ship groundings generally occur during severe storms, when moorings are more susceptible to being broken and the control of a vessel may be lost or compromised. The release of toxic chemicals from damaged tanks, pipelines, and vessel threaten aquatic organisms and habitats.

Changes to Community Composition

Major storm events may impact benthic communities through a variety of mechanisms, including increased sedimentation, introduction of contaminants, reduction in dissolved oxygen, short-term changes in salinity, and disturbance from increased flow. Monitoring of environmental impacts following Hurricane Fran in 1996 indicated that significant declines in benthic organism abundance were observed up to three month after the storm. However, significant declines in benthic abundance generally did not occur in areas where levels of dissolved oxygen recovered quickly after the storm (Mallin *et al.* 1999). Poorly flushed bays and inland river floodplains are areas that typically exhibit greater magnitude and duration of storm-related impacts.

Loss/Alteration of Habitat

The rate of accretion and erosion of coastal areas is influenced by wave energy impacting the shoreline, and natural events such as hurricanes will accelerate this process. Erosion may occur as a function of hydraulic scour produced by hurricane overwash and offshore-directed wave energy. Accretion of materials due to overwash deposition may result in subsequent flood tidal delta development. Loss or alteration of coastal habitat as a result of storms may be exacerbated by the effects of shoreline development and erosion control measures. For example, the creation of hardened shoreline structures (e.g., seawalls, jetties) and storm-water control systems can focus storm energy and redirect storm water to wetlands, resulting in increased erosion and habitat loss in productive fishery habitat.

Alteration of Hydrological Regimes

Hurricane and flood events result in large volumes of water delivered to the watershed in a relative short period of time. These events can alter the hydrology of wetlands, streams and rivers by increasing erosion and overwhelming flood control structures. Freshwater flows into rivers draining into Charleston Harbor increased as much as four times the historical average flows after Hurricane Hugo in 1989 (Van Dolah and Anderson 1991). Reduced dissolved oxygen concentrations were observed in all portions of the Charleston Harbor estuary following Hurricane Hugo, with hypoxic conditions in some of the rivers in the watershed. The decomposition of vegetation and the failure of septic and sewer systems overflowing into the watershed as a result of this hurricane was identified as the primary cause of the high organic loads (Van Dolah and Anderson 1991). At the other extreme, drought will result in reduced run-off and low flows in streams and rivers that drain into estuaries and bays. Low freshwater input resulted in dramatic reductions in phytoplankton and zooplankton in San Francisco Bay, reducing pelagic food for fish populations (Bennett *et al.* 1995). Larval starvation may limit recruitment. During low-flow years, toxins from agricultural and urban runoff are less diluted which can also harm fish.

Conservation Measures and Best Management Practices for Natural Disasters and Events

1. Require backup generating systems for publicly owned waste treatment facilities.
2. Prohibit development of high-risk facilities, such as animal waste lagoons, storage of hazardous chemicals within the 100-year floodplain.
3. Ensure that all industrial and municipal facilities involving potentially hazardous chemicals and materials have appropriate emergency spill response plans, including emergency notification systems, and spill cleanup procedures, training and equipment.
4. Encourage the protection and restoration of coastal wetlands and barrier islands, which buffer the affects of storm events by dissipating wave energy and retaining floodwaters.
5. Discourage new construction and development in or near coastal and riparian wetlands.
6. Discourage the use of "hard" shoreline stabilization, such as seawalls and bulkheads.
7. Emergency authorizations (e.g., federal Clean Water Act permits) for reconstruction projects should be limited to replacing structures that were in-place and functional at the time of the natural disaster/event, and not the expansion of structures and facilities.

Electromagnetic Fields

Anthropogenic activities are responsible for the majority of the overall electromagnetic fields (EMF) emitted into the environment, with natural sources making up the remainder. Levels of EMF from human-made sources have increased steadily over the past 50 to 100 years (WHO 2005). Anthropogenic sources of EMF include undersea power cables, high voltage power lines, radar, FM radio and TV transmitters, cell phones, high frequency transmitters for atmospheric research, and solar power satellites. The EMF created by undersea power cables may have some adverse affect on marine organisms. Undersea power cables transfer electric power across water, usually conducting very large direct currents (DC) of up to a thousand amperes or more. It has been inferred that undersea cables can interfere with the prey sensing or navigational abilities of animals in the immediate vicinity of the sea cables (See also the Cables and Pipelines subsection of the Energy Related Activities chapter). Few published, peer reviewed scientific articles on the environmental effects of electromagnetic fields on aquatic organisms exist. However, the World Health Organization co-sponsored an international seminar in October 1999 entitled "Effect of Electromagnetic Fields on the Living Environment" to focus attention on this subject. A review of the information presented at the seminar was prepared by Foster and Repacholi (2000).

Electromagnetic fields are the product of both natural and artificial sources. Natural sources of EMF include radiation from the Sun, the earth's magnetic fields, the atmosphere (e.g., lightning discharges), and geological processes (WHO 2005). Marine animals are also exposed to natural electric fields caused by sea currents moving through the geomagnetic field. Examples of anthropogenic sources of EMF include undersea power cables and U.S. Navy submarine communication systems (Foster and Repacholi 2000). Mild electroreception by teleost (bony) fishes occurs through external pit organs that interpret minute electrical currents in the water (Moyle and Cech 1988). However, elasmobranches (i.e., sharks, skates, and rays) are unique in that they possess well-developed electroreceptive organs, called Ampullae de Lorenzini, that enable them to detect weak electric fields in the surrounding seawater as low as 0.01 μV/m (Kalmijn 1971). Elasmobranchs are able to receive information about the positions of their prey, the drift of ocean currents, and their magnetic compass headings from electric fields in their surrounding environment.

Most aquatic organisms emanate low-frequency electric fields that can be detected by fish, such as skates and rays, through a process known as "passive electrolocation" or "passive electroreception". Passive electroreception allows animals to sense electric fields generated in the environment, thereby allowing predators to detect prey by the electric fields that individual fauna emanate. Elasmobranchs have demonstrated during controlled experiments the ability to detect artificially created electric fields (1 to 5 µA) that are similar to those produced by prey items (Kalmijn 1971). The other form of electroreception is "active electrorecption" and occurs when an animal detects changes in their own electric field caused by the electric field produced by prey in the vicinity. This ability to detect disturbances to an individual's own electric field is rare, occurring only in a few families of weakly electric fish, none of which are found in the Northwest Atlantic.

There is evidence that elasmobranches also use their ability to detect electric fields for the purpose of navigation. For example, blue sharks, *Prionace glauca*, have been observed migrating in the North Atlantic maintaining straight courses for hundreds of km over many days (Paulin 1995). The two modes of detection used for navigation are: 1) passive detection- when an animal estimates its drift from the electrical fields produced by interactions of tidal and wind-driven currents and the vertical component of the earth's magnetic field; or 2) active detection- when the animal derives its magnetic compass heading from the electrical field it generates by its interaction with the horizontal component of the earth's magnetic field (Gill and Taylor 2001).

Changes in Migration of Marine Organisms

Anthropogenic sources of EMFs may affect social behavior, communications, navigation and orientation of those animals that rely on the Earth's magnetic field. Certain fish rely on the natural (geomagnetic) static magnetic field as one of a number of parameters believed to be used as orientation and navigational cues. Stringrays have demonstrated their ability during training experiments to orient relative to uniform electric fields similar to those produced by ocean currents (Kalmijn 1982). The shark *Scyliorhinus canicula* and the skate *Raja clavata* have shown a remarkable sensitivity to electric fields (Kalmijn 1982). However, we are not aware of any published studies on anthropogenic EMFs that have demonstrated an adverse effect to marine organisms' ability to migrate. Foster and Repacholi (2000) noted the sensitivity of sharks to low frequency electric fields (a few Hz) and a potential mechanism for adverse effects from DC fields, but made no mention of adverse effects from EMFs.

Changes to Feeding Behavior

Electric or magnetic fields near sea cables may affect prey sensing of electrically or magnetically sensitive species. Submarine cables may attract species when the field intensity approximates that of their natural prey. Smooth dogfish *Mustelus canis* and the blue shark *Prionace glauca* have been observed to execute apparent feeding responses to dipole electric fields designed to mimic prey (Kalmijn 1982). Less is known about how elasmobranches respond in the presence of stronger EMFs that exist closer to the cable. Depending on the presence and strength of electric fields the feeding behavior of elasmobranches could be altered by submarine cables.

The possible affects of exposure to EMF depends on a coupling between the external field and the body of the animal and the biological response mechanisms. The size of the animal, frequency of the field, and whether the pathway of exposure is via air or water will determine effects to the animal. It has been suggested that monopolar power links are more likely to affect aquatic animals than bipolar links because they produce perceptible levels of fields over larger distances from the cables (Kalmijn 2000). Sea cables are isolated from the surrounding water by layers of insulation and metal sheathing, yet electric fields that can exceed natural ambient levels remain detectable (Foster and Repacholi 2000). The flow of seawater past the cables is another mechanism that creates electric fields in seawater, due to magnetic induction. The resulting field strength in the seawater can exceed naturally occurring levels and depends on the flow velocity, whether or not the observer is moving with respect to the water, and on the electrical conductivity of nearby surfaces (Foster and Repacholi 2000).

Further directed research should be conducted to examine the effect of EMFs from underwater transmission lines on marine organisms. Increased understanding is needed to understand the effects of cable burial within different substrata and the range of frequencies and sensitivities of electric fields that marine species are capable of detecting.

Conservation Recommendations for Electromagnetic Fields

1. Proposed submarine cable routes should be mapped with marine resource utilization in a geographic information system (GIS) database to provide information on potential interference with elasmobranch fishes and other organisms. Particular attention should be paid to known nursery and pupping grounds of coastal shark species.
2. Burying submarine cables below the seafloor may reduce potential interference with the electroreception of fishes. However, the benefits of cable burial to minimize potential impacts to elasmobranchs should be weighed with the adverse effects associated with trenching on the seafloor.
3. To the extent practicable, new submarine electric transmission lines should be placed within existing transmission corridors to minimize the cumulative effect of transmission lines across the ocean bottom.

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COMPENSATORY MITIGATION

Introduction

The purpose of this chapter is to describe the need and use of compensatory mitigation within the context of regulatory review of proposed coastal development activities. This topic has purposefully been included in a separate chapter of this report to reflect NMFS' view that compensatory mitigation is a process that is distinct and separate from impact avoidance and minimization. Only a cursory discussion of compensatory mitigation has been attempted in this report due to the complexity and depth that would be required to cover this topic. We have provided a list of websites and publications that the reader may want to refer for more detailed discussion of compensatory mitigation.

Compensatory mitigation is a means of offsetting unavoidable impacts to natural resources. It cannot be stressed strongly enough that compensatory mitigation should not be considered until after a thorough and exhaustive process of assessing less environmentally-damaging project alternatives and options to avoid and minimize impacts has been completed, and all remaining impacts are "unavoidable." The term "unavoidable impacts" is used ubiquitously in environmental impact assessments developed to meet the requirements of the National Environmental Policy Act (NEPA), Clean Water Act (CWA), Magnuson-Stevens Fishery Conservation and Management Act (MSA), and Fish and Wildlife Coordination Act.

The MSA, as amended in 1996, identified the continuing loss of marine, estuarine, and other aquatic habitats to be one of the greatest long-term threats to the viability of commercial and recreational fisheries. The consultation requirements of §305(b)(4)(A) of the MSA require NMFS to provide recommendations, which may include measures to avoid, minimize, mitigate, or otherwise offset adverse effects on essential fish habitat (EFH), to Federal or state agencies for activities that would adversely effect EFH.

According to NEPA regulations, environmental assessments and environmental impact statements must include a discussion of the means to mitigate adverse environmental impacts. However, the term "mitigation" includes avoidance and minimization in addition to compensatory mitigation, and NEPA does not strictly require agencies to first avoid and minimize before utilizing compensatory mitigation to offset adverse effects. NEPA regulations do, however, require agencies to assess and discuss the environmental effects of all reasonable alternatives, including the means to mitigate any adverse effects.

The Federal CWA 404(b)(1) Guidelines prohibit the discharge of dredge or fill material in waters of the United States if there is a practicable alternative. The 404(b)(1) Guidelines also require that all waters of the United States will be accorded the full measure of protection under the CWA, including the requirements for appropriate and practicable mitigation. "Appropriate" is based on the values and functions of the aquatic resource that will be impacted and "practicable" is defined as that which is available and capable of being done after taking into consideration the cost, existing technology, and logistics in light of overall project purposes. The Memorandum of Agreement (MOA) between the U.S. Environmental Protection Agency and the Department of the Army Concerning the Determination of Mitigation under the Clean Water Act Section 404(b)(1) Guidelines states, "Appropriate and practicable compensatory mitigation is required for unavoidable adverse impacts which remain after all appropriate and practicable minimization has been required". This MOA established a three-part sequential process to help guide mitigation decisions, which included: 1) avoidance – adverse impacts are to be avoided and no discharge shall be permitted if there is a practicable alternative with less adverse impact; 2) minimization – if impacts cannot be avoided, appropriate and practicable steps to minimize adverse impacts must be taken; and 3) compensation – appropriate and practicable compensatory mitigation is required for unavoidable adverse impacts which remain (DOA and US EPA 1989).

The need for exhausting all practicable alternatives to avoid and minimize adverse impacts prior to consideration of compensatory mitigation is necessary because of the inherent risks associated with compensatory mitigation. Establishing, re-establishing and rehabilitating, and enhancing degraded wetlands and/or aquatic habitats have inherent risks. Replicating or restoring the physical and chemical characteristics of fishery habitat, including soil/sediment hydrology and chemistry, hydrologic connections, and water quality are complex undertakings and can require years to achieve desired results. Replicating and restoring the full ecological functions and values of fishery habitat may not occur without additional effort and cost, and there are no assurances of success. In addition, evaluating mitigation performance and success can require considerable pre- and post-construction monitoring and assessment, which can be time consuming and costly. For these and other reasons, compensatory mitigation should be viewed as a "last resort" option to achieve effective mitigation, with avoidance and minimization of impacts being the initial focus during the impact assessment process.

Once all practicable alternatives have been considered satisfactorily and a least damaging practicable alternative has been selected that effectively avoids and minimizes adverse effects to the maximum extent practicable, measures to offset unavoidable impacts should be assessed and utilized. Compensatory mitigation can be accomplished on-site or off-site (i.e., in relation to the area being impacted), and can either be in-kind or out-of-kind (i.e., compensation with the same vs. different ecological functions and values). Generally, in order to achieve functional replacement of ecological resources, in-kind should be considered over out-of-kind compensatory mitigation. However, compensatory mitigation decisions are often made in the context of landscape and watershed implications, as well as logistical and technological limitations. Out-of-kind mitigation, should it be considered, should provide services of equal or greater ecological value and should only be employed if in-kind mitigation is deemed impracticable or unfeasible. However, replacing lost or degraded tidal wetlands or other intertidal/subtidal habitats with non-tidal wetlands should not occur.

Compensatory mitigation can be broadly categorized as restoration, creation, enhancement, and preservation (USACE 2002). Restoration includes re-establishment or rehabilitation of a wetland or other aquatic resource with the goal of returning natural or historic functions and characteristics to a former or degraded habitat. Restoration may result in a net gain in ecological function and area. Creation or establishment consists of the development of a wetland or other aquatic resource through manipulation of the physical, chemical or biological characteristics where a wetland did not previously exist. Creation results in a net gain in ecological function and area. Enhancement includes activities within existing wetlands that heighten, intensify, or improve one or more ecological functions. Enhancement may result in improved ecological function(s), but does not result in a gain in area. Preservation is designed to protect important wetland or other aquatic resources into perpetuity through implementation of appropriate legal and physical mechanisms (i.e., conservation easements, title transfers). Preservation may include protection of upland areas adjacent to wetlands or other aquatic resources. Preservation does not result in a net gain of wetland acres or other aquatic habitats and should only be used in exceptional circumstances.

Compensatory mitigation can be provided in the form of project-specific mitigation, mitigation banking, or in-lieu fee mitigation (US EPA 2003). Project specific mitigation is generally undertaken by a permittee or agency in order to compensate for resource impacts resulting from a specific action or permit. The permittee or agency performs the mitigation and is ultimately responsible for implementation and success of the mitigation. Mitigation banking is a wetland area that has been restored, created, enhanced or (in exceptional circumstances) preserved, which is then set aside to compensate for future impacts to wetlands or other aquatic resources. The value of a bank is determined by quantifying the resource functions restored or created in terms of "credits," which can be acquired, upon approval of regulatory agencies, to meet their requirements of compensatory mitigation. The bank sponsor is ultimately responsible for the success of the project. In-lieu fee mitigation involves a program where funds are paid to a natural resource management entity by a permittee or agency to meet their requirements of compensatory mitigation. The fee is to be used to fund the implementation of either specific or general wetland or other aquatic resource conservation projects. The management entity may be a third party (e.g., non-governmental organizations, land trusts) or a public agency that specializes in resource conservation, restoration, and enhancement programs.

Below are some general topics and recommendations regarding the assessment and implementation of compensatory mitigation for actions that may adversely affect fishery resources. It may be necessary to include some of these measures as permit conditions or in decision documents in order to ensure that compensatory mitigation is completed satisfactorily and within the agreed upon time frames.

Baseline Information

The primary purpose of providing effective compensatory mitigation should be to restore or replace the ecological functions and values of resources. In order to assess the effectiveness of compensatory mitigation, the baseline or existing functions and values of the mitigation site must be known, as well as the target functions and values for the completed restoration or replacement habitat. This can only be accomplished through site-specific monitoring and resource assessments. There are a number of assessment methodologies available to accomplish this, and it is important to determine the method(s) that should be used in advance because it will be necessary for the performance evaluation of the completed mitigation site.

Generally, compensatory mitigation should be provided for direct and indirect impacts, as well as short-term, long-term, and cumulative impacts to fishery resources. Indirect, long-term and cumulative impacts of a development project may be more difficult to identify and quantify than short-term impacts, but are no less important. In some cases, the adverse effects on aquatic resources due to indirect, long-term and cumulative impacts may be greater than the direct, short-term construction-related impacts. For example, the direct construction-related impacts of deepening a navigation channel for the purpose of expanding a commercial marina may only involve the removal of a foot or two of bottom sediment in the existing channel. But the dredging project may also result in other short-term impacts to benthic resources from sedimentation and turbidity and anchor damage from vessel(s). Expansion of the marina operation may result in long-term and cumulative impacts to seagrass and riparian vegetation from vessel wakes and prop scour, and chronic turbidity and sedimentation due to larger and more frequent vessel activity. Long-term and cumulative impacts from a development project may also determine whether compensatory mitigation is more appropriately located on-site or off-site.

Compensatory Mitigation Plan

A clear and concise description of the specific habitats and the functions and values that are intended to be restored should be provided in the mitigation plan. Wetlands and other aquatic habitats provide numerous functions and values within an ecosystem, so it is important to identify the specific functions and values that the compensatory mitigation is intended to restore or replace. Performance criteria should be established (e.g., 80 percent vegetation cover by target species by the end of the second growing season) and specific monitoring and analytical methods to assess the success of the mitigation should be stipulated in advance.

Adaptive management should be incorporated into mitigation plans, when appropriate. While clear and concise performance criteria are important in all compensatory mitigation plans, monitoring data and predetermined ecological indicators should be used to guide the progress of the mitigation and ensure mitigation objectives are met. Effective compensatory mitigation plans should recognize the importance of adaptive management and allow for corrective action when performance measures are not being met.

A compensatory mitigation plan should include requirements for monitoring and performance reporting, including the content and frequency of reports and who should receive the reports. Generally, the reports should be provided concurrently with the completion of performance monitoring to allow for corrective actions to be taken should success criteria not be met. Other features of a mitigation plan may include measures to ensure mitigation site protection, financial assurances, and a description of long-term maintenance requirements, if necessary, and the party or parties responsible for completing the mitigation requirements.

Contingency Plans

Contingency plans for the mitigation plan may be necessary to ensure that adequate compensation is provided, particularly for mitigation that is considered a high-risk endeavor, such as restoration of eelgrass beds. The contingency plan may be necessary to extend the completion of the mitigation plan, and it may require supplemental effort (e.g., planting) or call for alternative mitigations (e.g., out-of-kind). If it is determined that mitigation contingencies are necessary, they should be specified in the permit or decision document(s).

Mitigation Timing

To minimize the time lag between the loss of wetlands or other aquatic resources and the completion of the compensatory mitigation project, implementation of mitigation construction should begin as soon as possible. For example, if mitigation construction must begin during a specific time of year or the ecological functions and values at the mitigation site require multiple years before being realized, it may be appropriate for the compensatory mitigation project to begin before the resource impacts occur.

Interim Losses

In situations where delays in implementation of compensatory mitigation or a compensatory mitigation project require several years to complete, interim or temporal losses of ecological functions and values may be substantial. In these cases, compensation of the interim losses of ecological functions and values should be included in the compensatory mitigation plan. There are a number of ways in which compensation of interim losses can be assessed, such as increasing the ratio of acreage lost to acreage replaced. However, calculating interim losses using “loss of services" analyses, such as the Habitat Equivalency Analysis (HEA), has been used successfully in a number of restoration projects (NOAA 1995). The HEA assumes there is a one-to-one tradeoff between the resource services at the compensatory restoration site and the resource impact site. In other words, it assumes that the resources can be compensated for past losses through habitat replacement projects providing the replacement resources are the same type as the lost or damaged resources (i.e., in-kind mitigation).

Compensatory Mitigation Resources
Mitigation Guidance:
http://www.epa.gov/wetlandsmitigation
http://www.epa.gov/owow/wetlands/guidance
http://www2.eli.org/wmb/backgroundb.htm
http://books.nap.edu/catalog/10134.html#toc
http://www.gao.gov/new.items/d01325.pdf
http://www.mitigationactionplan.gov/Preservation_8-27-04.htm
http://www.nap.usace.army.mil/cenap-op/regulatory/draft_mit_guidelines.pdf
Habitat Equivalency Analysis:
http://www.csc.noaa.gov/coastal/economics/habitatequ.htm
http://www.darrp.noaa.gov/library/pdf/heaoverv.pdf

References for Compensatory Mitigation

Department of the Army and U.S. Environmental Protection Agency (DOA and US EPA). 1989. Memorandum of Agreement Between the Department of the Army and the Environmental Protection Agency Concerning the Determination of the Section 404 Program and the Application of the Exemptions Under Section 404(F) of the Clean Water Act.

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CONCLUSIONS AND RECOMMENDATIONS

The purpose of this chapter is to synthesize the information discussed in the previous chapters of this report, and to identify topics for future research and focus. In addition, the participants of the technical workshop identified non-fishing activities and effects that are known or suspected to have adverse impacts on fisheries habitat. We have attempted to draw some conclusions, based upon the results of the impact and effects scores, concerning those activities and effects that deserve further scrutiny and discussion. While many of these activities and effects clearly have known direct, adverse impacts on the quantity and quality of fisheries habitat, their effects at the population and ecosystem level are generally poorly understood or unknown. For example, there are a number of ports and harbors in the Gulf of Maine that are known to be the most contaminated sites in U.S. coastal waters for polycyclic aromatic hydrocarbons, chlorinated hydrocarbons, and trace metals (Buchsbaum 2005). Although the effects of these pollutants at the cellular, physiological and whole organism level have been documented, little information on the effects at the population and ecosystem level is available.

There were some notable results from the technical workshop on non-fishing impacts, particularly in the geographic areas that were scored high for some impact types and effects. As one might expect, the workshop participants considered impacts on fisheries habitats from non-fishing activities to be generally focused in nearshore coastal areas. Except for the Offshore Dredging and Disposal session, the majority of the high-scoring impact types and effects in each session were in the riverine and estuarine/nearshore ecosystems. These results are not particularly surprising considering the proximity of riverine and nearshore habitats to industrial facilities and shipping and human coastal development. However, one should not conclude from these results that species inhabiting offshore habitats are not susceptible to non-fishing impacts. Estuarine and wetland dependent fish and shellfish species account for about 75 percent of the total annual seafood harvest of the U.S. (Dahl 2006). Rivers, estuaries and coastal embayments are essential for fisheries because they serve as nurseries for the juvenile stages of species harvested offshore or as habitats for the prey of commercially important species (Deegan and Buchsbaum 2005).

Although nearly all impact types and effects were scored high for the riverine ecosystem in the Alterations of Freshwater Systems workshop session, several were also scored as high in the estuarine/nearshore ecosystem. For example, impaired fish passage and altered temperature regimes were scored high for riverine and estuarine/nearshore ecosystem in both dam construction/operation and water withdrawal impact types, suggesting that the participants viewed these activities and effects to have broad ecosystem impacts.

Most impact types and effects in both the chemical and physical effects workshop sessions were scored high in the both riverine and estuarine/nearshore ecosystems. However, some of these impact types and effects were also scored high in the marine/offshore ecosystem. For the chemical effects session, the release of nutrients/eutrophication, release of contaminants, introduction of harmful algal blooms, contaminant bioaccumulation/biomagnification, and all effects under combined sewer overflows impact type were scored high in all ecosystem types. The concern of the workshop participants regarding impacts to coastal resources due to eutrophication and pollution reflect some recently published assessments on threats to coastal habitats (USEPA 2004; Deegan and Buchsbaum 2005; Lotze *et al.* 2006). The National Coastal Condition Report (USEPA 2004) assessed the coastal water condition in the northeast to be the poorest in the nation, with 19 percent of estuarine waters in poor condition and another 42 percent in fair condition. One of the primary factors contributing to poor water condition in the northeast region is poor water quality, which is typically caused by high total nitrogen loading, low dissolved oxygen concentrations, and poor water clarity. In the northeast region, the contributing factors associated with nutrient enrichment are principally high human population density and, in the Mid-Atlantic states, agriculture (USEPA 2004). Harmful algal blooms (HABs) have been associated with eutrophication of coastal waters, which can deplete oxygen in the water, result in hypoxia or anoxia, and lead to large-scale fish kills (Deegan and Buchsbaum 2005). HABs may also contain species of algae that produce toxins, such as red tides, that can decimate large numbers of fish, contaminate shellfish species, and cause health problems in humans. The extent and severity of coastal eutrophication and HABs will likely continue, and may worsen, as coastal human population density increases. Considerable attention should be focused on the effects of eutrophication on populations of fisheries and the role of natural versus anthropogenic sources of nutrients in the occurrence of HABs.

For the physical effects session, entrainment and impingement effects were scored as high in all ecosystem types. Entrainment and impingement of eggs, larvae, and juvenile fish and shellfish are increasingly being identified as potential threats to fishery populations from a wide variety of activities, including industrial and municipal water intake facilities, electric power generating facilities, and liquefied natural regassification facilities (Hanson *et al.* 1977; Travnichek *et al.* 1993; Richkus and McLean 2000; Deegan and Buchsbaum 2005). Future research is needed to assess the long-term effects of entrainment and impingement on fish stocks.

The participants of the Global Effects and Other Impacts workshop session scored most impact types and effects in the estuarine/nearshore ecosystem as high. However, several effects in the climate change impact were scored high for all ecosystems, including alteration of temperature and hydrological regimes, alteration in weather patterns and changes in community structure. Although the effects of climate change on fisheries have not been the focus of intense discussion and research, we believe that greater emphasis on this topic will be necessary as the effects of global warming become more pronounced (Bigford 1991; Lotze *et al.* 2006).

A number of activities and effects were identified during the workshop and in the preparation of this report that may pose substantial threats to fisheries habitat, but the extent of the problems they represent and their implications to aquatic ecosystems are not well understood. Some of these activities and effects have only recently been recognized as potential threats, such as the effects of endocrine disrupting chemicals on aquatic organisms or threats to fisheries habitat from global warming, and will require additional research to better understand the mechanism and scope of the problem. However, other activities and effects such as sedimentation impacts on benthic habitats and biota have been the focus of considerable research and attention, but questions remain as to the lethal and sublethal thresholds of sedimentation on individual species and its effect on populations. For example, the sedimentation caused by navigation channel dredging is known to cause mortality in the demersal eggs of winter flounder (Berry *et al.* 2004; Klein-MacPhee *et al.* 2004; Wilber *et al.* 2005). However, a better understanding of the upper lethal limits for sediment depth and the duration of burial is needed. In addition, how does grain size and the type and amount of contamination affect egg and larval survival, how do natural suspended sediment concentration levels affect egg and larvae survival rates, and what are the implications at the population level?

A number of energy-related activities were assessed for adverse effects on fisheries habitat in the technical workshop and in the Energy Related Activities chapter, including offshore liquefied natural gas platforms, wind turbines, and wave and tidal energy facilities. Although various impacts were discussed, there have not been any facilities of this type constructed in the northeast region of the U.S. at the time of this report. While we believe the assessments of these types of facilities are based upon the best available information, further monitoring and assessments will be necessary when, and if, they are constructed.

The workshop participants identified a number of chemical effects in several sessions that may have a high degree of impact on fisheries habitat, such as endocrine disrupting chemicals and pharmaceuticals in treated wastewater. Personal care products (PPCPs) can persist in treated wastewater and have been found in natural surface waters at very high concentrations (parts per thousand (USEPA 1999). Unfortunately, few PPCPs have associated aquatic toxicity data, they are extremely persistent in the environment, and they are introduced into surface waters in very high concentrations (USEPA 1999). Some of these PPCPs include steroid compounds, which may be endocrine disruptors. Endocrine disruptors can mimic the functions of sex hormones, androgen and estrogen, and can interfere with reproductive functions and potentially result in population-level impacts. Some chemicals shown to be estrogenic include PCB congeners, pesticides (e.g., dieldrin, DDT), and compounds used in some industrial manufacturing (e.g., phthalates, alkylphenols) (Thurberg and Gould 2005). In addition, some heavy metal compounds have also been implicated in disrupting endocrine secretions of marine organisms (Brodeur *et al.* 1997). Additional investigation into the effects of PPCPs and endocrine disruptors on aquatic organisms and their potential impacts at the population and ecosystem level is needed.

In addition, the workshop participants identified a number of adverse effects on aquatic ecosystems from introduced/nuisance species, particularly in the estuarine/nearshore ecosystem. Introduction of non-native invasive species into marine and estuarine waters pose a significant threat to living marine resources in the U.S. (Carlton 2001). Non-native species introductions occur through a wide range of activities, including ballast water releases from ships, aquaculture operations, fish stocking and pest control programs, and aquarium discharges (Hanson *et al.* 2003; Niimi 2004). The rate of introductions has increased exponentially over the past 200 years and it does not appear that this rate will level off in the near future (Carlton 2001). Increased research focused towards reducing the rate of non-native species introductions is needed, in addition to a better understanding as to the potential effects of non-native species on commercial fisheries in the U.S.

Overfishing is likely the greatest factor in the decline of groundfish species in New England (Buchsbaum 2005), and is responsible for the majority of species depletions and extinctions worldwide (Lotze *et al.* 2006). However, habitat loss and degradation (including pollution, eutrophication, and sedimentation) closely follow exploitation as a causative agent in fishery declines, and may be equally or more important for some species such as Atlantic salmon (Buchsbaum 2005; Lotze *et al.* 2006). Cumulative effects likely play a role in a large majority of historic changes in fish stocks. Worldwide, nearly half of all marine and estuarine species depletions and extinctions have been attributed to multiple human impacts, most notably exploitation and habitat loss (Lotze *et al.* 2006). It is imperative that reduced exploitation, habitat protection, and improved water quality must be applied holistically, and the cumulative effects of multiple human interactions must be considered in both management and conservation strategies (Lotze *et al.* 2006).

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Appendix
Non-Fishing Impacts Technical Workshop
Attendee List

Name	Organization/Affiliation	City and State
Michael Johnson	NOAA Fisheries	Gloucester, MA
Sean McDermott	NOAA Fisheries	Gloucester, MA
Chris Boelke	NOAA Fisheries	Gloucester, MA
Marcy Scott	NOAA Fisheries	Gloucester, MA
Lou Chiarella	NOAA Fisheries	Gloucester, MA
David Tomey	NOAA Fisheries	Gloucester, MA
Jennifer Anderson	NOAA Fisheries	Gloucester, MA
Mike Ludwig	NOAA Fisheries	Milford, CT
Diane Rusanowsky	NOAA Fisheries	Milford, CT
Anita Riportella	NOAA Fisheries	Highlands, NJ
Stan Gorski	NOAA Fisheries	Highlands, NJ
Andy Draxler	NOAA Fisheries	Highlands, NJ
Ric Ruebsamen	NOAA Fisheries	St. Petersburg, FL
Jeanne Hanson	NOAA Fisheries	Anchorage, AK
Heather Ludemann	NOAA Fisheries	Silver Spring, MD
Kimberly Lellis	NOAA Fisheries	Silver Spring, MD
David Wiley	Stellwagen Bank National Marine Sanctuary	Situate, MA
Leslie-Ann McGee	New England Fishery Management Council	Woods Hole, MA
Sally McGee	New England Fishery Management Council/ Environmental Defense	Mystic, CT
Eric Nelson	U.S. Environmental Protection Agency	Boston, MA
Phil Colarusso	U.S. Environmental Protection Agency	Boston, MA
Cathy Rogers	U.S. Army Corps of Engineers	Concord, MA
Michael Hayduk	U.S. Army Corps of Engineers	Philadelphia, PA
Brenda Schrecengost	U.S. Army Corps of Engineers	Philadelphia, PA
Steven Mars	U.S. Fish &Wildlife Service	Trenton, NJ
Michelle Dione	Wells National Estuarine Research Reserve	Wells, ME
John Sowles	Maine Dept. of Marine Resources	W. Boothbay Harbor, ME
Brian Swan	Maine Dept. of Marine Resources	Augusta, ME
Ray Grizzle	University of New Hampshire	Durham, NH
Mashkoor Malik	University of New Hampshire	Durham, NH
Vincent Malkoski	Massachusetts Division of Marine Fisheries	Boston, MA
Stephanie Cunningham	Massachusetts Division of Marine Fisheries	Gloucester, MA
Tony Wilber	Massachusetts Coastal Zone Management	Boston, MA
Joe Pelczarski	Massachusetts Coastal Zone Management	Boston, MA
Chris Powell	Rhode Island Dept. of Fish & Wildife	Jamestown, RI
Mark Johnson	Connecticut Dept. of Environmental Protection	Hartford, CT
Karen Chytalo	New York Dept. of Environmental Conservation	East Setauket, NY
Drew Carey	Coastal Vision	Newport, RI
Donna Bilkovic	Virginia Institute of Marine Science	Gloucester Point, VA
Robert Van Dolah	South Carolina Division of Natural Resources	Charleston, SC
Trevor Kenchington	Gadus Associates/Fisheries Survival Fund	Canada
Phil Ruhle	New England Fishery Management Council/ F/V Sea Breeze/	RI
Gib Brogan	Oceana	CT

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John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

PHASE 1

APPENDIX E
"AFFECTED BIOLOGICAL ENVIRONMENT – SPAWNING INFORMATION"

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1.0 METHODS

The sources of information used to describe the spawning periods for a managed species include the EFH species source documents (1st and 2nd editions) and the new EFH species update memos and references therein, plus a few published sources that were not included in the source documents or update memos. Also presented, where applicable, are egg distribution and abundance information from the Northeast Fisheries Science Center (NEFSC) Marine Monitoring Assessment and Prediction (MARMAP) ichthyoplankton surveys (1978-1987) and the Georges Bank U.S. Global Ocean Ecosystems Dynamics (GLOBEC) ichthyoplankton surveys (1995-1999). See Table 1 for a summary of these data.

Table 1. Peak spawning periods.

Species	Ja n	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Notes
American plaice			M	P	P	M							GLOBEC: Georges Bank peak egg abundance also in March.
Atlantic cod, GB	M	P	P	P	M						M	M	GLOBEC: peak February-March, mostly on Northeast Peak.
Atlantic cod, GOM	P	P	P	P	P	M					M	M	Peak spawning period varies depending on location; spawning occurs later in year in more northerly regions.
Atlantic halibut (Can.)	M	M	M	M	M						P	P	Spawning on slopes of continental shelf and offshore banks.
Atlantic herring, GB							M	P	P	P	M		Includes Nantucket Shoals.
Atlantic herring, GOM								M	P	P	P	M	Coastal areas, includes Jeffreys Ledge.
Atlantic salmon										M	M		Spawn in freshwater; no peak periods given.
Haddock, GB	M	P	P	P	M	M							Concentrated on Northeast Peak.
Haddock, GOM		P	P	P	M								Two primary spawning sites are Jeffreys Ledge, Stellwagen Bank.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Notes
Monkfish			M	M	P	P	M	M	M				
Ocean pout								P	P	P	M	M	Earlier peak spawning (August-October) in the south.
Offshore hake		M	M	M	M	M	M	M	M	M			No peak periods given; spawning occurs over a protracted period or continually throughout the year.
Pollock	P	P	M	M					M	M	P	P	Spawning time more variable in north than in south.
Redfish				M	P	P	P	P					Eggs fertilized internally, larvae released. MARMAP: peak August.
Red hake, GOM					M	M	P	P	M				
Red hake, GB					P	P	M	M	M				
Red hake, MAB/SNE			M	M	M	M	M	M	M	M			No peak periods given.
Red hake, NYB					P	P	M	M	M	M	M		
Silver hake					P	P	P	P	M	M			Peak May-June in southern stock, July-August in northern stock.
White hake, southern stock				M	M								Deep waters along continental slope, primarily off southern Georges Bank and Mid-Atlantic Bight.

Species	Ja n	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Notes
													No peak periods given.
Windowpane, GB				M	M	M	P	P	M	M			MARMAP.
Windowpane, MAB		M	M	M	P	M	M	M	P	P	M		Split spawning season. MARMAP data included.
Winter flounder	M	P	P	P	P						M	M	Spawning occurs earlier in southern part of range. Peak: February, March in Mass. Bay and south of Cape Cod and somewhat later along coast of Maine continuing into May. GB peak (MARMAP/GLOBEC egg collections): March-May.
Witch flounder, GB/GOM				M	P	P	P	P	M	M	M		Spawning occurs progressively later from south to north.
Witch flounder, MAB			M	M	P	P	M	M					Spawning occurs progressively later from south to north.
Yellowtail flounder			M	P	P	P	M	M					

M:Major spawning months
P:Peak spawning months
Information obtained from EFH Source Documents and Update Memos.
Table does not include Atlantic sea scallops, barndoor skate, clearnose skate, deep-sea red crab, little skate, rosette skate, smooth skate, thorny skate, winter skate.

2.0 AMERICAN PLAICE

Information on the spawning periods of American plaice (*Hippoglossoides platessoides*) comes from the EFH Source Document (Johnson 2004 and references therein).

In the northern part of its range (Canada), plaice spawn in the summer (Hebert and Wearing-Wilde 2002). In the southern part of its range in the **Gulf of Maine**, the spawning season extends from March through the middle of June, with *peak* spawning activity in April and May (Bigelow and Schroeder 1953; Colton *et al.* 1979; Smith *et al.* 1975). Nursery areas are found in coastal waters of the **Gulf of Maine** (Bigelow and Schroeder 1953). Spawning occurs at depths < 90 m and spawning adults migrate from deeper depths into shallower grounds before spawning (Bigelow and Schroeder 1953).

The NEFSC MARMAP ichthyoplankton surveys (1978-1987) captured eggs throughout the year. During February and March, eggs were collected on **Stellwagen Bank**, **off Cape Ann, on Jeffreys Ledge, along coastal Maine, and on Georges Bank**. During April and May, the *highest* egg concentrations occurred along the **eastern edge of Georges Bank and along the coastal areas off eastern Massachusetts, the Gulf of Maine, southwest Nova Scotia, and Browns Bank**. From June through December, eggs were collected almost exclusively along the **coastal areas in the Gulf of Maine**; some eggs were collected on **Georges Bank** and the Scotian Shelf.

GLOBEC ichthyoplankton surveys on **Georges Bank** during 1995-1999 show that American plaice eggs were generally restricted to locations within depth zones ≥ 56 m. They were most abundant at greater depths on **Georges Bank** (56-110 m); **along the Great South Channel, the central and eastern part of the southern flank and the northern part of the Northeast Channel** where depths are > 185 m. Very few eggs were captured during January. Catches increased tenfold by February along the eastern part of the **Northeast Peak** reaching *peak* numbers by March. The occurrence of eggs extended eastward along the **southern flank of Georges Bank** and into the **eastern section of Georges Basin**. By April, the *high* concentrations shifted toward the **western part of the southern flank**. In May and June catches of eggs declined dramatically, with centers of abundance still along the **southern flank of Georges Bank**.

3.0 ATLANTIC COD

Information on the spawning periods of Atlantic cod (*Gadus morhua*) comes from the EFH Source Document (Lough 2005 and references therein).

On **Georges Bank**, an analysis of the MARMAP ichthyoplankton data set indicates that 60% of spawning occurs between February 23 and April 6, based on the abundance of Stage III eggs, back-calculated to spawning date. Ninety percent occurs between mid-November and mid-May, with a median date of mid-March (Colton *et al.* 1979; Page *et al.* 1998). Spawning begins along the **southern flank of Georges Bank** and progresses toward the north and west. It ends latest in the year on the **eastern side of the bank**. Historically, cod have spawned on both **eastern and western Georges Bank**. During the MARMAP period (1978-1987), spawning could either be split between **eastern and western Georges Bank**, **or occur predominantly on one side or the other** (Lough *et al*. 2002). Composite egg distributions indicate that the *most intense* spawning activity occurs on the **Northeast Peak of Georges Bank** (Page *et al.* 1998). Data from the more recent U.S. GLOBEC Georges Bank surveys (1995-1999) also indicated *peak* spawning occurs during the February-March period and mostly on the **Northeast Peak** (Mountain *et al.* 2003).

The results of the present compilation of egg distributions indicate that *most* spawning occurs not only on the **Northeast Peak of Georges Bank**, but also around the **perimeter of the Gulf of Maine, and over the inner half of the continental shelf off southern New England**. It occurs year-round, with a *peak* in winter and spring. *Peak* spawning is related to environmental conditions. It is delayed until spring when winters are severe and *peak*s in winter when they are mild (Smith *et al.* 1979; Smith *et al.* 1981). Spawning *peak*s in April on Browns Bank (Hurley and Campana 1989). Within the **Gulf of Maine**, cod generally spawn throughout the winter and early spring in most locations, but the period of *peak* spawning varies depending on location (Schroeder 1930). In general, spawning occurs later in the year in the more northerly regions. Within **Massachusetts Bay**, Fish (1928) reported *peak* spawning activity during January and February. Bigelow and Welsh (1924) noted that **north of Cape Ann, Massachusetts**, most spawning occurred between February and April and further north, between **Cape Elizabeth and Mt. Desert Island, Maine**, the *peak* spawning period was between March and May. Reproduction also occurs in **nearshore areas, such as Beverly-Salem Harbor, MA**, where eggs are found November through July (with a *peak* in April).

4.0 ATLANTIC HALIBUT

Information on the spawning periods of Atlantic halibut (*Hippoglossus hippoglossus*) comes from the EFH Update Memo (Essential Fish Habitat Source Document Update Memo: Atlantic Halibut, *Hippoglossus hippoglossus*, Life History and Habitat Characteristics, 2004, and references therein).

Spawning in the western Atlantic is believed to occur on the **slopes of the continental shelf and on the offshore banks** (McCracken 1958; Nickerson 1978; Neilson *et al*. 1993), at depths of at least 183 m (Scott and Scott 1988), over rough or rocky bottom (Collins 1887). Spawning occurs during late winter and early spring (McCracken 1958; Scott and Scott 1988; Miller *et al*. 1991; Methven *et al*. 1992; Trumble *et al*. 1993), with *peak* spawning having been reported during November to December (Neilson *et al*. 1993). Kohler (1964) reported that spawning occurred during winter to early spring on the **Scotian Shelf**, during February to April in the **Gulf of St. Lawrence**, and during winter to late spring off **Newfoundland** (Kohler 1964). DFO Canada (2003) reports that halibut in the **Gulf of St. Lawrence** appear to spawn from January to May. In northern Norway, spawning has been reported during December to March, with peak spawning from late January to early February (Haug 1990). However, historical descriptions of spawning have reported ripe halibut as late as August (Goode 1884).

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5.0 ATLANTIC HERRING

Information on the spawning periods of Atlantic herring (*Clupea harengus*) comes from the EFH Source Document (Stevenson and Scott 2005 and references therein).

In the northwest Atlantic, herring spawn from **Labrador to Nantucket Shoals**. Spawning occurs in the spring, summer, and fall in more northern latitudes, but summer and fall spawning predominates in the **Gulf of Maine-Georges Bank region** (Haegele and Schweigert 1985).

In U.S. waters of the **Gulf of Maine**, herring eggs have been observed along the **eastern Maine coast**, at several **other locations along the Maine coast** (e.g., outer Penobscot Bay and near Boothbay), on Jeffreys Ledge and Stellwagen Bank, and on **eastern Georges Bank**. **Nantucket Shoals** is known to be an important spawning ground based on the concentrations of recently-hatched larvae that were repeatedly collected there during the 1970s and 1980s (Grimm 1983; Smith and Morse 1993). High concentrations of recently-hatched larvae have also been collected in the vicinity of **Cultivator Shoals on western Georges Bank**, in the vicinity of **Stellwagen Bank and Jeffreys Ledge**, and on the **outer continental shelf in southern New England** (Grimm 1983; Smith and Morse 1993). High densities of recently-hatched larvae have also been observed in **Saco Bay and Casco Bay on the southern Maine coast** (Graham *et al*. 1972b, *et al*. 1973).

The spawning season in the **Gulf of Maine-Georges Bank** region begins in July and lasts until December. Spawning begins earlier in the northern areas of the **Gulf**. Off southwestern Nova Scotia, spawning occurs from July to November and *peak*s in September-October (Boyar 1968; Das 1968, 1972) Spawning in **eastern Maine coastal waters** during 1983-1988 extended from late July through early October, with *peak* spawning in late August (Stevenson 1989), but more recent egg bed surveys (1997-2002) in the same area indicated that spawning did not start until late August and lasted until October 21 (Neal and Brehme 2001; Neal 2003). Based on larval surveys, Graham *et al*. (1972b) concluded that spawning *peak*s in mid-September to mid-October in **eastern Maine** and in October in **western Maine**. Boyar *et al*. (1973) reported that spawning on **Jeffreys Ledge** in 1972 started in early September and *peak*ed during the first three weeks of October. On **Georges Bank**, spawning occurs from late August to December (Boyar 1968; Berenbeim and Sigajev 1978; Lough *et al*. 1980) with a *peak* in September-October (Boyar 1968; Pankratov and Sigajev 1973; Grimm 1983). On **Nantucket Shoals**, spawning *peak*s from October to early November, 1-2 weeks later than on **Georges Bank** (Lough *et al*. 1980; Grimm 1983). Larval surveys conducted during 1971-1975 indicated that spawning on **Georges Bank** started on the **Northeast Peak** of the Bank in September and extended southwest to **Nantucket Shoals** in October, declined in November and was absent in December (Grimm 1983).

6.0 ATLANTIC SALMON

Information on the spawning periods of Atlantic salmon (*Salmo salar*) comes from the EFH Source Document (Maltz et al., in draft, and references therein).

Spawning in freshwater occurs in late October through November. U.S. Atlantic salmon populations are typically spring run with the majority of fish entering rivers in June through August. Therefore, depending upon their date of return, these fish may spend 1-6 months in the river prior to spawning. Incubation time may be 4-7 months in **Maine rivers** (DeCola 1970).

Additional References

Maltz, E.M., J.F. Kocik, and B. Cullum. Draft. Essential Fish Habitat Source Document: Atlantic salmon, *Salmo sala*r, Life History and Habitat Characteristics.

7.0 ATLANTIC SEA SCALLOP

Information on the spawning periods of the Atlantic sea scallop (*Placopecten magellanicus*) comes from the EFH Source Document (Hart *et al*. 2004 and references therein).

Shumway *et al.* (1988) summarized the gametogenic cycle of sea scallops from **Maine**. Spawning takes place in September/October and the animals enter a reproductively quiescent or rest period. Barber *et al.* (1988) found that spawning and reabsorption of mature ova was evident in September and to a greater extent in October, after which the animals underwent a period of recovery (December/January).

Spawning generally occurs synchronously when males extrude sperm and the females release eggs en masse into the water, but it may occur over a more protracted period of time depending on environmental conditions. It has been suggested that year-class strength may correlate with the degree of spawning synchrony, rather than fecundity per se (Langton *et al.* 1987).

A *major annual spawning period* occurs during late summer to fall (August to October) (Parsons *et al.* 1992a) although spring or early summer spawning can also occur, especially in the **Mid-Atlantic** (Barber *et al.* 1988; DuPaul *et al.* 1989; Schmitzer *et al.* 1991; Davidson *et al.* 1993; Almeida *et al.* 1994; Dibacco *et al.* 1995). The timing of spawning can vary with latitude, starting in summer in southern areas and in fall in the northern areas. MacKenzie *et al.* (1978) reported that **off the coast of North Carolina and Virginia**, spawning generally occurred as early as July and that further north on the **Mid-Atlantic shelf** spawning occurred in August. However, there are exceptions to this pattern. MacDonald and Thompson (1988) report that scallops off of **New Jersey** spawned up to two months later than scallops from Newfoundland (September-November versus late August-early September). They found no clearly identifiable latitudinal trends in the timing of spawning. A biannual spawning cycle on the **Mid-Atlantic shelf** has been reported south of the **Hudson Canyon**, with spawning occurring both in the spring and fall (DuPaul *et al.* 1989; Schmitzer *et al.* 1991; Davidson *et al.* 1993). Kirkley and DuPaul (1991) found that *spring spawning in the* **Mid-Atlantic** *is the more predictable and dominant spawning event*, while fall spawning is minor, temporally irregular, and sometimes does not occur. Schmitzer *et al.* (1991) also reported that the *spring spawning was of longer duration and the scallops showed greater fecundity than in the fall.*

North of the Hudson Canyon there is generally a single annual spawning event starting in late summer or early fall. However, there are some reports of biannual spawning (spring and fall) in the **Gulf of Maine** and **Georges Bank**, with the *fall spawning being dominant* (Barber *et al.* 1988; Almeida *et al*. 1994, DiBacco *et al.* 1995). On **Georges Bank** fall spawning generally occurs in late September or early October (Posgay and Norman 1958; MacKenzie *et al.* 1978; McGarvey *et al.* 1992; DiBacco *et al.* 1995). In **Cape Cod Bay**, spawning occurs in late September and early October (Posgay 1950). In the **Gulf of Maine** spawning occurs in August and September (Drew 1906; Welch 1950; Baird 1953; Culliney 1974; Robinson *et al.* 1981; Barber *et al.* 1988). In the Bay of Fundy the spawning period extends from late July to November (Stevenson 1936; Dickie 1955; Beninger 1987; MacDonald and Thompson 1988; Dadswell and Parsons 1992).

Scallops beds generally spawn synchronously in a short time, going from completely ripe to completely spent in less than a week (Posgay and Norman 1958; Posgay 1976). “Dribble spawning” over an extended time period has been reported in scallops from Newfoundland coastal waters (Naidu 1970) and possibly in the **Gulf of Maine** (Langton *et al*. 1987) and in **New Jersey** in June and July (MacDonald and Thompson 1988). A rapid temperature change, the presence in the water of gametes from other scallops, agitation, or tides may trigger scallop spawning (Parsons *et al.* 1992a).

8.0 BARNDOOR SKATE

Information on the spawning periods of barndoor skate (*Dipturus laevis*) comes from the EFH Source Document (Packer *et al*. 2003 and references therein).

Females containing fully formed egg capsules have been taken in December and January (Vladykov 1936; Bigelow and Schroeder 1953), although it is not known if egg capsule production and deposition is restricted to the winter (McEachran 2002).

9.0 CLEARNOSE SKATE

Information on the spawning periods of clearnose skate (*Raja eglanteria*) comes from the EFH Source Document (Packer *et al*. 2003 and references therein).

The patterns of estradiol concentrations and follicle dynamics indicate the presence of a well-defined annual reproductive cycle, in which mating and egg deposition take place from December to mid May (Rasmussen *et al*. 1999). **North of Cape Hatteras** the egg cases are deposited in the spring and summer; in **Delaware Bay**, Fitz and Daiber (1963) reported spawning to occur only in the spring. Off the central west coast of Florida, egg deposition occurs from December through mid-May (Luer and Gilbert 1985).

Additional References

Rasmussen L E., L, D. L. Hess, and C.A. Luer. 1999. Alterations in serum steroid concentrations in the clearnose skate, *Raja eglanteria*: correlations with season and reproductive status. J. Exp. Zool. 284: 575–585.

10.0 *DEEP-SEA RED CRAB*

Information on the spawning periods of red deepsea crab [*Chaceon (Geryon) quidquedens*] comes from the EFH Source Document (Steimle *et al*. 2002 and references therein).

Erdman *et al*. (1991) suggested that the egg brooding period may be about nine months, at least for the Gulf of Mexico population, and larvae are hatched in the early spring there. There is no evidence of any restricted seasonality in spawning activity in any geographic region of the population, although a mid-winter *peak* is suggested as larval releases are reported to extend from January to June (Wigley *et al*. 1975; Haefner 1978; Lux *et al*. 1982; Erdman *et al*. 1991; Biesiot and Perry 1995). Laboratory studies also found hatching to occur from April to June (Perkins 1973). Gerrior (1981), however, suggested that red crab egg hatching occurred later, between July and October, based on the ratio of egg-bearing to non-egg-bearing crabs.

11.0 HADDOCK

Information on the spawning periods of haddock (*Melanogrammus aeglefinus*) comes from the EFH Source Document (Brodziak 2005 and references therein).

Georges Bank is the *principal* haddock spawning area in the northeast U.S. continental shelf ecosystem. Haddock spawning is concentrated on the **Northeast Peak** of Georges Bank. The western edge of Georges Bank also supports a smaller spawning concentration (Walford 1938).

Although the *vast majority* of reproductive output originates from **Georges Bank**, some limited spawning activity occurs on **Nantucket Shoals** (Smith and Morse 1985) and along the **South Channel** (Colton and Temple 1961). In the **Gulf of Maine**, **Jeffreys Ledge** and **Stellwagen Bank** are the two primary spawning sites (Colton 1972). In addition, Ames (1997) also reported numerous small, isolated spawning areas in **inshore Gulf of Maine waters**. Based on interviews with retired commercial fishers from Maine and New Hampshire, Ames (1997) identified 100 haddock spawning sites, covering roughly 500 square miles, from **Ipswich Bay to Grand Manan Channel.**

The timing of haddock spawning activity varies among areas. In general, spawning occurs later in more northerly regions (Page and Frank 1989; Lapolla and Buckley 2005). There is also inter-annual variation in the onset and *peak* of spawning activity. On **Georges Bank**, spawning occurs from January to June (Smith and Morse 1985), usually *peak*ing from February to early-April (Smith and Morse 1985; Lough and Bolz 1989; Page and Frank 1989; Brander and Hurley 1992; Lapolla and Buckley 2005) but the timing can vary by a month or more depending upon water temperature (Marak and Livingstone 1970; Page and Frank 1989). In the **Gulf of Maine**, spawning occurs from early February to May, usually *peaking* in February to April (Bigelow and Schroeder 1953). Overall, cooler water temperatures tend to delay haddock spawning and may contract the duration of spawning activity (Marak and Livingstone 1970; Page and Frank 1989).

During 1978-1987, MARMAP ichthyoplankton surveys caught haddock eggs from **New Jersey to southwest Nova Scotia**. The highest densities were found on **Georges Bank** and Browns Bank, which are important haddock spawning areas (Colton and Temple 1961; Laurence and Rogers 1976; Brander and Hurley 1992). Eggs were collected from January through August. The *highest concentrations* occurred in April, followed by March and May. This pattern is consistent with the timing of peak spawning from March to May (Bigelow and Schroeder 1953; Page and Frank 1989; Brander and Hurley 1992). In particular, the *highest mean densities* of eggs occurred in April (77.3 eggs/10 m^2) and March (21.1 eggs/10 m^2). By July and August, mean densities had decreased substantially (< 0.1 eggs/10 m^2).

Data from the more recent U.S. GLOBEC Georges Bank surveys (February-July, 1995; January-June, 1996-1999) showed the *highest concentration* of eggs to be on the eastern, Canadian side of **Georges Bank**, with peaks occurring during February-March and into April.

12.0 LITTLE SKATE

Information on the spawning periods of little skate (*Leucoraja erinacea*) comes from the EFH Source Document (Packer *et al*. 2003 and references therein).

Egg cases are found partially to fully developed in mature females year-round but several authors report that they are most frequently encountered from late October-January and from June-July (Fitz and Daiber 1963; Richards *et al*. 1963; Scott and Scott 1988); Bigelow and Schroeder (1953) also mention that eggs are taken off **southern New England** mostly from July to September.

In **Block Island Sound**, Johnson (1979) also reported pregnant little skate were present during all months of the year, but the seasonal percentages of pregnant females varied. *Periods of relatively high pregnancy-frequency* were October-December and April-May, while low periods occurred in August-September and February-March. *Peaks* in egg production were in November and May when 34% and 44% of the females examined were pregnant, respectively. The lowest levels of production came in September and March when approximately 1% of the females were pregnant.

Johnson (1979) found the mean number of mature and maturing eggs per fish increased significantly prior to and during the spawning *peaks*, reaching maxima in October and May. The average number of mature and maturing eggs decreased significantly between what appears to be two spawning seasons with minima in August and January. The greatest ovarian production occurred in the spring. In **Delaware Bay**, Fitz and Daiber (1963) also showed that the greatest ovarian production occurred in the spring, while the size and number of eggs was at a minimum in February and March.

Johnson (1979) reported that ovarian weight also increased significantly during two spawning seasons. Comparison of the female gonad weight expressed as a percentage of total body weight demonstrated two seasonal *peaks* with maxima occurring in October and May; these seasonal peaks represented and increase in ovarian production. After the height of spawning, the female gonad weight dropped off significantly, reaching a minima in January and August.

Rate of egg laying in Johnson’s (1979) study varied from 0.20-0.67 eggs/d, with an average rate of 0.39 eggs/d. Johnson (1979) suggests that an average female little skate which spawns twice annually (once during fall and spring) produces approximately 30 eggs/yr. Bigelow and Schroeder (1953) observed that eggs in aquaria were laid at intervals of from five days to several weeks, and were partially buried in sand.

Gestation is at least six months or more. Aquarium studies mentioned by Bigelow and Schroeder (1953) showed that eggs laid in May-July hatched between the end of November and beginning of January, about 5-6 months. Richards *et al*. (1963) also determined that eggs spawned in the late spring and early summer required five to six months to hatch. Since the water temperature of the aquarium in which the eggs were kept was slightly above that of the natural environment, it is possible that the incubation time was underestimated. Perkins (1965) in a study conducted at **Boothbay Harbor, Maine**, found under aquarium conditions where the water temperature closely approximated that of the inshore waters, eggs deposited in November and December hatched after twelve months of incubation. Johnson (1979) performed flow-through seawater system studies using ambient temperatures resembling those of the **inshore waters of Block Island Sound** at 20 m. The incubation period ranged from 112-366 d and was dependent on month of deposition. Eggs deposited in September 1975 hatched after an average of 360 d. Incubation time decreased progressively from September, and eggs deposited in July 1977 developed and hatched in an average of 122 d. The rate of embryonic growth appeared to be directly related to temperature. In Perkins (1965) study, incubation of eggs deposited in November and December showed the first embryonic activity in March when the water temperature had risen to 7EC.

13.0 MONKFISH

Information on the spawning periods of monkfish (goosefish) (*Lophius americanus*) comes from the EFH Update Memo (Essential Fish Habitat Source Document Update Memo: Goosefish, *Lophius americanus*, Life History and Habitat Characteristics, 2006, and references therein).

Spawning occurs from spring through early fall with a *peak* in May-June (Wood 1982; Armstrong *et al*. 1992) although pelagic individuals (larvae and juveniles) have been reported for all months of the year except December, suggesting that spawning occurs at some level for most months of the year **within the species' geographic range**. Regionally, goosefish has been reported to spawn in the early spring off the **Carolinas**, in May-July off of **New Jersey**, in May-June in the **Gulf of Maine**, and into September in Canadian waters (Scott and Scott 1988; Hartley 1995). *Peak* gonadosomatic indices (GSI) occurred in March-June for males and in May-June for females (Armstrong *et al*. 1992). Spawning locations are not well known but are thought to be on inshore shoals to offshore (Connolly 1920; Wood 1982; Scott and Scott 1988).

Eggs were only occasionally caught (N = 28) in the NEFSC MARMAP ichthyoplankton surveys from the Gulf of Maine to North Carolina. Eggs were not collected in **Sandy Hook Bay** by Croker (1965) and were only rarely found in **Long Island Sound** by Merriman and Sclar (1952) and Wheatland (1956). Egg veils were reported from late May through late July in waters (18-40 m depth) off of **Barnegat Light, New Jersey** (R.C. Chambers, NMFS/NEFSC/James J. Howard Marine Sciences Laboratory, unpublished data). Eggs have been reported in open coastal bays and sounds in low numbers (Smith 1898; Herman 1963; Caruso 2002).

14.0 OCEAN POUT

Information on the spawning periods of ocean pout (*Macrozoarces americanus*) comes from the EFH Source Document (Steimle *et al*. 1999 and references therein).

Spawning occurs in the late summer through early winter (*peak* in September-October) with earlier *peak*s (August-October) in the south (Wilk and Morse 1979). Spawning occurs on hard bottom, sheltered areas (Bigelow and Schroeder 1953), including artificial reefs and shipwrecks, at depths of < 50 m and temperatures of 10°C or less (Clark and Livingstone 1982). These spawning/nesting habitats **include the saline parts of New England estuaries** (Jury *et al.* 1994).

15.0 OFFSHORE HAKE

Information on the spawning periods of offshore hake (*Merluccius albidus*) comes from the EFH Update Memo (Essential Fish Habitat Source Document Update Memo: Offshore Hake, *Merluccius albidus*, Life History and Habitat Characteristics, 2004, and references therein).

There is little information available on the reproductive biology of offshore hake. Spawning appears to occur over a protracted period or even continually throughout the year from the **Scotian Shelf through the Middle Atlantic Bight**. For example, in New England, Cohen *et al*. (1990) indicates that spawning occurs from April to July at depths ranging from 330-550 m. Eggs and larvae have also been collected off of **Massachusetts** from April through July (Marak 1967). Smith *et al*. (1980) reported that eggs and larvae were also present from April through June **south of New England** and in February and March **south of Long Island, NY**. Colton *et al*. (1979) indicated that while there was some uncertainty in the timing of offshore hake spawning in the **Mid-Atlantic Bight**, it appears to extend from June through September. This is supported by results from the **New York Bight** where Wilk *et al*. (1990) showed that while mean gonadosomatic indices (GSI) were highest in June and July, females in various stages of gonadal development were collected from spring through late fall.

Offshore hake eggs were collected as part of the NEFSC MARMAP ichthyoplankton surveys from 1978-1987. They were most abundant along the continental shelf from **eastern Georges Bank to the Middle Atlantic Bight just south of Delaware Bay and infrequently off Cape Hatteras**. Egg densities exceeded 10 per 10 m^2 during the first four years of the survey, but declined to less than 5 per 10 m^2 during the final five years, with the exception of 1984 (Berrien and Sibunka 1999). Eggs were collected in every month of the year, although the catch varied seasonally.

In January and February, eggs were sparsely distributed with small numbers collected from off **Georges Bank to Delaware Bay and Cape Hatteras**. From March through June, eggs were collected in larger numbers as density increased along the outer margin of the continental shelf with abundance highest from **east of Georges Bank to off the Hudson Canyon**, although small numbers were collected from **south of Delaware Bay to as far north as the Northeast Channel**. From July through September, the numbers of eggs dropped sharply and were irregularly distributed from southeast of **Georges Bank to Delaware Bay**. Abundance rose again in October with a distribution similar to that in April, ranging from the **Northeast Channel to the Mid-Atlantic Bight off the Hudson Canyon**. Abundance decreased again during November and December with a distribution generally similar to that in January and February.

16.0 POLLOCK

Information on the spawning periods of pollock (*Pollachius virens*) comes from the EFH Source Document (Cargnelli *et al*. 1999, and references therein).

The principal pollock spawning sites in the northwest Atlantic are in the **western Gulf of Maine, Great South Channel, Georges Bank**, and on the Scotian Shelf. In the **Gulf of Maine**, spawning is concentrated in **Massachusetts Bay, Stellwagen Bank, and from Cape Ann to the Isle of Shoals** (Steele 1963; Hardy 1978; Collette and Klein-MacPhee 2002). Spawning is believed to occur throughout the Scotian Shelf; Emerald, LaHave, and Browns banks are the principal sites (Mayo *et al.* 1989).

Spawning takes place from September to April. Spawning time is more variable in northern sites than in southern sites. In the **Gulf of Maine** spawning occurs from November to February (Steele 1963; Colton and Marak 1969), *peaking* in December (Collette and Klein-MacPhee 2002). On the Scotian Shelf, spawning occurs from September to April (Markle and Frost 1985; Clay *et al.* 1989) and *peak*s from December to February (Clay *et al.* 1989).

The 1978-1987 MARMAP offshore ichthyoplankton surveys collected eggs during October to June from off **Delaware Bay to southwest Nova Scotia**. *Highest monthly mean egg densities* occurred in November (24.4 eggs/10 m^2), December (36.8 eggs/10 m^2), January (86.1 eggs/10 m^2) and February (19.6 eggs/10 m^2) in **Massachusetts Bay, Georges Bank, and Browns Bank**. Egg densities were considerably lower in months prior to and after this period ($\leq$ 1.40 eggs/m^2). This concurs with reports that *peak* spawning occurs during November to February (Hardy 1978; Fahay 1983; Clay *et al.* 1989).

17.0 REDFISH

Information on the spawning periods of redfish (*Sebastes* spp.) comes from the EFH Update Memo (Essential Fish Habitat Source Document Update Memo: Acadian redfish, *Sebastes* spp., Life History and Habitat Characteristics, 2004, and references therein).

Nothing is known about redfish breeding behavior, but eggs are fertilized internally and develop into larvae within the oviduct and are released near the end of the yolk sac phase (Klein-MacPhee and Collette 2002). Copulation probably occurs from October to January, but fertilization is delayed until February to April (Ni and Templeman 1985; Klein-MacPhee and Collette 2002). **Larvae are released throughout the range of the adults**, perhaps in mid-water, from April to August; the release of larvae lasts for 3-4 months with a *peak* in late May to early June (Steele 1957; Kelly and Wolf 1959; Kelly *et al.* 1972; Kenchington 1984; Klein-MacPhee and Collette 2002).

MARMAP surveys (1977-1987) collected larvae on the continental slope **south and east of Georges Bank** and throughout the **Gulf of Maine** from March through October. Only a few larvae were collected in March on the **slope southeast of Georges Bank**. These larvae are possibly a mix of *S. fasciatus* and *S. mentella*. [Kenchington (1984) reviewed evidence that larvae collected along the continental slope on the Scotian Shelf in early spring are *S. mentella*.] In April, larvae were more abundant on the slope and the first larvae appeared in the **Gulf of Maine** and in the **Northeast Channel**. In May, larvae were more dispersed on the slope and in the **Gulf of Maine**. In June and July, larvae were randomly distributed throughout the **Gulf of Maine** and in the **Great South Channel**. Larval abundance *peaked* in August, and by September, larvae were scarce and were found only in the **Gulf of Maine**. Only a few larvae were collected in October.

18.0 RED HAKE

Information on the spawning periods of red hake (*Urophycis chuss*) comes from the EFH Update Memo (Essential Fish Habitat Source Document Update Memo: Red Hake, *Urophycis chuss*, Life History and Habitat Characteristics, 2004, and references therein).

Major spawning areas occur on the **southwestern part of Georges Bank** and on the **continental shelf off southern New England and eastern Long Island**; however, a nearly ripe female was collected during April in **Chesapeake Bay** (Hildebrand and Schroeder 1928). Spawning adults and eggs are also common in the **marine parts of most coastal bays between Narragansett Bay, Rhode Island, and Massachusetts Bay**, but rarely in coastal areas to the south or north (Jury *et al.* 1994; Stone *et al.* 1994). Based on condition of the gonads from red hake collected in the **New York Bight**, spawning occurs at temperatures between 5-10°C from April through November (Wilk *et al.* 1990). Approximate spawning seasons for red hake are March through October for **Middle Atlantic Bight and Southern New England** and May through September for **Georges Bank and Gulf of Maine** (Link and Burnett 2001). In the **Gulf of Maine**, spawning may not begin until June with a *peak* during July to August (Dery 1988; Scott and Scott 1988). In the **New York Bight and on Georges Bank**, spawning red hake are most abundant in May to June (Collette and Klein-MacPhee 2002). Eklund (1988) reported a *peak* in their gonadosomatic index (GSI) during May to July and the presence of ripe eggs in June to July off **Delaware**.

Hatching occurs in 3-7 days during May and September (Able and Fahay 1998).

19.0 ROSETTE SKATE

Information on the spawning periods of rosette skate (*Leucoraja garmani virginica*) comes from the EFH Source Document (Packer *et al*. 2003 and references therein).

North of Cape Hatteras the egg capsules are found in mature females year-round but are most frequent during the summer (McEachran 1970).

20.0 SILVER HAKE

Information on the spawning periods of silver hake (*Merluccius bilinearis*) comes from the EFH Source Document (Lock and Packer 2004, and references therein).

Silver hake eggs and larvae have been collected in all months on the continental shelf in U.S. waters, although the onset of spawning varies regionally (Bigelow and Schroeder 1953; Marak and Colton 1961; Sauskan and Serebryakov 1968; Fahay 1974; Morse *et al*. 1987; Waldron 1988; Berrien and Sibunka 1999). The primary spawning grounds most likely coincide with concentrations of ripe adults and newly spawned eggs. These grounds occur **between Cape Cod, Massachusetts, and Montauk Point, New York** (Fahay 1974), on the **southern and southeastern slope of Georges Bank** (Sauskan 1964) and the **area north of Cape cod to Cape Ann**, Massachusetts (Bigelow and Schroeder 1953).

Spawning begins in January along the **shelf and slope in the Middle Atlantic Bight**. During May, spawning proceeds north and east to **Georges Bank**. By June spawning spreads into the **Gulf of Maine** and continues to be centered on **Georges Bank** through summer. In October, spawning is centered in **southern New England** and by December is observed again along the shelf and slope in the **Middle Atlantic Bight**. *Peak* spawning occurs May to June in the southern stock and July to August in the northern stock (Brodziak 2001). Over the U.S. continental shelf, significant numbers of eggs are produced beginning in May. Numbers increase through August and decline rapidly during September and October (Berrien and Sibunka 1999).

Silver hake eggs were found throughout the area surveyed during the NEFSC MARMAP ichthyoplankton surveys. They were most abundant in the deeper parts of **Georges Bank** (> 60 m) and the shelf off **southern New England**. Eggs were captured in all months of the year. From January to March, eggs occurred in small numbers in the deep waters of the **Middle Atlantic Bight**. By April, the occurrence of eggs extended eastward along the **southern edge of Georges Bank** and the total number of eggs increased slightly. During May and June the catches of eggs extended into the shelf and into nearshore waters of the **Middle Atlantic Bight and southern New England areas**. Some eggs were captured in the **western part of the Gulf of Maine**. By July and August the center of abundance had shifted east onto **Georges Bank with southern New England and the Gulf of Maine** continuing to show some catches of eggs. In September and October the occurrences of eggs began to decline with centers of abundance still on **Georges Bank** and extending into **southern New England**. Few eggs were captured in November or December, but those that were occurred in deeper waters of the **Middle Atlantic Bight**.

21.0 SMOOTH SKATE

Information on the spawning periods of smooth skate (*Malacoraja senta*) comes from the EFH Source Document (Packer *et al*. 2003 and references therein).

Females with fully formed egg capsules are found both in summer and winter (McEachran 2002). Timing of spawning is not known, although Sulikowski *et al*. (in review) may eventually provide some answers for the **Gulf of Maine**.

Additional References

Sulikowski, J.A., J. Kneebone, S. Elzey, P. Danley, W.H. Howell and P.W.C. Tsang. In review. The reproductive cycle of the smooth skate, *Malacoraja senta*, in the Gulf of Maine.

22.0 THORNY SKATE

Information on the spawning periods of thorny skate (*Amblyraja radiata*) comes from the EFH Source Document (Packer *et al*. 2003 and references therein).

Females with fully formed egg capsules are captured over the entire year (Templeman 1982a), although the percentage of mature females with capsules is higher during the summer (McEachran 2002). A recent study by Sulikowski et al. (2005) in the **Gulf of Maine off New Hampshire** indicates that thorny skate have a reproductive cycle that is continuous throughout the year. Bigelow and Schroeder (1953a) reported that females with ripe eggs have been taken in Nova Scotian waters or in the **Gulf of Maine** in April, June, July, and September.

Additional References

Sulikowski, J.A., J. Kneebone, S. Elzey, P. Danley, W.H. Howell and P.W.C Tsang. 2005. The reproductive cycle of the thorny skate, *Amblyraja radiata*, in the Gulf of Maine. Fish. Bull. (U.S.) 103: 536-543.

23.0 WHITE HAKE

Information on the spawning periods of white hake (*Urophycis tenuis*) comes from the EFH Source Document (Cargnelli *et al*. 1999, and references therein).

The northern stock of white hake spawns in late summer (August-September) in the southern Gulf of St. Lawrence and on the Scotian Shelf (Markle *et al*. 1982). The timing and extent of spawning in the **Georges Bank-Middle Atlantic Bight** stock has not been clearly determined. Based on the distribution and abundance of pelagic juveniles, as well as circulation patterns throughout the region, Fahay and Able (1989) suggested that the southern stock spawns in early spring (April-May) in **deep waters along the continental slope,** *primarily* off **southern Georges Bank and the Middle Atlantic Bight** (Lang *et al*. 1996). The spawning contribution of the **Gulf of Maine** population is negligible (Fahay and Able 1989).

24.0 WINDOWPANE

Information on the spawning periods of windowpane (*Scophthalmus aquosus*) comes from the EFH Source Document (Chang *et al*. 1999, and references therein).

Gonadal development indices (Wilk *et al.* 1990) and egg and larval distributions (Colton and St. Onge 1974; Smith *et al.* 1975; Colton *et al*. 1979; Morse *et al.* 1987) indicate that spawning occurs throughout most of the year. Spawning begins in February or March in **inner shelf** waters, *peaks* in the **Middle Atlantic Bight** in May, and extends onto **Georges Bank** during the summer (Able and Fahay 1998). Spawning also occurs in the **southern portion of the Middle Atlantic Bight** in the autumn (Smith *et al*. 1975). There is a split spawning season in the **central Middle Atlantic Bight** with *peaks* in the spring and autumn (Morse and Able 1995; Able and Fahay 1998). Evidence for a split spawning season is available for **Virginia and North Carolina** (Smith *et al.* 1975), for **Long Island Sound**, **New York** (Wheatland 1956), and for **Great South Bay, New York** (Dugay *et al.* 1989; Monteleone 1992). Gonad development indicated that split spawning off **New Jersey and New York** *peaks* in May and in September (Wilk *et al.* 1990). However, neither Perlmutter (1939) nor Smith *et al.* (1975) found evidence for a split spawning season in **Long Island Sound** or in oceanic waters north of **Virginia**. Colton and St. Onge (1974) collected larvae on **Georges Ban**k from July to November but found no indication of a split spawning season.

Some spawning may occur in the **high salinity portions of estuaries in the Middle Atlantic Bight**, including **Great South Bay, New York** (Monteleone 1992), **Sandy Hook Bay, New Jersey** (Croker 1965), inside **Hereford Inlet, New Jersey** (Allen *et al.* 1978), and in the **coastal habitats of the Carolinas** (Wenner and Sedberry 1989).

Windowpane eggs have been collected in several studies (Colton and St. Onge 1974; Smith *et al.* 1975; Colton *et al.* 1979; Morse *et al.* 1987; Berrien and Sibunka 1999). During the MARMAP ichthyoplankton surveys, eggs were collected at 16% of the stations sampled; primarily at depths < 40 m between **Georges Bank** and **Cape Hatteras**. Eggs densities were generally low in the **Gulf of Maine**. Eggs were collected in nearshore shelf waters in the **Middle Atlantic Bight** from February to November. Egg densities *peaked* in May and October. Eggs were present on **Georges Bank** from April through October and density *peaked* during July-August.

25.0 WINTER FLOUNDER

Information on the spawning periods of winter flounder (*Pseudopleuronectes americanus*) comes from the EFH Source Document and EFH Update Memo (Pereira *et al*. 1999; Pereira 2004, and references therein).

With the exception of the **Georges Bank** population, adult winter flounder migrate inshore in the fall and early winter and spawn in late winter and early spring. Winter flounder spawn from winter through spring, with *peak* spawning occurring during February and March in **Massachusetts Bay and south of Cape Cod** and somewhat later along the **coast of Maine** continuing into May (Bigelow and Schroeder 1953). Spawning occurs earlier (November to April) in the **southern part of the range** (Klein-MacPhee 2002). With the exception of **Georges Bank and Nantucket Shoals**, winter flounder eggs are generally collected from very shallow waters (less than about 5 m).

Data from recent U.S. GLOBEC Georges Bank surveys (February-July, 1995; January-June, 1996-1999) showed **Georges Bank** eggs occurred during March-June, with the highest numbers in March and May on the central and northern sections on the Bank. Winter flounder eggs have also been collected in standard plankton tows utilizing bongo nets by the NEFSC MARMAP survey. In some cases this was probably due to the nets accidentally hitting the bottom, but this explanation is not sufficient to explain the large numbers of eggs collected on **Georges Bank and Nantucket Shoals**, especially during April. The large numbers of eggs collected on **Georges Bank** are probably due to the unique hydrodynamic conditions found there. The water mass on **central Georges Bank** is characterized by lack of stratification at any time of year due to good vertical mixing (Backus and Bourne 1987). These same forces probably lift demersal eggs up into the water column and make them available to sampling by bongo net.

Pereira *et al*. (1999) and Pereira (2004) discuss **inshore locations** where winter flounder eggs have been found.

26.0 WINTER SKATE

Information on the spawning periods of winter skate (*Leucoraja ocellata*) comes from the EFH Source Document (Packer *et al*. 2003, and references therein).

Bigelow and Schroeder (1953) report egg deposition to occur during summer and fall off Nova Scotia and, quoting Scattergood, probably in the **Gulf of Maine** as well. They also state that egg deposition continues into December and January off **southern New England**.

A recent study by Sulikowski *et al*. (2004) in the **Gulf of Maine off New Hampshire** indicates that several morphological parameters and steroid hormones have been shown to *peak* in female winter skates during the summer, and egg-case production is highest in the fall. However, the presence of reproductively capable females during most months of the year and spermatocysts within the male testis year round implies that reproduction could occur at other times of the year. Thus, the Sulikowski *et al*. (2004) study, combined with the criteria described by Wourms (1977) and Hamlett and Koob (1999), collectively support the conclusion that winter skate display a partially defined reproductive cycle with a single *peak* (Sulikowski *et al*. 2004).

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27.0 WITCH FLOUNDER

Information on the spawning periods of witch flounder (*Glyptocephalus cynoglossus*) comes from the EFH Source Document (Cargnelli *et al*. 1999, and references therein).

Witch flounder spawn from March to November, with *peak* spawning occurring in summer. The general trend is for spawning to occur progressively later from south to north (Martin and Drewry 1978; Brander and Hurley 1992). In the **Gulf of Maine-Georges Bank** region, spawning occurs from April to November, and *peaks* from May to August (Bigelow and Schroeder 1953; Evseenko and Nevinsky 1975; Burnett *et al*. 1992; O'Brien *et al*. 1993). The **western and northern areas of the Gulf of Maine** tend to be the most active spawning sites (Burnett *et al*. 1992). In the **Middle Atlantic Bight**, spawning occurs from April to August, *peaking* in May or June (Smith *et al*. 1975; Martin and Drewry 1978), and the most important spawning grounds are off **Long Island** (Smith *et al*. 1975).

The MARMAP offshore ichthyoplankton surveys found eggs earlier in the **Middle Atlantic Bight** than in **New England**, where eggs were not found until May. This agrees with studies suggesting that spawning occurs later to the north (Martin and Drewry 1978; Brander and Hurley 1992). The highest egg densities appear to be in the **Gulf of Maine and Massachusetts Bay** in May and June. High densities of eggs occurred in May (monthly mean 5.7 eggs/10 m^2) in **Massachusetts Bay, along the south flank of Georges Bank and throughout the Middle Atlantic Bight**. The highest abundances occurred in June (monthly mean 8.0 eggs/10 m^2) off **New England**, particularly in the **Gulf of Maine and Georges Bank**. This concurs with reports that spawning peaks in May and June (Smith *et al*. 1975; Martin and Drewry 1978; Neilson *et al*. 1988).

28.0 YELLOWTAIL FLOUNDER

Information on the spawning periods of yellowtail flounder (*Limanda ferruginea*) comes from the EFH Update Memo and EFH Source Document (Essential Fish Habitat Source Document Update Memo: Yellowtail Flounder, *Limanda ferruginea*, Life History and Habitat Characteristics, 2006; Johnson *et al*. 1999, and references therein).

Spawning generally occurs from March through August at temperatures of 5-12^{o}C (Fahay 1983). Collections from the MARMAP ichthyoplankton surveys (1977-1987) showed little or no spawning activity during February. By March and April, eggs appeared on the continental shelf off **New Jersey and Long Island, on Georges Bank, northwest of Cape Cod**, and on Browns Bank. The distribution and abundance of eggs expanded in **southern New England** in May. On **Georges Bank**, the distribution and abundance of eggs expanded in June and declined thereafter; spawning ended in August. Eggs were found in the **Gulf of Maine** from April to September. The densest egg concentrations occurred on the northeast and southwest part of **Georges Bank, west from Nantucket Shoals to New Jersey, northwest of Cape Cod along western Gulf of Maine**, and off southwest Nova Scotia. *Peak* abundances were from April to June.

During the **Georges Bank** GLOBEC ichthyoplankton surveys (1995-1999), yellowtail eggs were found in all months sampled (excluding January). They were most abundant at depths > 60 m, especially along the **Northeast Peak**, all regions of the **Southern Flank**, as well as the **Great South Channel**. Egg concentrations *peaked* in April and by May eggs extended into the **Southern Flank and central Georges Bank**. Fewer eggs were captured in June and even less in July.

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ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

PHASE 1

APPENDIX F
"AFFECTED HUMAN ENVIRONMENT – SOCIAL ENVIRONMENT: *COUNTY PROFILES*"

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1.0 Introduction and Background

In order to provide the most up-to-date information possible, this section relies primarily on the Census' 2005 American Community Survey (ACS). Unlike the full 2000 census, these data are limited to the household population and exclude the population living in institutions, college dormitories, and other group quarters. Further, detail may not add to totals due to rounding, and percentages are based on unrounded numbers. The narratives are excerpted from those accessible through the Census' American Factfinder site at http://factfinder.census.gov/home/saff/main.html. (Enter County and State, choose the 2005 tab, and at the right choose "Narrative Profile".)

However, the 2005 ACS does not present data for all geographic areas – especially for areas with a population of under 65,000. For counties which are not represented in the 2005 American Community Survey (see asterisked counties in Table 1) we have used 2000 data instead. Narratives profiles are not available for 2000 data, so we have used the 2005 narrative profiles as a template and then filled in the appropriate 2000 data.

This Appendix contains profiles for all counties identified in bold in the tables of landings and value by FMP by county in the main section of the AHE (see

Table 1 for a summary).

As the reader goes through the summaries patterns will begin to emerge, of which communities show the heaviest direct dependence in terms of industries and occupations. However, recent work by the Community Panels Project on the importance of infrastructure hubs serves as a reminder that regional links are just as important to healthy fisheries as are local infrastructure and jobs.

In some counties tourism and recreational fishing have emerged as important to local economies. These are sometimes in conflict with commercial fisheries operations, but can also offer opportunities to strengthen a community's general ties to the water.

As County Profiles begin to draw general pictures, the reader is urged to then turn to the more in-depth community profiles to flesh out in more detail the issues and processes occurring along the coast.

As actual actions begin to be proposed for Phase 2 of the EFH Omnibus, these profiles and the other information in the AHE will become increasingly important for analyzing any such proposed measures.

Table 1. Counties Profiled in the Appendix

STATE	COUNTY
Connecticut	New London
Massachusetts	Barnstable
	Bristol
	Essex
	Plymouth
	Suffolk
Maryland	Worcester *
Maine	Cumberland*
	Hancock*
	Knox*
	Lincoln*
	Washington*
North Carolina	Dare*
New Hampshire	Rockingham
New Jersey	Atlantic
	Cape May
	Ocean
New York	Suffolk
Rhode Island	Newport
	Washington
Virginia	City of Hampton
	City of Newport News
	Northumberland*
	York*

2.0 Connecticut

2.1 New London County

POPULATION OF New London County: In 2005, New London County had a household population of 253,000 - 130,000 (51 percent) females and 124,000 (49 percent) males. The median age was 38.7 years. Twenty-four percent of the population were under 18 years and 13 percent were 65 years and older.

For people reporting one race alone, 87 percent were White; 5 percent were Black or African American; 1 percent was American Indian and Alaska Native; 3 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander, and 3 percent were some other race. Three percent reported two or more races. Six percent of the people in New London County were Hispanic. Eighty-three percent of the people in New London County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 105,000 households in New London County. The average household size was 2.4 people.
Families made up 66 percent of the households in New London County. This figure includes both married-couple families (52 percent) and other families (14 percent). Non-family households made up 34 percent of all households in New London County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 87 percent of the people at least one year old living in New London County were living in the same residence one year earlier; 8 percent had moved during the past year from another residence in the same county, 1 percent from another county in the same state, 3 percent from another state, and 1 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

DISABILITY: In New London County, among people at least five years old in 2005, 15 percent reported a disability. The likelihood of having a disability varied by age - from 9 percent of people 5 to 20 years old, to 12 percent of people 21 to 64 years old, and to 34 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 37 percent; Sales and office occupations, 23 percent; Service occupations, 21 percent; Production, transportation, and material moving occupations, 10 percent; and Construction, extraction, maintenance and repair occupations, 9 percent. Farming, fishing, and forestry occupations constitute 0.3 percent. Seventy-seven percent of the people employed were Private wage and salary workers; 16 percent were Federal, state, or local government workers; and 7 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Eighty percent of New London County workers drove to work alone in 2005, 11 percent carpooled, 2 percent took public transportation, and 3 percent used other means. The remaining 3 percent worked at home. Among those who commuted to work, it took them on average 20.7 minutes to get to work.

INCOME: The median income of households in New London County was $59,268. Eighty-three percent of the households received earnings and 19 percent received retirement income other than Social Security. Twenty-six percent of the households received Social Security. The average income from Social Security was $14,184. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 6 percent of people were in poverty. Eight percent of related children under 18 were below the poverty level, compared with 6 percent of people 65 years old and over. Three percent of all families and 16 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, New London County had a total of 115,000 housing units, 9 percent of which were vacant. Of the total housing units, 68 percent were in single-unit structures, 29 percent were in multi-unit structures, and 3 percent were mobile homes. Fifteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, New London County had 105,000 occupied housing units - 72,000 (68 percent) owner occupied and 33,000 (32 percent) renter occupied. Three percent of the households did not have telephone service and 6 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Thirty-nine percent had two vehicles and another 24 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,585, non-mortgaged owners $495, and renters $836. Thirty percent of owners with mortgages, 16 percent of owners without mortgages, and 39 percent of renters in New London County spent 30 percent or more of household income on housing.

3.0 Massachusetts

3.1 Barnstable County

POPULATION OF Barnstable County: In 2005, Barnstable County had a household population of 221,000 - 116,000 (52 percent) females and 105,000 (48 percent) males. The median age was 45.6 years. Nineteen percent of the population were under 18 years and 23 percent were 65 years and older.

For people reporting one race alone, 96 percent were White; 2 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 1 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 1 percent were some other race. One percent reported two or more races. Two percent of the people in Barnstable County were Hispanic. Ninety-four percent of the people in Barnstable County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 100,000 households in Barnstable County. The average household size was 2.2 people.

Families made up 67 percent of the households in Barnstable County. This figure includes both married-couple families (52 percent) and other families (15 percent). Non-family households made up 33 percent of all households in Barnstable County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 88 percent of the people at least one year old living in Barnstable County were living in the same residence one year earlier; 7 percent had moved during the past year from another residence in the same county, 2 percent from another county in the same state, 2 percent from another state, and 1 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

DISABILITY: In Barnstable County, among people at least five years old in 2005, 14 percent reported a disability. The likelihood of having a disability varied by age - from 7 percent of people 5 to 20 years old, to 9 percent of people 21 to 64 years old, and to 31 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 32 percent; Sales and office occupations, 27 percent; Service occupations, 23 percent; Construction, extraction, maintenance and repair occupations, 11 percent; and Production, transportation, and material moving occupations, 6 percent. Farming, fishing, and forestry occupations constitute 0.7 percent. Seventy-three percent of the people employed were Private wage and salary workers; 14 percent were Federal, state, or local government workers; and 13 percent were Self-employed in own not incorporated business workers– a category where fishermen might be found.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Barnstable County was $54,439. Seventy-two percent of the households received earnings and 25 percent received retirement income other than Social Security. Forty-one percent of the households received Social Security. The average income from Social Security was $14,696. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 7 percent of people were in poverty. Nine percent of related children under 18 were below the poverty level, compared with 5 percent of people 65 years old and over. Five percent of all families and 18 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Barnstable County had a total of 154,000 housing units, 35 percent of which were vacant. Of the total housing units, 86 percent were in single-unit structures, 13 percent were in multi-unit structures, and 1 percent was mobile homes. Fifteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Barnstable County had 100,000 occupied housing units - 80,000 (80 percent) owner occupied and 20,000 (20 percent) renter occupied. One percent of the households did not have telephone service and 3 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-three percent had two vehicles and another 19 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,635, non-mortgaged owners $483, and renters $1,037. Forty-four percent of owners with mortgages, 16 percent of owners without mortgages, and 45 percent of renters in Barnstable County spent 30 percent or more of household income on housing.

3.2 Bristol County

POPULATION OF Bristol County: In 2005, Bristol County had a household population of 533,000 - 276,000 (52 percent) females and 258,000 (48 percent) males. The median age was 38.1 years. Twenty-four percent of the population were under 18 years and 13 percent were 65 years and older.

For people reporting one race alone, 91 percent were White; 4 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 2 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 3 percent were some other race. One percent reported two or more races. Five percent of the people in Bristol County were Hispanic. Eighty-eight percent of the people in Bristol County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 208,000 households in Bristol County. The average household size was 2.6 people.

Families made up 68 percent of the households in Bristol County. This figure includes both married-couple families (50 percent) and other families (18 percent). Non-family households made up 32 percent of all households in Bristol County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Thirteen percent of the people living in Bristol County in 2005 were foreign born. Eighty-seven percent were native, including 68 percent who were born in Massachusetts.

Among people at least five years old living in Bristol County in 2005, 21 percent spoke a language other than English at home. Of those speaking a language other than English at home, 18 percent spoke Spanish and 82 percent spoke some other language; 41 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2005, 88 percent of the people at least one year old living in Bristol County were living in the same residence one year earlier; 8 percent had moved during the past year from another residence in the same county, 3 percent from another county in the same state, 1 percent from another state, and 1 percent from abroad.

EDUCATION: In 2005, 78 percent of people 25 years and over had at least graduated from high school and 22 percent had a bachelor's degree or higher. Among people 16 to 19 years old, 8 percent were dropouts; they were not enrolled in school and had not graduated from high school.

The total school enrollment in Bristol County was 130,000 in 2005. Nursery school and kindergarten enrollment was 15,000 and elementary or high school enrollment was 88,000 children. College or graduate school enrollment was 26,000.

DISABILITY: In Bristol County, among people at least five years old in 2005, 17 percent reported a disability. The likelihood of having a disability varied by age - from 9 percent of people 5 to 20 years old, to 14 percent of people 21 to 64 years old, and to 40 percent of those 65 and older.

INDUSTRIES: In 2005, for the employed population 16 years and older, the leading industries in Bristol County were Educational services, health care and social assistance, 23 percent, and Manufacturing, 15 percent. Agriculture, forestry, fishing and hunting, and mining constituted less than 1 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 32 percent; Sales and office occupations, 24 percent; Service occupations, 18 percent; Production, transportation, and material moving occupations, 15 percent; and Construction, extraction, maintenance and repair occupations, 11 percent. Farming, fishing, and forestry occupations constitute 0.2 percent. Eighty-two percent of the people employed were Private wage and salary workers; 13 percent were Federal, state, or local government workers; and 5 percent were Self-employed in own not incorporated business workers– a category where fishermen might be found.

TRAVEL TO WORK: Eighty-two percent of Bristol County workers drove to work alone in 2005, 10 percent carpooled, 3 percent took public transportation, and 3 percent used other means. The remaining 2 percent worked at home. Among those who commuted to work, it took them on average 25.4 minutes to get to work.

INCOME: The median income of households in Bristol County was $51,132. Seventy-nine percent of the households received earnings and 17 percent received retirement income other than Social Security. Twenty-eight percent of the households received Social Security. The average income from Social Security was $12,213. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 10 percent of people were in poverty. Fifteen percent of related children under 18 were below the poverty level, compared with 10 percent of people 65 years old and over. Nine percent of all families and 27 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Bristol County had a total of 223,000 housing units, 7 percent of which were vacant. Of the total housing units, 54 percent were in single-unit structures, 44 percent were in multi-unit structures, and 2 percent were mobile homes. Fourteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Bristol County had 208,000 occupied housing units - 131,000 (63 percent) owner occupied and 77,000 (37 percent) renter occupied. Four percent of the households did not have telephone service and 10 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Thirty-seven percent had two vehicles and another 18 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,599, non-mortgaged owners $460, and renters $703. Thirty-six percent of owners with mortgages, 18 percent of owners without mortgages, and 46 percent of renters in Bristol County spent 30 percent or more of household income on housing.

3.3 Essex County

POPULATION OF Essex County: In 2005, Essex County had a household population of 722,000 - 372,000 (52 percent) females and 350,000 (48 percent) males. The median age was 38.7 years. Twenty-five percent of the population were under 18 years and 13 percent were 65 years and older.

For people reporting one race alone, 85 percent were White; 3 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 3 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 9 percent were some other race. Two percent reported two or more races. Fourteen percent of the people in Essex County were Hispanic. Seventy-nine percent of the people in Essex County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 275,000 households in Essex County. The average household size was 2.6 people.

Families made up 67 percent of the households in Essex County. This figure includes both married-couple families (48 percent) and other families (18 percent). Non-family households made up 33 percent of all households in Essex County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Thirteen percent of the people living in Essex County in 2005 were foreign born. Eighty-seven percent were native, including 68 percent who were born in Massachusetts.

Among people at least five years old living in Essex County in 2005, 22 percent spoke a language other than English at home. Of those speaking a language other than English at home, 61 percent spoke Spanish and 39 percent spoke some other language; 42 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2005, 88 percent of the people at least one year old living in Essex County were living in the same residence one year earlier; 8 percent had moved during the past year from another residence in the same county, 2 percent from another county in the same state, 2 percent from another state, and 1 percent from abroad.

EDUCATION: In 2005, 88 percent of people 25 years and over had at least graduated from high school and 35 percent had a bachelor's degree or higher. Among people 16 to 19 years old, 7 percent were dropouts; they were not enrolled in school and had not graduated from high school.

The total school enrollment in Essex County was 186,000 in 2005. Nursery school and kindergarten enrollment was 24,000 and elementary or high school enrollment was 122,000 children. College or graduate school enrollment was 40,000.

DISABILITY: In Essex County, among people at least five years old in 2005, 13 percent reported a disability. The likelihood of having a disability varied by age - from 8 percent of people 5 to 20 years old, to 10 percent of people 21 to 64 years old, and to 34 percent of those 65 and older.

INDUSTRIES: In 2005, for the employed population 16 years and older, the leading industries in Essex County were Educational services, health care and social assistance, 21 percent, and Manufacturing, 13 percent. Agriculture, forestry, fishing and hunting, and mining constitute less than 1 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 40 percent; Sales and office occupations, 25 percent; Service occupations, 15 percent; Production, transportation, and material moving occupations, 12 percent; and Construction, extraction, maintenance and repair occupations, 8 percent. Farming, fishing, and forestry occupations constitute 0.2 percent. Eighty-one percent of the people employed were Private wage and salary workers; 12 percent were Federal, state, or local government workers; and 7 percent were Self-employed in own not incorporated business workers– a category where fishermen might be found.

TRAVEL TO WORK: Seventy-eight percent of Essex County workers drove to work alone in 2005, 9 percent carpooled, 5 percent took public transportation, and 5 percent used other means. The remaining 4 percent worked at home. Among those who commuted to work, it took them on average 27.1 minutes to get to work.

INCOME: The median income of households in Essex County was $57,164. Seventy-nine percent of the households received earnings and 17 percent received retirement income other than Social Security. Twenty-seven percent of the households received Social Security. The average income from Social Security was $13,274. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 11 percent of people were in poverty. Sixteen percent of related children under 18 were below the poverty level, compared with 10 percent of people 65 years old and over. Nine percent of all families and 27 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Essex County had a total of 294,000 housing units, 7 percent of which were vacant. Of the total housing units, 57 percent were in single-unit structures, 43 percent were in multi-unit structures, and 1 percent was mobile homes. Eleven percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Essex County had 275,000 occupied housing units - 182,000 (66 percent) owner occupied and 93,000 (34 percent) renter occupied. Four percent of the households did not have telephone service and 10 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Thirty-eight percent had two vehicles and another 15 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,896, non-mortgaged owners $592, and renters $923. Forty-two percent of owners with mortgages, 25 percent of owners without mortgages, and 50 percent of renters in Essex County spent 30 percent or more of household income on housing.

3.4 Plymouth County

POPULATION OF Plymouth County: In 2005, Plymouth County had a household population of 481,000 - 247,000 (51 percent) females and 234,000 (49 percent) males. The median age was 38.3 years. Twenty-six percent of the population were under 18 years and 11 percent were 65 years and older.

For people reporting one race alone, 87 percent were White; 7 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 1 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 4 percent were some other race. One percent reported two or more races. Three percent of the people in Plymouth County were Hispanic. Eighty-five percent of the people in Plymouth County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 172,000 households in Plymouth County. The average household size was 2.8 people.

Families made up 71 percent of the households in Plymouth County. This figure includes both married-couple families (54 percent) and other families (18 percent). Non-family households made up 29 percent of all households in Plymouth County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 90 percent of the people at least one year old living in Plymouth County were living in the same residence one year earlier; 6 percent had moved during the past year from another residence in the same county, 3 percent from another county in the same state, 1 percent from another state, and 1 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.
DISABILITY: In Plymouth County, among people at least five years old in 2005, 12 percent reported a disability. The likelihood of having a disability varied by age - from 7 percent of people 5 to 20 years old, to 10 percent of people 21 to 64 years old, and to 33 percent of those 65 and older.

INDUSTRIES: In 2005, for the employed population 16 years and older, the leading industries in Plymouth County were Educational services, health care and social assistance, 22 percent, and Retail Trade, 14 percent. Agriculture, forestry, fishing and hunting, and mining constitute 1 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 36 percent; Sales and office occupations, 28 percent; Service occupations, 16 percent; Construction, extraction, maintenance and repair occupations, 10 percent; and Production, transportation, and material moving occupations, 9 percent. Farming, fishing, and forestry occupations constitute 0.3 percent. Seventy-eight percent of the people employed were Private wage and salary workers; 13 percent were Federal, state, or local government workers; and 8 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Eighty percent of Plymouth County workers drove to work alone in 2005, 9 percent carpooled, 4 percent took public transportation, and 3 percent used other means. The remaining 4 percent worked at home. Among those who commuted to work, it took them on average 31.9 minutes to get to work.

INCOME: The median income of households in Plymouth County was $66,778. Eighty-four percent of the households received earnings and 18 percent received retirement income other than Social Security. Twenty-eight percent of the households received Social Security. The average income from Social Security was $12,899. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 6 percent of people were in poverty. Seven percent of related children under 18 were below the poverty level, compared with 7 percent of people 65 years old and over. Four percent of all families and 15 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Plymouth County had a total of 189,000 housing units, 9 percent of which were vacant. Of the total housing units, 77 percent were in single-unit structures, 21 percent were in multi-unit structures, and 2 percent were mobile homes. Sixteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Plymouth County had 172,000 occupied housing units - 134,000 (78 percent) owner occupied and 38,000 (22 percent) renter occupied. Two percent of the households did not have telephone service and 5 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-three percent had two vehicles and another 21 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,862, non-mortgaged owners $558, and renters $903. Thirty-nine percent of owners with mortgages, 25 percent of owners without mortgages, and 45 percent of renters in Plymouth County spent 30 percent or more of household income on housing.

3.5 Suffolk County

POPULATION OF Suffolk County: In 2005, Suffolk County had a household population of 620,000 - 321,000 (52 percent) females and 299,000 (48 percent) males. The median age was 33.8 years. Twenty-one percent of the population were under 18 years and 11 percent were 65 years and older.

For people reporting one race alone, 61 percent were White; 22 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 8 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 9 percent were some other race. Two percent reported two or more races. Eighteen percent of the people in Suffolk County were Hispanic. Fifty percent of the people in Suffolk County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 271,000 households in Suffolk County. The average household size was 2.3 people.

Families made up 50 percent of the households in Suffolk County. This figure includes both married-couple families (29 percent) and other families (21 percent). Non-family households made up 50 percent of all households in Suffolk County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Twenty-eight percent of the people living in Suffolk County in 2005 were foreign born. Seventy-two percent were native, including 49 percent who were born in Massachusetts.

Among people at least five years old living in Suffolk County in 2005, 37 percent spoke a language other than English at home. Of those speaking a language other than English at home, 45 percent spoke Spanish and 55 percent spoke some other language; 51 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2005, 78 percent of the people at least one year old living in Suffolk County were living in the same residence one year earlier; 14 percent had moved during the past year from another residence in the same county, 4 percent from another county in the same state, 3 percent from another state, and 2 percent from abroad.

EDUCATION: In 2005, 83 percent of people 25 years and over had at least graduated from high school and 37 percent had a bachelor's degree or higher. Among people 16 to 19 years old, 6 percent were dropouts; they were not enrolled in school and had not graduated from high school.

The total school enrollment in Suffolk County was 160,000 in 2005. Nursery school and kindergarten enrollment was 14,000 and elementary or high school enrollment was 85,000 children. College or graduate school enrollment was 61,000.

DISABILITY: In Suffolk County, among people at least five years old in 2005, 16 percent reported a disability. The likelihood of having a disability varied by age - from 7 percent of people 5 to 20 years old, to 13 percent of people 21 to 64 years old, and to 47 percent of those 65 and older.

INDUSTRIES: In 2005, for the employed population 16 years and older, the leading industries in Suffolk County were Educational services, health care and social assistance, 28 percent, and Professional, scientific, and management, and administrative and waste management services, 15 percent. Agriculture, forestry, fishing and hunting, and mining constitute less than 1 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 39 percent; Sales and office occupations, 26 percent; Service occupations, 21 percent; Production, transportation, and material moving occupations, 9 percent; and Construction, extraction, maintenance and repair occupations, 5 percent. Farming, fishing, and forestry occupations constitute 0.1 percent. Eighty-four percent of the people employed were Private wage and salary workers; 12 percent were Federal, state, or local government workers; and 4 percent were Self-employed in own not incorporated business workers– a category where fishermen might be found.

TRAVEL TO WORK: Forty-six percent of Suffolk County workers drove to work alone in 2005, 8 percent carpooled, 30 percent took public transportation, and 13 percent used other means. The remaining 3 percent worked at home. Among those who commuted to work, it took them on average 30.1 minutes to get to work.

INCOME: The median income of households in Suffolk County was $43,180. Seventy-eight percent of the households received earnings and 11 percent received retirement income other than Social Security. Twenty-one percent of the households received Social Security. The average income from Social Security was $11,210. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 21 percent of people were in poverty. Thirty percent of related children under 18 were below the poverty level, compared with 20 percent of people 65 years old and over. Sixteen percent of all families and 32 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Suffolk County had a total of 294,000 housing units, 8 percent of which were vacant. Of the total housing units, 19 percent were in single-unit structures, 81 percent were in multi-unit structures, and less than 0.5 percent was mobile homes. Five percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Suffolk County had 271,000 occupied housing units - 101,000 (37 percent) owner occupied and 170,000 (63 percent) renter occupied. Six percent of the households did not have telephone service and 33 percent of the households did not have access to a car, truck, or van for private use. Nineteen percent had two vehicles and another 5 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,963, non-mortgaged owners $617, and renters $1,059. Forty-five percent of owners with mortgages, 27 percent of owners without mortgages, and 51 percent of renters in Suffolk County spent 30 percent or more of household income on housing.

4.0 Maryland

4.1 *Worcester (2005 data not available)*

POPULATION OF Worcester County: In 2000, Worcester County had a household population of 45,862 – 23,848 (51.2 percent) females and 22,695 (48.8 percent) males. The median age was 43.0 years. Twenty and a half percent of the population were under 18 years and 20.1 percent were 65 years and older.

For people reporting one race alone, 81.2 percent were White; 16.7 percent were Black or African American; 0.2 percent was American Indian and Alaska Native; 0.6 percent were Asian; less than 0.0 percent was Native Hawaiian and Other Pacific Islander, and 0.4 percent were some other race. One percent reported two or more races. One and a third percent of the people in Worcester County were Hispanic. Eighty and 4/10 percent of the people in Worcester County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 105,000 households in Worcester County. The average household size was 2.3 people.

Families made up 67.4 percent of the households in Worcester County. This figure includes both married-couple families (53.2 percent) and other families (10.8 percent). Non-family households made up 32.6 percent of all households in Worcester County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Three percent of the people living in Worcester County in 2000 were foreign born. Ninety-eight percent were native, including 58.7 percent who were born in Maryland.

Among people at least five years old living in Worcester County in 2000, 5.1 percent spoke a language other than English at home. Of those speaking a language other than English at home, 2 percent spoke Spanish and 2.7 percent spoke some other language; 1.9 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 55.3 percent of the people at least five years old living in Worcester County were living in the same residence five years earlier; 19.2 percent had moved during the past five years from another residence in the same county, 13.8 percent from another county in the same state, 10.8 percent from another state, and 0.9 percent from abroad.

EDUCATION: In 2000, 81.7 percent of people 25 years and over had at least graduated from high school and 21.7 percent had a bachelor's degree or higher.

The total school enrollment in Worcester County was 9,832 in 2000. Nursery school and kindergarten enrollment was 1,169 and elementary or high school enrollment was 6,982 children. College or graduate school enrollment was 1,681.

DISABILITY: In Worcester County, among people at least five years old in 2000, 20.7 percent reported a disability. The likelihood of having a disability varied by age - from 8.9 percent of people 5 to 20 years old, to 19.3 percent of people 21 to 64 years old, and to 37.2 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in Worcester County were; Arts, entertainment, recreation, accommodation and food services, 17.7 percent, Educational services, health care and social assistance, 17.2 percent, and Retail trade, 13.4 percent. Agriculture, forestry, fishing and hunting, and mining constituted 2.2 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 29.3 percent; Sales and office occupations, 27.8 percent; Service occupations, 21.2 percent; Construction, extraction, maintenance and repair occupations, 11.6 percent; and Production, transportation, and material moving occupations, 9.2 percent. Farming, fishing, and forestry occupations constituted 0.9 percent. Seventy five percent of the people employed were Private wage and salary workers; 16.2 percent were Federal, state, or local government workers; and 8.9 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Eighty percent of Worcester County workers drove to work alone in 2000, 10.3 percent carpooled, 1.5 percent took public transportation, and 3.8 percent used other means. The remaining 4.9 percent worked at home. Among those who commuted to work, it took them on average 23.3 minutes to get to work.

INCOME: The median income of households in Worcester County was $40,650. Seventy-six percent of the households received earnings and 25.7 percent received retirement income other than Social Security. Thirty-five percent of the households received Social Security. The average income from Social Security was $11,962. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2000, 9.6 percent of people were in poverty. Seventeen percent of related children under 18 were below the poverty level, compared with 6.4 percent of people 65 years old and over. Seven percent of all families and 26.1 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2000, Worcester County had a total of 47,360 housing units, 52 percent of which were vacant. Of the total housing units, 43.3 percent were in single-unit structures, 47.4 percent were in multi-unit structures, and 9 percent were mobile homes. Twenty percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, Worcester County had 19,694 occupied housing units – 14,769 (75 percent) owner occupied and 4,925 (25 percent) renter occupied. Two percent of the households did not have telephone service and 7.8 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-one percent had two vehicles and another 16.6 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $942, non-mortgaged owners $299, and renters $574. Twenty-two percent of owners and 32.5 percent of renters in Worcester County spent 30 percent or more of household income on housing.

5.0 Maine

5.1 Cumberland

POPULATION OF Cumberland County: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSEHOLDS AND FAMILIES: In 2005 there were 114,000 households in Cumberland County. The average household size was 2.3 people.

Families made up 61 percent of the households in Cumberland County. This figure includes both married-couple families (46 percent) and other families (15 percent). Non-family households made up 39 percent of all households in Cumberland County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 85 percent of the people at least one year old living in Cumberland County were living in the same residence one year earlier; 10 percent had moved during the past year from another residence in the same county, 2 percent from another county in the same state, 3 percent from another state, and less than 0.5 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

DISABILITY: In Cumberland County, among people at least five years old in 2005, 15 percent reported a disability. The likelihood of having a disability varied by age - from 7 percent of people 5 to 20 years old, to 12 percent of people 21 to 64 years old, and to 37 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 40 percent; Sales and office occupations, 28 percent; Service occupations, 15 percent; Production, transportation, and material moving occupations, 9 percent; and Construction, extraction, maintenance and repair occupations, 8 percent. Farming, fishing, and forestry occupations constitute 0.2 percent. Seventy-nine percent of the people employed were Private wage and salary workers; 12 percent were Federal, state, or local government workers; and 9 percent were Self-employed in own not incorporated business workers– a category where fishermen might be found.

TRAVEL TO WORK: Seventy-eight percent of Cumberland County workers drove to work alone in 2005, 8 percent carpooled, 2 percent took public transportation, and 6 percent used other means. The remaining 6 percent worked at home. Among those who commuted to work, it took them on average 21.2 minutes to get to work.

INCOME: The median income of households in Cumberland County was $50,057. Eighty-two percent of the households received earnings and 16 percent received retirement income other than Social Security. Twenty-six percent of the households received Social Security. The average income from Social Security was $13,532. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 11 percent of people were in poverty. Thirteen percent of related children under 18 were below the poverty level, compared with 9 percent of people 65 years old and over. Eight percent of all families and 27 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Cumberland County had a total of 130,000 housing units, 12 percent of which were vacant. Of the total housing units, 69 percent were in single-unit structures, 27 percent were in multi-unit structures, and 4 percent were mobile homes. Eighteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Cumberland County had 114,000 occupied housing units - 77,000 (68 percent) owner occupied and 37,000 (32 percent) renter occupied. Four percent of the households did not have telephone service and 8 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Thirty-nine percent had two vehicles and another 19 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,405, non-mortgaged owners $480, and renters $788. Thirty-three percent of owners with mortgages, 19 percent of owners without mortgages, and 49 percent of renters in Cumberland County spent 30 percent or more of household income on housing.

5.2 Hancock County (2005 data not available)

POPULATION OF Hancock County: In 2000, Hancock County had a household population of 51,971 – 26,467 (51.1 percent) females and 25,324 (48.9 percent) males. The median age was 40.7 years. Twenty two percent of the population were under 18 years and 16 percent were 65 years and older.

For people reporting one race alone, 97.6 percent were White; 0.3 percent were Black or African American; 0.4 percent was American Indian and Alaska Native; 0.4 percent were Asian; less than 0.0 percent was Native Hawaiian and Other Pacific Islander, and 0.2 percent were some other race. One percent reported two or more races. Six-tenths of a percent of the people in Hancock County were Hispanic. Ninety-seven percent of the people in Hancock County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 21,864 households in Hancock County. The average household size was 2.3 people.

Families made up 65.1 percent of the households in Hancock County. This figure includes both married-couple families (53.5 percent) and other families (8.1 percent). Non-family households made up 34.9 percent of all households in Hancock County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Two percent of the people living in Hancock County in 2000 were foreign born. Ninety-eight percent were native, including 62.5 percent who were born in Maine.

Among people at least five years old living in Hancock County in 2000, 3.6 percent spoke a language other than English at home. Of those speaking a language other than English at home, 1 percent spoke Spanish and 2.55 percent spoke some other language; 0.9 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 61.7 percent of the people at least five years old living in Hancock County were living in the same residence five years earlier; 19.6 percent had moved during the past five years from another residence in the same county, 7.3 percent from another county in the same state, 10.3 percent from another state, and 1.1 percent from abroad.

EDUCATION: In 2000, 87.7 percent of people 25 years and over had at least graduated from high school and 27.2 percent had a bachelor's degree or higher.

The total school enrollment in Hancock County was 12,336 in 2000. Nursery school and kindergarten enrollment was 1,076 and elementary or high school enrollment was 8,701 children. College or graduate school enrollment was 2,559.

DISABILITY: In Hancock County, among people at least five years old in 2000, 19.2 percent reported a disability. The likelihood of having a disability varied by age - from 8.9 percent of people 5 to 20 years old, to 17.9 percent of people 21 to 64 years old, and to 37.9 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in Hancock County were; Educational services, health care and social assistance, 22.1 percent, Retail trade, 12.2 percent, Manufacturing, 95. percent and Arts, entertainment, recreation, accommodation and food services, 9 percent. Agriculture, forestry, fishing and hunting, and mining constituted 5.3 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 30.7 percent; Sales and office occupations, 23.1 percent; Service occupations, 17.1 percent; Construction, extraction, maintenance and repair occupations, 13.2 percent; and Production, transportation, and material moving occupations, 11.9 percent. Farming, fishing, and forestry occupations constituted 4.1 percent. Seventy percent of the people employed were Private wage and salary workers; 14 percent were Federal, state, or local government workers; and 15.9 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Seventy-five percent of Hancock County workers drove to work alone in 2000, 10.3 percent carpooled, 11.2 percent took public transportation, and 7.5 percent used other means. The remaining 6.3 percent worked at home. Among those who commuted to work, it took them on average 22.4 minutes to get to work.

INCOME: The median income of households in Hancock County was $35,811. Seventy-nine percent of the households received earnings and 18.3 percent received retirement income other than Social Security. Thirty percent of the households received Social Security. The average income from Social Security was $10,497. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2000, 10.2 percent of people were in poverty. Further data on poverty cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2000, Hancock County had a total of 33,945 housing units, 64.4 percent of which were vacant. Of the total housing units, 81.7 percent were in single-unit structures, 8.7 percent were in multi-unit structures, and 9.2 percent were mobile homes. Nineteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, Hancock County had 21,864 occupied housing units – 16,550 (75.7 percent) owner occupied and 5,314 (24.3 percent) renter occupied. Two percent of the households did not have telephone service and 6.1percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-three percent had two vehicles and another 17 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $901, non-mortgaged owners $288, and renters $514. Twenty-two percent of owners and 33.7 percent of renters in Hancock County spent 30 percent or more of household income on housing.

5.3 Knox County (2005 data not available)

POPULATION OF Knox County: In 2000, Knox County had a household population of 39,618 – 20,291 (51.2 percent) females and 19,327 (48.8 percent) males. The median age was 41.4 years. Twenty –two percent of the population were under 18 years and 17 percent were 65 years and older.

For people reporting one race alone, 98.3 percent were White; 0.2 percent were Black or African American; 0.2 percent was American Indian and Alaska Native; 0.4 percent were Asian; less than 0.0 percent was Native Hawaiian and Other Pacific Islander, and 0.1 percent were some other race. One percent reported two or more races. Six-tenths of a percent of the people in Knox County were Hispanic. Ninety-eight percent of the people in Knox County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 16,608 households in Knox County. The average household size was 2.3 people.

Families made up 64.6 percent of the households in Knox County. This figure includes both married-couple families (52.2 percent) and other families (9.0 percent). Non-family households made up 35.5 percent of all households in Knox County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Two percent of the people living in Knox County in 2000 were foreign born. Ninety-eight percent were native, including 64.3 percent who were born in Maine.

Among people at least five years old living in Knox County in 2000, 3.4 percent spoke a language other than English at home. Of those speaking a language other than English at home, 0.7 percent spoke Spanish and 2.7 percent spoke some other language; 0.6 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 59.5 percent of the people at least five years old living in Knox County were living in the same residence five years earlier; 23.3 percent had moved during the past five years from another residence in the same county, 7.3 percent from another county in the same state, 9.2 percent from another state, and 0.7 percent from abroad.

EDUCATION: In 2000, 87.5 percent of people 25 years and over had at least graduated from high school and 26.3 percent had a bachelor's degree or higher.

The total school enrollment in Knox County was 8,546 in 2000. Nursery school and kindergarten enrollment was 1,059 and elementary or high school enrollment was 6,341 children. College or graduate school enrollment was 1,146.

DISABILITY: In Knox County, among people at least five years old in 2000, 17.6 percent reported a disability. The likelihood of having a disability varied by age - from 8 percent of people 5 to 20 years old, to 15.1 percent of people 21 to 64 years old, and to 36.5 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in Knox County were Educational services, health care and social assistance, 20.4 percent, Retail trade, 13.6 percent and Manufacturing, 10.5 percent. Agriculture, forestry, fishing and hunting, and mining constituted 6.0 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 29.7 percent; Sales and office occupations, 25.3 percent; Service occupations, 15.4 percent and Production, transportation, and material moving occupations, 13.4 percent. Farming, fishing, and forestry occupations constituted 5.0 percent. Seventy percent of the people employed were Private wage and salary workers; 13 percent were Federal, state, or local government workers; and 17 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Seventy-five percent of Knox County workers drove to work alone in 2000, 10.3 percent carpooled, 11.1 percent took public transportation, and 6.8 percent used other means. The remaining 7.1 percent worked at home. Among those who commuted to work, it took them on average 18.9 minutes to get to work.

INCOME: The median income of households in Knox County was $36,774. Seventy-eight percent of the households received earnings and 17.5 percent received retirement income other than Social Security. Thirty percent of the households received Social Security. The average income from Social Security was $10,950. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2000, Knox County had a total of 21,612 housing units, 23 percent of which were vacant. Of the total housing units, 77.8 percent were in single-unit structures, 14 percent were in multi-unit structures, and 7.9 percent were mobile homes. Fifteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, Knox County had 16,608 occupied housing units – 12,287 (74 percent) owner occupied and 4,321 (26 percent) renter occupied. Two percent of the households did not have telephone service and 6.6 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-four percent had two vehicles and another 13.8 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $878, non-mortgaged owners $328, and renters $517. Twenty-two percent of owners and 34.6 percent of renters in Knox County spent 30 percent or more of household income on housing.

5.4 Lincoln County (2005 data not available)

POPULATION OF Lincoln County: In 2000, Lincoln County had a household population of 33,616 – 17,227 (51.2 percent) females and 16,389 (48.8 percent) males. The median age was 42.6 years. Twenty–three percent of the population were under 18 years and 18 percent were 65 years and older.

For people reporting one race alone, 98.5 percent were White; 0.2 percent were Black or African American; 0.3 percent was American Indian and Alaska Native; 0.4 percent were Asian; less than 0.0 percent was Native Hawaiian and Other Pacific Islander, and 0.1 percent were some other race. One percent reported two or more races. Five-tenths of a percent of the people in Lincoln County were Hispanic. Ninety-eight percent of the people in Lincoln County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 14,158 households in Lincoln County. The average household size was 2.4 people.

Families made up 67.4 percent of the households in Lincoln County. This figure includes both married-couple families (56.1 percent) and other families (7.7 percent). Non-family households made up 32.6 percent of all households in Lincoln County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Two percent of the people living in Lincoln County in 2000 were foreign born. Ninety-eight percent were native, including 61.7 percent who were born in Maine.

Among people at least five years old living in Lincoln County in 2000, 2.8 percent spoke a language other than English at home. Of those speaking a language other than English at home, 0.6 percent spoke Spanish and 2.2 percent spoke some other language; 0.6 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 64.9 percent of the people at least five years old living in Lincoln County were living in the same residence five years earlier; 16.4 percent had moved during the past five years from another residence in the same county, 8.7 percent from another county in the same state, 9.5 percent from another state, and 0.5 percent from abroad.

EDUCATION: In 2000, 87.9 percent of people 25 years and over had at least graduated from high school and 26.7 percent had a bachelor's degree or higher.

The total school enrollment in Lincoln County was 7,510 in 2000. Nursery school and kindergarten enrollment was 813 and elementary or high school enrollment was 5,721 children. College or graduate school enrollment was 976.

DISABILITY: In Lincoln County, among people at least five years old in 2000, 19.8 percent reported a disability. The likelihood of having a disability varied by age - from 9.2 percent of people 5 to 20 years old, to 17.1 percent of people 21 to 64 years old, and to 40.6 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in Lincoln County were Educational services, health care and social assistance, 22.3 percent, Manufacturing, 12.7 percent and Retail trade, 12.4 percent. Agriculture, forestry, fishing and hunting, and mining constituted 6.4 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 31.7 percent; Sales and office occupations, 21.7 percent; Service occupations, 15.4 percent, Production, transportation, and material moving occupations, 13.2 percent and Construction, extraction, and maintenance occupations, 12.8 percent. Farming, fishing, and forestry occupations constituted 5.1 percent. Sixty-six percent of the people employed were Private wage and salary workers; 16 percent were Federal, state, or local government workers; and 17.7 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Seventy-seven percent of Lincoln County workers drove to work alone in 2000, 12.3 percent carpooled, 0.2 percent took public transportation, and 4.8 percent used other means. The remaining 6.2 percent worked at home. Among those who commuted to work, it took them on average 23.4 minutes to get to work.

INCOME: The median income of households in Lincoln County was $38,686. Seventy-seven percent of the households received earnings and 20.9 percent received retirement income other than Social Security. Thirty-three percent of the households received Social Security. The average income from Social Security was $11,226. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2000, Lincoln County had a total of 20,849 housing units, 32 percent of which were vacant. Of the total housing units, 82.1 percent were in single-unit structures, 6.9 percent were in multi-unit structures, and 10.8 percent were mobile homes. Seventeen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, Lincoln County had 14,158 occupied housing units – 11,755 (83 percent) owner occupied and 2,403 (17 percent) renter occupied. One percent of the households did not have telephone service and 5.8 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-three percent had two vehicles and another 19.5 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $880, non-mortgaged owners $295, and renters $541. Twenty-two percent of owners and 34 percent of renters in Lincoln County spent 30 percent or more of household income on housing.

5.5 Washington County (2005 data not available)

POPULATION OF Washington County: In 2000, Washington County had a household population of 33,941 – 17,365 (51.2 percent) females and 16,576 (48.8 percent) males. The median age was 40.5 years. Twenty –three percent of the population were under 18 years and 17.3 percent were 65 years and older.

For people reporting one race alone, 93.5 percent were White; 0.3 percent were Black or African American; 4.4 percent was American Indian and Alaska Native; 0.3 percent were Asian; less than 0.0 percent was Native Hawaiian and Other Pacific Islander, and 0.4 percent were some other race. One percent reported two or more races. Eight-tenths of a percent of the people in Washington County were Hispanic. Ninety-three percent of the people in Washington County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 14,118 households in Washington County. The average household size was 2.3 people.

Families made up 65.9 percent of the households in Washington County. This figure includes both married-couple families (52.1 percent) and other families (9.5 percent). Non-family households made up 34.1 percent of all households in Washington County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Four percent of the people living in Washington County in 2000 were foreign born. Ninety-five percent were native, including 70.7 percent who were born in Maine.

Among people at least five years old living in Washington County in 2000, 5.4 percent spoke a language other than English at home. Of those speaking a language other than English at home, 1 percent spoke Spanish and 2.2 percent spoke some other language; 1.1 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 66.7 percent of the people at least five years old living in Washington County were living in the same residence five years earlier; 19.2 percent had moved during the past five years from another residence in the same county, 5.1 percent from another county in the same state, 7.9 percent from another state, and 1 percent from abroad.

EDUCATION: In 2000, 79.9 percent of people 25 years and over had at least graduated from high school and 15.7 percent had a bachelor's degree or higher.

The total school enrollment in Washington County was 8,044 in 2000. Nursery school and kindergarten enrollment was 803 and elementary or high school enrollment was 5,698 children. College or graduate school enrollment was 1,543.

DISABILITY: In Washington County, among people at least five years old in 2000, 19.8 percent reported a disability. The likelihood of having a disability varied by age - from 9.8 percent of people 5 to 20 years old, to 27.9 percent of people 21 to 64 years old, and to 46.4 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in Washington County were Educational services, health care and social assistance, 26.3 percent, Manufacturing, 14 percent, Agriculture, forestry, fishing and hunting, and mining, 10.9 percent and Retail trade, 10.8 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 25.4 percent; Sales and office occupations, 20.6 percent; Service occupations, 17.8 percent and Production, transportation, and material moving occupations, 17.1 percent. Farming, fishing, and forestry occupations constituted 8.2 percent. Sixty-six percent of the people employed were Private wage and salary workers; 17.5 percent were Federal, state, or local government workers; and 13.4 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Seventy-six percent of Washington County workers drove to work alone in 2000, 12.1 percent carpooled, 0.5 percent took public transportation, and 6.5 percent used other means. The remaining 5 percent worked at home. Among those who commuted to work, it took them on average 19.2 minutes to get to work.

INCOME: The median income of households in Washington County was $25,869. Seventy-two percent of the households received earnings and 16.9 percent received retirement income other than Social Security. Thirty-four percent of the households received Social Security. The average income from Social Security was $9,281. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2000, Washington County had a total of 21,919 housing units, 35.6 percent of which were vacant. Of the total housing units, 78 percent were in single-unit structures, 9.2 percent were in multi-unit structures, and 12.7 percent were mobile homes. Fourteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, Washington County had 14,118 occupied housing units – 10,969 (77.7 percent) owner occupied and 3,149 (22.3 percent) renter occupied. Two percent of the households did not have telephone service and 8.5 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty percent had two vehicles and another 16 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $648, non-mortgaged owners $238, and renters $408. Twenty-one percent of owners and 30.7 percent of renters in Washington County spent 30 percent or more of household income on housing.

6.0 North Carolina

6.1 Dare County (2005 data not available)

POPULATION OF Dare County: In 2000, Dare County had a household population of 29,967 – 14,869 (49.6 percent) females and 15,098 (50.4 percent) males. The median age was 40.4 years. Twenty –one percent of the population were under 18 years and 13.8 percent were 65 years and older.

For people reporting one race alone, 94.7 percent were White; 2.7 percent were Black or African American; 0.3 percent was American Indian and Alaska Native; 0.4 percent were Asian; less than 0.0 percent was Native Hawaiian and Other Pacific Islander, and 0.9 percent were some other race. One percent reported two or more races. Two percent of the people in Dare County were Hispanic. Ninety-four percent of the people in Dare County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 12,690 households in Dare County. The average household size was 2.3 people.

Families made up 66.6 percent of the households in Dare County. This figure includes both married-couple families (55 percent) and other families (8.1 percent). Non-family households made up 33.4 percent of all households in Dare County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Two and five-tenths of a percent of the people living in Dare County in 2000 were foreign born. Ninety-eight percent were native, including 34.7 percent who were born in North Carolina.

Among people at least five years old living in Dare County in 2000, 4.1 percent spoke a language other than English at home. Of those speaking a language other than English at home, 2.3 percent spoke Spanish and 1.7 percent spoke some other language; 1.5 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 49.8 percent of the people at least five years old living in Dare County were living in the same residence five years earlier; 21.7 percent had moved during the past five years from another residence in the same county, 6.9 percent from another county in the same state, 20.1 percent from another state, and 1.5 percent from abroad.

EDUCATION: In 2000, 88.5 percent of people 25 years and over had at least graduated from high school and 27.6 percent had a bachelor's degree or higher.

The total school enrollment in Dare County was 6,006 in 2000. Nursery school and kindergarten enrollment was 648 and elementary or high school enrollment was 4,676 children. College or graduate school enrollment was 682.

DISABILITY: In Dare County, among people at least five years old in 2000, 15.4 percent reported a disability. The likelihood of having a disability varied by age - from 6.5 percent of people 5 to 20 years old, to 14.2 percent of people 21 to 64 years old, and to 33.2 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in Dare County were Retail trade, 14.6 percent, Arts, entertainment, recreation, accommodation and food services, 14.2 percent and Construction, 13.7 percent. Agriculture, forestry, fishing and hunting, and mining constituted 3.4 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 29.8 percent; Sales and office occupations, 25.9 percent; Service occupations, 17 percent and Construction, extraction, and maintenance occupations, 16.3 percent. Farming, fishing, and forestry occupations constituted 3.5 percent. Sixty-eight percent of the people employed were Private wage and salary workers; 16.9 percent were Federal, state, or local government workers; and 15.1 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Seventy-seven percent of Dare County workers drove to work alone in 2000, 14.2 percent carpooled, 0.1 percent took public transportation, and 4.1 percent used other means. The remaining 4.7 percent worked at home. Among those who commuted to work, it took them on average 19.9 minutes to get to work.

INCOME: The median income of households in Dare County was $42,411. Eighty-two percent of the households received earnings and 22.6 percent received retirement income other than Social Security. Twenty-seven percent of the households received Social Security. The average income from Social Security was $11,500. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2000, Dare County had a total of 26,671 housing units, 52.4 percent of which were vacant. Of the total housing units, 82.8 percent were in single-unit structures, 8.9 percent were in multi-unit structures, and 8.1 percent were mobile homes. Thirty-four percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, Dare County had 12,690 occupied housing units - 9,460 (74.5 percent) owner occupied and 3,230 (25.5 percent) renter occupied. Two percent of the households did not have telephone service and 3.3 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-six percent had two vehicles and another 16.6 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,012, non-mortgaged owners $310, and renters $638. Twenty-nine percent of owners and 30.3 percent of renters in Dare County spent 30 percent or more of household income on housing.

7.0 New Hampshire

7.1 Rockingham County

POPULATION OF Rockingham County: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSEHOLDS AND FAMILIES: In 2005 there were 113,000 households in Rockingham County. The average household size was 2.6 people.

Families made up 71 percent of the households in Rockingham County. This figure includes both married-couple families (56 percent) and other families (14 percent). Non-family households made up 29 percent of all households in Rockingham County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 88 percent of the people at least one year old living in Rockingham County were living in the same residence one year earlier; 5 percent had moved during the past year from another residence in the same county, 2 percent from another county in the same state, 4 percent from another state, and less than 0.5 percent from abroad.

EDUCATION: In 2005, 92 percent of people 25 years and over had at least graduated from high school and 36 percent had a bachelor's degree or higher. Among people 16 to 19 years old, 6 percent were dropouts; they were not enrolled in school and had not graduated from high school.

The total school enrollment in Rockingham County was 75,000 in 2005. Nursery school and kindergarten enrollment was 7,700 and elementary or high school enrollment was 53,000 children. College or graduate school enrollment was 14,000.

DISABILITY: In Rockingham County, among people at least five years old in 2005, 13 percent reported a disability. The likelihood of having a disability varied by age - from 7 percent of people 5 to 20 years old, to 10 percent of people 21 to 64 years old, and to 39 percent of those 65 and older.

INDUSTRIES: In 2005, for the employed population 16 years and older, the leading industries in Rockingham County were Educational services, health care and social assistance, 18 percent, and Manufacturing, 14 percent. Agriculture, forestry, fishing and hunting, and mining constitute 1 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 38 percent; Sales and office occupations, 27 percent; Service occupations, 13 percent; Production, transportation, and material moving occupations, 12 percent; and Construction, extraction, maintenance and repair occupations, 10 percent. Farming, fishing, and forestry occupations constitute 0.4 percent. Seventy-nine percent of the people employed were Private wage and salary workers; 12 percent were Federal, state, or local government workers; and 9 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Rockingham County was $66,190. Eighty-six percent of the households received earnings and 17 percent received retirement income other than Social Security. Twenty-four percent of the households received Social Security. The average income from Social Security was $14,296. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 5 percent of people were in poverty. Six percent of related children under 18 were below the poverty level, compared with 6 percent of people 65 years old and over. Three percent of all families and 15 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Rockingham County had a total of 121,000 housing units, 7 percent of which were vacant. Of the total housing units, 73 percent were in single-unit structures, 21 percent were in multi-unit structures, and 6 percent were mobile homes. Twenty-two percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Rockingham County had 113,000 occupied housing units - 87,000 (78 percent) owner occupied and 25,000 (22 percent) renter occupied. Four percent of the households did not have telephone service and 3 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-four percent had two vehicles and another 27 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,800, non-mortgaged owners $645, and renters $961. Thirty-nine percent of owners with mortgages, 26 percent of owners without mortgages, and 51 percent of renters in Rockingham County spent 30 percent or more of household income on housing.

8.0 New Jersey

8.1 Atlantic County

POPULATION OF Atlantic County: In 2005, Atlantic County had a household population of 264,000 - 137,000 (52 percent) females and 128,000 (48 percent) males. The median age was 38.2 years. Twenty-five percent of the population were under 18 years and 13 percent were 65 years and older.

For people reporting one race alone, 68 percent were White; 16 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 6 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 9 percent were some other race. Two percent reported two or more races. Fourteen percent of the people in Atlantic County were Hispanic. Sixty-two percent of the people in Atlantic County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 102,000 households in Atlantic County. The average household size was 2.6 people.

Families made up 66 percent of the households in Atlantic County. This figure includes both married-couple families (47 percent) and other families (19 percent). Non-family households made up 34 percent of all households in Atlantic County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 87 percent of the people at least one year old living in Atlantic County were living in the same residence one year earlier; 9 percent had moved during the past year from another residence in the same county, 2 percent from another county in the same state, 2 percent from another state, and 1 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

DISABILITY: In Atlantic County, among people at least five years old in 2005, 14 percent reported a disability. The likelihood of having a disability varied by age - from 5 percent of people 5 to 20 years old, to 12 percent of people 21 to 64 years old, and to 36 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Service occupations, 30 percent; Management, professional and related occupations, 27 percent; Sales and office occupations, 25 percent; Construction, extraction, maintenance and repair occupations, 9 percent; and Production, transportation, and material moving occupations, 8 percent. Farming, fishing, and forestry occupations constitute 0.7 percent. Eighty percent of the people employed were Private wage and salary workers; 15 percent were Federal, state, or local government workers; and 5 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Atlantic County was $50,377. Eighty-two percent of the households received earnings and 17 percent received retirement income other than Social Security. Twenty-nine percent of the households received Social Security. The average income from Social Security was $12,820. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 9 percent of people were in poverty. Ten percent of related children under 18 were below the poverty level, compared with 10 percent of people 65 years old and over. Six percent of all families and 17 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Atlantic County had a total of 123,000 housing units, 17 percent of which were vacant. Of the total housing units, 65 percent were in single-unit structures, 33 percent were in multi-unit structures, and 2 percent were mobile homes. Nineteen percent of the housing units were built since 1990.

CCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Atlantic County had 102,000 occupied housing units - 69,000 (68 percent) owner occupied and 33,000 (32 percent) renter occupied. Three percent of the households did not have telephone service and 14 percent of the households did not have access to a car, truck, or van for private use.

Multi Vehicle households were not rare. Thirty-six percent had two vehicles and another 16 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,496, non-mortgaged owners $631, and renters $835. Forty-one percent of owners with mortgages, 30 percent of owners without mortgages, and 46 percent of renters in Atlantic County spent 30 percent or more of household income on housing.

8.2 Cape May County

POPULATION OF Cape May County: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSEHOLDS AND FAMILIES: In 2005 there were 44,000 households in Cape May County. The average household size was 2.2 people.

Families made up 68 percent of the households in Cape May County. This figure includes both married-couple families (53 percent) and other families (15 percent). Non-family households made up 32 percent of all households in Cape May County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 91 percent of the people at least one year old living in Cape May County were living in the same residence one year earlier; 5 percent had moved during the past year from another residence in the same county, 2 percent from another county in the same state, 2 percent from another state, and less than 0.5 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

DISABILITY: In Cape May County, among people at least five years old in 2005, 14 percent reported a disability. The likelihood of having a disability varied by age - from 5 percent of people 5 to 20 years old, to 10 percent of people 21 to 64 years old, and to 31 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Cape May County was $51,744. Seventy-four percent of the households received earnings and 25 percent received retirement income other than Social Security. Thirty-eight percent of the households received Social Security. The average income from Social Security was $14,248. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2005, Cape May County had a total of 98,000 housing units, 56 percent of which were vacant. Of the total housing units, 66 percent were in single-unit structures, 31 percent were in multi-unit structures, and 3 percent were mobile homes. Twenty-two percent of the housing units were built since 1990.

8.3 Ocean County

POPULATION OF Ocean County: In 2005, Ocean County had a household population of 550,000 - 288,000 (52 percent) females and 263,000 (48 percent) males. The median age was 40.4 years. Twenty-four percent of the population were under 18 years and 20 percent were 65 years and older.

For people reporting one race alone, 93 percent were White; 3 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 2 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 2 percent were some other race. One percent reported two or more races. Six percent of the people in Ocean County were Hispanic. Eighty-eight percent of the people in Ocean County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 221,000 households in Ocean County. The average household size was 2.5 people.

Families made up 67 percent of the households in Ocean County. This figure includes both married-couple families (55 percent) and other families (12 percent). Non-family households made up 33 percent of all households in Ocean County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Eight percent of the people living in Ocean County in 2005 were foreign born. Ninety-two percent were native, including 64 percent who were born in New Jersey.

Among people at least five years old living in Ocean County in 2005, 11 percent spoke a language other than English at home. Of those speaking a language other than English at home, 45 percent spoke Spanish and 55 percent spoke some other language; 41 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2005, 89 percent of the people at least one year old living in Ocean County were living in the same residence one year earlier; 5 percent had moved during the past year from another residence in the same county, 3 percent from another county in the same state, 2 percent from another state, and less than 0.5 percent from abroad.

EDUCATION: In 2005, 87 percent of people 25 years and over had at least graduated from high school and 23 percent had a bachelor's degree or higher. Among people 16 to 19 years old, 5 percent were dropouts; they were not enrolled in school and had not graduated from high school.

The total school enrollment in Ocean County was 131,000 in 2005. Nursery school and kindergarten enrollment was 16,000 and elementary or high school enrollment was 86,000 children. College or graduate school enrollment was 28,000.

DISABILITY: In Ocean County, among people at least five years old in 2005, 16 percent reported a disability. The likelihood of having a disability varied by age - from 5 percent of people 5 to 20 years old, to 13 percent of people 21 to 64 years old, and to 37 percent of those 65 and older.

INDUSTRIES: In 2005, for the employed population 16 years and older, the leading industries in Ocean County were Educational services, health care and social assistance, 22 percent, and Retail Trade, 16 percent. Agriculture, forestry, fishing and hunting, and mining constitute less than 1 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 30 percent; Sales and office occupations, 30 percent; Service occupations, 17 percent; Construction, extraction, maintenance and repair occupations, 12 percent; and Production, transportation, and material moving occupations, 11 percent. Farming, fishing, and forestry occupations constitute 0.2 percent. Seventy-eight percent of the people employed were Private wage and salary workers; 16 percent were Federal, state, or local government workers; and 6 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Eighty-one percent of Ocean County workers drove to work alone in 2005, 11 percent carpooled, 2 percent took public transportation, and 3 percent used other means. The remaining 3 percent worked at home. Among those who commuted to work, it took them on average 31.8 minutes to get to work.

INCOME: The median income of households in Ocean County was $52,065. Sixty-eight percent of the households received earnings and 29 percent received retirement income other than Social Security. Forty-two percent of the households received Social Security. The average income from Social Security was $15,071. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 7 percent of people were in poverty. Eleven percent of related children under 18 were below the poverty level, compared with 5 percent of people 65 years old and over. Six percent of all families and 19 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Ocean County had a total of 269,000 housing units, 18 percent of which were vacant. Of the total housing units, 84 percent were in single-unit structures, 14 percent were in multi-unit structures, and 2 percent were mobile homes. Twenty-three percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Ocean County had 221,000 occupied housing units - 182,000 (82 percent) owner occupied and 39,000 (18 percent) renter occupied. Three percent of the households did not have telephone service and 6 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Thirty-six percent had two vehicles and another 18 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,666, non-mortgaged owners $564, and renters $1,077. Forty-five percent of owners with mortgages, 29 percent of owners without mortgages, and 55 percent of renters in Ocean County spent 30 percent or more of household income on housing.

9.0 New York

9.1 Suffolk County

POPULATION OF Suffolk County: In 2005, Suffolk County had a household population of 1.4 million - 732,000 (51 percent) females and 713,000 (49 percent) males. The median age was 38 years. Twenty-six percent of the population were under 18 years and 12 percent were 65 years and older.

For people reporting one race alone, 86 percent were White; 7 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 3 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 4 percent were some other race. Two percent reported two or more races. Thirteen percent of the people in Suffolk County were Hispanic. Seventy-six percent of the people in Suffolk County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 484,000 households in Suffolk County. The average household size was 3 people.

Families made up 76 percent of the households in Suffolk County. This figure includes both married-couple families (61 percent) and other families (15 percent). Non-family households made up 24 percent of all households in Suffolk County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Thirteen percent of the people living in Suffolk County in 2005 were foreign born. Eighty-seven percent were native, including 79 percent who were born in New York.

Among people at least five years old living in Suffolk County in 2005, 18 percent spoke a language other than English at home. Of those speaking a language other than English at home, 56 percent spoke Spanish and 44 percent spoke some other language; 42 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2005, 91 percent of the people at least one year old living in Suffolk County were living in the same residence one year earlier; 6 percent had moved during the past year from another residence in the same county, 2 percent from another county in the same state, 1 percent from another state, and less than 0.5 percent from abroad.

EDUCATION: In 2005, 90 percent of people 25 years and over had at least graduated from high school and 31 percent had a bachelor's degree or higher. Among people 16 to 19 years old, 3 percent were dropouts; they were not enrolled in school and had not graduated from high school.

The total school enrollment in Suffolk County was 391,000 in 2005. Nursery school and kindergarten enrollment was 46,000 and elementary or high school enrollment was 256,000 children. College or graduate school enrollment was 89,000.

DISABILITY: In Suffolk County, among people at least five years old in 2005, 13 percent reported a disability. The likelihood of having a disability varied by age - from 6 percent of people 5 to 20 years old, to 10 percent of people 21 to 64 years old, and to 36 percent of those 65 and older.

INDUSTRIES: In 2005, for the employed population 16 years and older, the leading industries in Suffolk County were Educational services, health care and social assistance, 24 percent, and Retail Trade, 12 percent. Agriculture, forestry, fishing and hunting, and mining constitute less than 1 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 38 percent; Sales and office occupations, 28 percent; Service occupations, 15 percent; Construction, extraction, maintenance and repair occupations, 10 percent; and Production, transportation, and material moving occupations, 9 percent. Farming, fishing, and forestry occupations constitute 0.2 percent. Seventy-six percent of the people employed were Private wage and salary workers; 18 percent were Federal, state, or local government workers; and 6 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Seventy-nine percent of Suffolk County workers drove to work alone in 2005, 9 percent carpooled, 6 percent took public transportation, and 3 percent used other means. The remaining 3 percent worked at home. Among those who commuted to work, it took them on average 30.3 minutes to get to work.

INCOME: The median income of households in Suffolk County was $77,109. Eighty-three percent of the households received earnings and 22 percent received retirement income other than Social Security. Thirty percent of the households received Social Security. The average income from Social Security was $15,070. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 5 percent of people were in poverty. Five percent of related children under 18 were below the poverty level, compared with 7 percent of people 65 years old and over. Three percent of all families and 10 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Suffolk County had a total of 539,000 housing units, 10 percent of which were vacant. Of the total housing units, 86 percent were in single-unit structures, 13 percent were in multi-unit structures, and 1 percent was mobile homes. Fourteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Suffolk County had 484,000 occupied housing units - 404,000 (83 percent) owner occupied and 80,000 (17 percent) renter occupied. One percent of the households did not have telephone service and 4 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-five percent had two vehicles and another 25 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $2,211, non-mortgaged owners $859, and renters $1,287. Forty-eight percent of owners with mortgages, 28 percent of owners without mortgages, and 50 percent of renters in Suffolk County spent 30 percent or more of household income on housing.

10.0 Rhode Island

10.1 Newport County

POPULATION OF Newport County: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSEHOLDS AND FAMILIES: In 2005 there were 33,000 households in Newport County. The average household size was 2.4 people.

Families made up 64 percent of the households in Newport County. This figure includes both married-couple families (54 percent) and other families (10 percent). Non-family households made up 36 percent of all households in Newport County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 88 percent of the people at least one year old living in Newport County were living in the same residence one year earlier; 7 percent had moved during the past year from another residence in the same county, 1 percent from another county in the same state, 3 percent from another state, and 1 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.
DISABILITY: In Newport County, among people at least five years old in 2005, 14 percent reported a disability. The likelihood of having a disability varied by age - from 8 percent of people 5 to 20 years old, to 11 percent of people 21 to 64 years old, and to 34 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Newport County was $58,455. Eighty-one percent of the households received earnings and 20 percent received retirement income other than Social Security. Twenty-nine percent of the households received Social Security. The average income from Social Security was $13,102. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2005, Newport County had a total of 41,000 housing units, 17 percent of which were vacant. Of the total housing units, 64 percent were in single-unit structures, 33 percent were in multi-unit structures, and 3 percent were mobile homes. Sixteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Newport County had 33,000 occupied housing units - 22,000 (65 percent) owner occupied and 12,000 (35 percent) renter occupied. One percent of the households did not have telephone service and 7 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty percent had two vehicles and another 18 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,791, non-mortgaged owners $555, and renters $808. Thirty-six percent of owners with mortgages, 20 percent of owners without mortgages, and 36 percent of renters in Newport County spent 30 percent or more of household income on housing.

10.2 Washington County

POPULATION OF Washington County: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSEHOLDS AND FAMILIES: In 2005 there were 50,000 households in Washington County. The average household size was 2.5 people.

Families made up 65 percent of the households in Washington County. This figure includes both married-couple families (53 percent) and other families (12 percent). Non-family households made up 35 percent of all households in Washington County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 86 percent of the people at least one year old living in Washington County were living in the same residence one year earlier; 8 percent had moved during the past year from another residence in the same county, 3 percent from another county in the same state, 2 percent from another state, and 1 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

DISABILITY: In Washington County, among people at least five years old in 2005, 13 percent reported a disability. The likelihood of having a disability varied by age - from 7 percent of people 5 to 20 years old, to 10 percent of people 21 to 64 years old, and to 33 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Washington County was $62,536. Eighty-one percent of the households received earnings and 24 percent received retirement income other than Social Security. Twenty-nine percent of the households received Social Security. The average income from Social Security was $15,466. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2005, Washington County had a total of 60,000 housing units, 17 percent of which were vacant. Of the total housing units, 81 percent were in single-unit structures, 17 percent were in multi-unit structures, and 3 percent were mobile homes. Nineteen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Washington County had 50,000 occupied housing units - 36,000 (73 percent) owner occupied and 14,000 (27 percent) renter occupied. Four percent of the households did not have telephone service and 3 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-eight percent had two vehicles and another 23 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,630, non-mortgaged owners $514, and renters $830. Twenty-eight percent of owners with mortgages, 20 percent of owners without mortgages, and 45 percent of renters in Washington County spent 30 percent or more of household income on housing.

11.0 Virginia

11.1 City of Hampton County

POPULATION OF Hampton city: In 2005, Hampton city had a household population of 134,000 - 70,000 (52 percent) females and 64,000 (48 percent) males. The median age was 36 years. Twenty-six percent of the population were under 18 years and 11 percent were 65 years and older.

For people reporting one race alone, 48 percent were White; 48 percent were Black or African American; less than 0.5 percent was American Indian and Alaska Native; 2 percent were Asian; less than 0.5 percent was Native Hawaiian and Other Pacific Islander and 1 percent were some other race. Two percent reported two or more races. Three percent of the people in Hampton city were Hispanic. Forty-five percent of the people in Hampton city were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2005 there were 55,000 households in Hampton city. The average household size was 2.4 people.

Families made up 63 percent of the households in Hampton city. This figure includes both married-couple families (43 percent) and other families (20 percent). Non-family households made up 37 percent of all households in Hampton city. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 83 percent of the people at least one year old living in Hampton city were living in the same residence one year earlier; 7 percent had moved during the past year from another residence in the same county, 6 percent from another county in the same state, 3 percent from another state, and 1 percent from abroad.

EDUCATION: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

DISABILITY: In Hampton city, among people at least five years old in 2005, 16 percent reported a disability. The likelihood of having a disability varied by age - from 4 percent of people 5 to 20 years old, to 15 percent of people 21 to 64 years old, and to 41 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Hampton city was $45,105. Eighty-one percent of the households received earnings and 27 percent received retirement income other than Social Security. Twenty-six percent of the households received Social Security. The average income from Social Security was $10,879. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 13 percent of people were in poverty. Twenty-four percent of related children under 18 were below the poverty level, compared with 12 percent of people 65 years old and over. Eleven percent of all families and 33 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Hampton city had a total of 59,000 housing units, 6 percent of which were vacant. Of the total housing units, 72 percent were in single-unit structures, 26 percent were in multi-unit structures, and 2 percent were mobile homes. Seventeen percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Hampton city had 55,000 occupied housing units - 34,000 (61 percent) owner occupied and 21,000 (39 percent) renter occupied. Six percent of the households did not have telephone service and 6 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Thirty-eight percent had two vehicles and another 23 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,176, non-mortgaged owners $378, and renters $757. Thirty-two percent of owners with mortgages, 15 percent of owners without mortgages, and 39 percent of renters in Hampton city spent 30 percent or more of household income on housing.

11.2 City of Newport News County

POPULATION OF Newport News city: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSEHOLDS AND FAMILIES: In 2005 there were 73,000 households in Newport News city. The average household size was 2.4 people.

Families made up 69 percent of the households in Newport News city. This figure includes both married-couple families (48 percent) and other families (21 percent). Non-family households made up 31 percent of all households in Newport News city. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

GEOGRAPHIC MOBILITY: In 2005, 83 percent of the people at least one year old living in Newport News city were living in the same residence one year earlier; 8 percent had moved during the past year from another residence in the same county, 4 percent from another county in the same state, 4 percent from another state, and 1 percent from abroad.

EDUCATION: In 2005, 87 percent of people 25 years and over had at least graduated from high school and 21 percent had a bachelor's degree or higher. Among people 16 to 19 years old, 7 percent were dropouts; they were not enrolled in school and had not graduated from high school.

The total school enrollment in Newport News city was 50,000 in 2005. Nursery school and kindergarten enrollment was 7,200 and elementary or high school enrollment was 31,000 children. College or graduate school enrollment was 11,000.

DISABILITY: In Newport News city, among people at least five years old in 2005, 15 percent reported a disability. The likelihood of having a disability varied by age - from 7 percent of people 5 to 20 years old, to 13 percent of people 21 to 64 years old, and to 43 percent of those 65 and older.

INDUSTRIES: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

OCCUPATIONS AND TYPE OF EMPLOYER: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

TRAVEL TO WORK: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

INCOME: The median income of households in Newport News city was $46,641. Eighty-five percent of the households received earnings and 21 percent received retirement income other than Social Security. Twenty-two percent of the households received Social Security. The average income from Social Security was $12,358. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: In 2005, 14 percent of people were in poverty. Twenty-two percent of related children under 18 were below the poverty level, compared with 8 percent of people 65 years old and over. Eleven percent of all families and 35 percent of families with a female householder and no husband present had incomes below the poverty level.

HOUSING CHARACTERISTICS: In 2005, Newport News city had a total of 77,000 housing units, 5 percent of which were vacant. Of the total housing units, 64 percent were in single-unit structures, 34 percent were in multi-unit structures, and 3 percent were mobile homes. Twenty-one percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2005, Newport News city had 73,000 occupied housing units - 40,000 (54 percent) owner occupied and 34,000 (46 percent) renter occupied. Five percent of the households did not have telephone service and 10 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Thirty-eight percent had two vehicles and another 19 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,198, non-mortgaged owners $400, and renters $793. Thirty-three percent of owners with mortgages, 11 percent of owners without mortgages, and 46 percent of renters in Newport News city spent 30 percent or more of household income on housing.

11.3 Northumberland County (2005 data not available)

POPULATION OF Northumberland County: In 2000, Northumberland County had a household population of 12,259 – 6,411 (52.3 percent) females and 5,848 (47.7 percent) males. The median age was 50.1 years. Nineteen percent of the population were under 18 years and 26.2 percent were 65 years and older.

For people reporting one race alone, 72.2 percent were White; 26.6 percent were Black or African American; 0.1 percent was American Indian and Alaska Native; 0.2 percent were Asian; less than 0.0 percent was Native Hawaiian and Other Pacific Islander, and 0.3 percent were some other race. One percent reported two or more races. Six-tenths of a percent of the people in Northumberland County were Hispanic. Seventy-two percent of the people in Northumberland County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 5,470 households in Northumberland County. The average household size was 2.2 people.

Families made up 69.2 percent of the households in Northumberland County. This figure includes both married-couple families (57.3 percent) and other families (8.7 percent). Non-family households made up 30.8 percent of all households in Northumberland County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Two percent of the people living in Northumberland County in 2000 were foreign born. Ninety-eight percent were native, including 67.7 percent who were born in Virginia.

Among people at least five years old living in Northumberland County in 2000, 2.5 percent spoke a language other than English at home. Of those speaking a language other than English at home, 1 percent spoke Spanish and 1.5 percent spoke some other language; 0.8 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 64.4 percent of the people at least five years old living in Northumberland County were living in the same residence five years earlier; 12.4 percent had moved during the past five years from another residence in the same county, 14.3 percent from another county in the same state, 7.7 percent from another state, and 1 percent from abroad.

EDUCATION: In 2000, 75.9 percent of people 25 years and over had at least graduated from high school and 21.7 percent had a bachelor's degree or higher.

The total school enrollment in Northumberland County was 2,114 in 2000. Nursery school and kindergarten enrollment was 379 and elementary or high school enrollment was 1,524 children. College or graduate school enrollment was 211.

DISABILITY: In Northumberland County, among people at least five years old in 2000, 23.7 percent reported a disability. The likelihood of having a disability varied by age - from 9 percent of people 5 to 20 years old, to 20.9 percent of people 21 to 64 years old, and to 38.4 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in Northumberland County were Educational, health and social services, 20.8 percent, Retail trade, 12 percent and Manufacturing, 10.2 percent. Agriculture, forestry, fishing and hunting, and mining constituted 5.9 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 30 percent; Sales and office occupations, 23.3 percent; Service occupations, 16.4 percent, Production, transportation, and material moving occupations, 14 percent and Construction, extraction, and maintenance occupations, 12.4 percent. Farming, fishing, and forestry occupations constituted 3.8 percent. Sixty-seven percent of the people employed were Private wage and salary workers; 19.3 percent were Federal, state, or local government workers; and 12.8 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Eighty-one percent of Northumberland County workers drove to work alone in 2000, 9.8 percent carpooled, 1.3 percent took public transportation, and 3 percent used other means. The remaining 4.7 percent worked at home. Among those who commuted to work, it took them on average 28.4 minutes to get to work.

INCOME: The median income of households in Northumberland County was $38,129. Sixty-eight percent of the households received earnings and 33.6 percent received retirement income other than Social Security. Forty-five percent of the households received Social Security. The average income from Social Security was $11,590. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2000, Northumberland County had a total of 8,057 housing units, 32 percent of which were vacant. Of the total housing units, 86.8 percent were in single-unit structures, 1.2 percent were in multi-unit structures, and 11.7 percent were mobile homes. Twenty-six percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, Northumberland County had 5,470 occupied housing units – 4,783 (87.4 percent) owner occupied and 687 (12.6 percent) renter occupied. Three percent of the households did not have telephone service and 6.3 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-three percent had two vehicles and another 20.4 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $853, non-mortgaged owners $250, and renters $478. Twenty-four percent of owners and 22.1 percent of renters in Northumberland County spent 30 percent or more of household income on housing.

11.4 York County (2005 data not available)

POPULATION OF York County: In 2000, York County had a household population of 56,297 – 28,647 (50.9 percent) females and 27,650 (49.1 percent) males. The median age was 36.5 years. Twenty-nine percent of the population were under 18 years and 9.1 percent were 65 years and older.

For people reporting one race alone, 80 percent were White; 13.4 percent were Black or African American; 0.3 percent was American Indian and Alaska Native; 3.2percent were Asian; less than 0.1 percent was Native Hawaiian and Other Pacific Islander, and 0.9 percent were some other race. Two percent reported two or more races. Three percent of the people in York County were Hispanic. Seventy-nine percent of the people in York County were White non-Hispanic. People of Hispanic origin may be of any race.

HOUSEHOLDS AND FAMILIES: In 2000 there were 20,000 households in York County. The average household size was 2.8 people.

Families made up 79.4 percent of the households in York County. This figure includes both married-couple families (67.3 percent) and other families (9.6 percent). Non-family households made up 20.6 percent of all households in York County. Most of the no family households were people living alone, but some were comprised of people living in households in which no one was related to the householder.

NATIVITY AND LANGUAGE: Five percent of the people living in York County in 2000 were foreign born. Ninety-five percent were native, including 39.5 percent who were born in Virginia.

Among people at least five years old living in York County in 2000, 7.2 percent spoke a language other than English at home. Of those speaking a language other than English at home, 2.3 percent spoke Spanish and 4.9 percent spoke some other language; 2 percent reported that they did not speak English "very well."

GEOGRAPHIC MOBILITY: In 2000, 47.8 percent of the people at least five years old living in York County were living in the same residence five years earlier; 10.4 percent had moved during the past five years from another residence in the same county, 18.1 percent from another county in the same state, 18.9 percent from another state, and 4.8 percent from abroad.

EDUCATION: In 2000, 91.7 percent of people 25 years and over had at least graduated from high school and 37.4 percent had a bachelor's degree or higher.

The total school enrollment in York County was 17,228 in 2000. Nursery school and kindergarten enrollment was 2,260 and elementary or high school enrollment was 11,902 children. College or graduate school enrollment was 3,066.

DISABILITY: In York County, among people at least five years old in 2000, 13.3 percent reported a disability. The likelihood of having a disability varied by age - from 6.3 percent of people 5 to 20 years old, to 13.1 percent of people 21 to 64 years old, and to 34.4 percent of those 65 and older.

INDUSTRIES: In 2000, for the employed population 16 years and older, the leading industries in York County were Educational, health and social services, 21.2 percent, Public administration, 10.9 percent, Retail trade, 10.8 percent, Manufacturing, 10.4 percent, and Arts, entertainment, recreation, accommodation and food services, 10.2 percent. Agriculture, forestry, fishing and hunting, and mining constituted 0.2 percent.

OCCUPATIONS AND TYPE OF EMPLOYER: Among the most common occupations were: Management, professional, and related occupations, 45.9 percent; Sales and office occupations, 24.3 percent and Service occupations, 14.1 percent. Farming, fishing, and forestry occupations constituted 0.3 percent. Sixty-nine percent of the people employed were Private wage and salary workers; 25.9 percent were Federal, state, or local government workers; and 5 percent were Self-employed in own not incorporated business workers – a category where fishermen might be found.

TRAVEL TO WORK: Eighty-six percent of York County workers drove to work alone in 2000, 9 percent carpooled, 0.5 percent took public transportation, and 2.4 percent used other means. The remaining 2.5 percent worked at home. Among those who commuted to work, it took them on average 23.7 minutes to get to work.

INCOME: The median income of households in York County was $57,956. Eighty-seven percent of the households received earnings and 27.3 percent received retirement income other than Social Security. Twenty-one percent of the households received Social Security. The average income from Social Security was $10,820. These income sources are not mutually exclusive; that is, some households received income from more than one source.

POVERTY AND PARTICIPATION IN GOVERNMENT PROGRAMS: Data for this section cannot be displayed because the number of sample cases is too small. Displaying the data would risk disclosing information for individuals.

HOUSING CHARACTERISTICS: In 2000, York County had a total of 20,701 housing units, 3 percent of which were vacant. Of the total housing units, 86.2 percent were in single-unit structures, 11.6 percent were in multi-unit structures, and 2.1 percent were mobile homes. Thirty-three percent of the housing units were built since 1990.

OCCUPIED HOUSING UNIT CHARACTERISTICS: In 2000, York County had 20,000 occupied housing units – 15,157 (75.8 percent) owner occupied and 4,843 (24.2 percent) renter occupied. Six-tenths of a percent of the households did not have telephone service and 2.6 percent of the households did not have access to a car, truck, or van for private use. Multi Vehicle households were not rare. Forty-six percent had two vehicles and another 27.8 percent had three or more.

HOUSING COSTS: The median monthly housing costs for mortgaged owners was $1,233, non-mortgaged owners $319, and renters $708. Nineteen percent of owners and 23.1 percent of renters in York County spent 30 percent or more of household income on housing.

New England Fishery Management Council
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John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

PHASE 1

APPENDIX G
"AFFECTED HUMAN ENVIRONMENT – SOCIAL ENVIRONMENT: COMMUNITY PROFILES"

TABLE OF CONTENTS

1.0 INTRODUCTION AND BACKGROUND

These community profiles have been prepared by graduate students under the supervision of the Social Sciences Branch of the NMFS Northeast Fisheries Science Center. These profiles are compiled from NMFS permit and landings data, demographic data from the 2000 Census (to allow full coverage of all communities), data from a variety of archival sources including books, articles, reports and web pages, and in some cases phone calls to knowledgeable individuals in the communities (e.g., librarians, postmasters, harbor masters, town council members, heads of fishing-related organizations). The profiles are in the process of being finalized, and will be updated with 2006 landings data.

This section contains draft profiles for all ports listed in the AHE as top ports for any FMP grouping per the landings data (see Table 1) or for Homeport or Owner's Residence per the permit files (see Table 2). Since there is overlap between the Northeast and the Southeast Region fisheries, the port of Wanchese, NC appears in the list even though this FMP deals only with the Northeast Region. North Carolina obviously has many other important ports, but they do not rise to the level of significance necessary with regard to Northeast fisheries to warrant inclusion here.

All census data (including those found in figures) are from the American Factfinder page of the Census for that community from the 2000 Census (see http://factfinder.census.gov/home/saff/main.html). Reference maps reproduced here are located at the upper right of each community's Factfinder page.
Occasional comparative data from 1990 can be found at http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_tabId=DEC2&_submenuId=datasets_1&_lang=en&_ts=190737473449. Data on religious affiliation from the American Religion Data Archive can be found at http://www.thearda.com/. All landings data are from the NMFS Landing Database (informally known as "the weighout"). Permit data are from the NMFS Northeast Regional Office permit database. Other data are referenced via endnotes within the text.

Table 1. Top Ports for All Individual FMP Groupings

Port	***ST***	***FMP Species***
New London	CT	small mesh groundfish
Boston	MA	large mesh groundfish, monkfish
Chatham	MA	dogfish, monkfish
Fall River	MA	red crab
Gloucester	MA	large mesh groundfish, small mesh groundfish, dogfish, monkfish, herring

Port	***ST***	***FMP Species***
New Bedford	MA	large mesh groundfish, small mesh groundfish, scallops, monkfish, herring, bluefish, skates, squid/mackerel/butterfish, summer flounder/scup/black sea bass ,surf clams/ocean quahogs
Plymouth	MA	Dogfish
Ocean City	MD	surf clams/ocean quahogs
Jonesport	ME	surf clams/ocean quahogs
Portland	ME	large mesh groundfish, monkfish, herring
Rockland	ME	Herring
Stonington	ME	Lobster
Vinalhaven	ME	Lobster
Wanchese	NC	"other fish", bluefish, summer flounder/scup/black sea bass
Newington	NH	Herring
Atlantic City	NJ	surf clams/ocean quahogs
Barnegat Light/Long Beach	NJ	tilefish, scallops, monkfish, bluefish
Belford/Middletown	NJ	bluefish, summer flounder/scup/black sea bass
Cape May	NJ	scallops, squid/mackerel/butterfish
Point Pleasant	NJ	summer flounder/scup/black sea bass, surf clams/ocean quahogs
Hampton Bays/Shinnecock	NY	tilefish, bluefish
Montauk	NY	tilefish, small mesh groundfish, bluefish, squid/mackerel/butterfish, summer flounder/scup/black sea bass
North Kingstown	RI	squid/mackerel/butterfish
Point Judith	RI	small mesh groundfish, monkfish, bluefish, skates, squid/mackerel/butterfish, summer flounder/scup/black sea bass
Tiverton	RI	Skates
Hampton	VA	summer flounder/scup/black sea bass
Newport News	VA	Scallops

Table 2. Top Ports for Permits by Homeport or Owner's Residence

Port	***ST***	***Homeport***	***Owner's Residence***
Chatham	MA	yes	yes
Fairhaven	MA	no	yes
Gloucester	MA	yes	yes
New Bedford	MA	yes	yes
Plymouth	MA	yes	no

Port	*ST*	*Homeport*	*Owner's Residence*
Scituate	MA	yes	no
Beals	ME	no	yes
Harpswell	ME	yes	yes
Jonesport	ME	yes	no
Portland	ME	yes	no
Stonington	ME	yes	no
Vinalhaven	ME	no	yes
Portsmouth	NH	yes	no
Barnegat Light/Long Beach	NJ	yes	no
Cape May	NJ	yes	yes
Point Pleasant	NJ	yes	no
Montauk	NY	yes	yes
Point Judith	RI	yes	no
Wakefield	RI	No	yes

The full list of all 34 communities profiled is found in Table 3, below.

Table 3. List of All Communities Profiled for this Amendment

State	*Community*
Maine	Beals
	Harpswell
	Jonesport
	Stonington
	Vinalhaven
	Rockland
	Portland
New Hampshire	Portsmouth
	Newington
Massachusetts	Boston
	Gloucester
	Chatham
	Scituate
	New Bedford
	Fairhaven
	Fall River
	Plymouth
Rhode Island	North Kingstown
	Point Judith
	Tiverton

	Wakefield
Connecticut	New London
New York	Montauk
	Hampton Bays-Shinnecock
New Jersey	Barnegat Light/Long Beach
	Point Pleasant
	Cape May
	Belford-Middleton
	Atlantic City
Maryland	Ocean City
Virginia	Hampton
	Newport News
North Carolina	Wanchese

2.0 MAINE

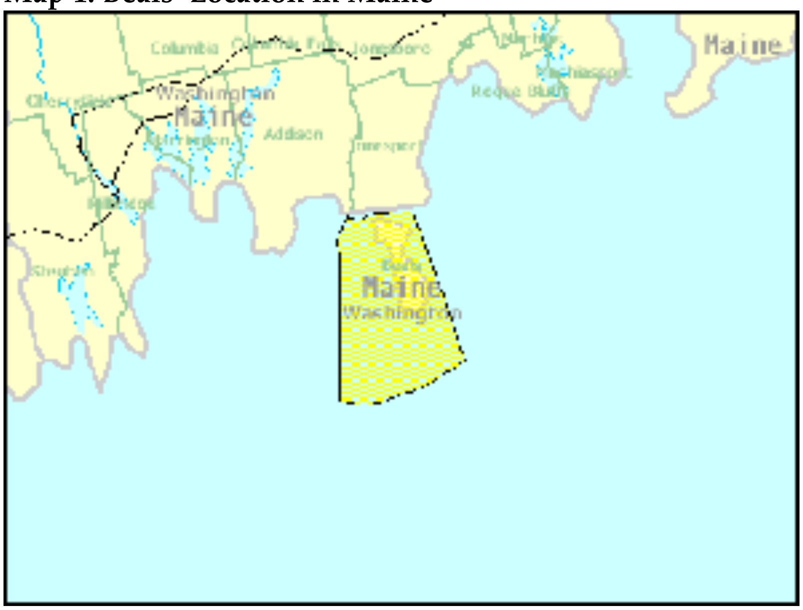
2.1 BEALS, ME

2.1.1 People and Places

Regional orientation

The city of Beals, Maine (4431:11°N, 67:36:56°W) is located in Washington County. Beals Island is connected to Jonesport by a bridge. Beals Island is 73.59 miles from Bar Harbor, 120.94 miles from Rockland, and 159.80 miles from Augusta. Beals contains 5.6 square miles of land area.[1]

Map 1. Beals' Location in Maine



Historical/Background information

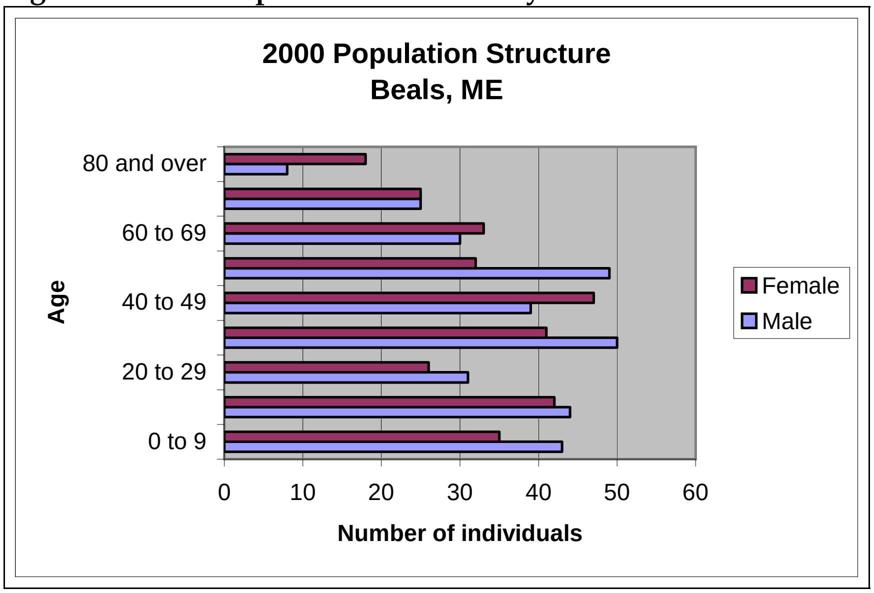
On Beals Island, 50-75% of the population depends directly on fishing and, as in many other Downeast communities, there is relatively little non-fishing related employment. In 2004, lobster fishing is the dominant fishery, but community members point out that their industry has a history of fishing a multiplicity of species. The only income apart from fishing-related businesses is seasonal tourism. The survival of the entire community depends on access to sustainable resources.[2]

Demographic Profile

According to Census 2000 data, Beals has a total population of 618, down 7.3% from the reported population in 1990. Of this total in 2000, 48.4% were female and 51.6% were male. The median age was 39.7 years and 72% of the population was 21 years or older while 20.7% were 62 or older.

Beals' age structure shows a preponderance of the 40-59 years age group. The 20-29 age group is smaller than both the 10-19 years and the 30-39 years age groups, showing that young people are apparently leaving the community after high school. Among the 30-39 years and 50-59 years age groups men are preponderant, perhaps showing that women are leaving the community. In the 40-49 years age group, however, women outnumber men.

Figure 1. Beals' Population Structure by Sex in 2000



The majority of the population of Beals was white (97.6%) in 2000, with 1.3% of residents Black or African American, 0.6% Native American, 0.2% Asian, and 0% Pacific Islander or Hawaiian. Only 2.1% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including the following: English (35.6%), Irish (12.3%), and French (7.3%). With regard to region of birth, 87.3% were born in Maine, 9.8% were born in a different state and 2.6% were born outside of the U.S. (including 0% who were not United States citizens).

Figure 2. Beals' Racial Structure in 2000

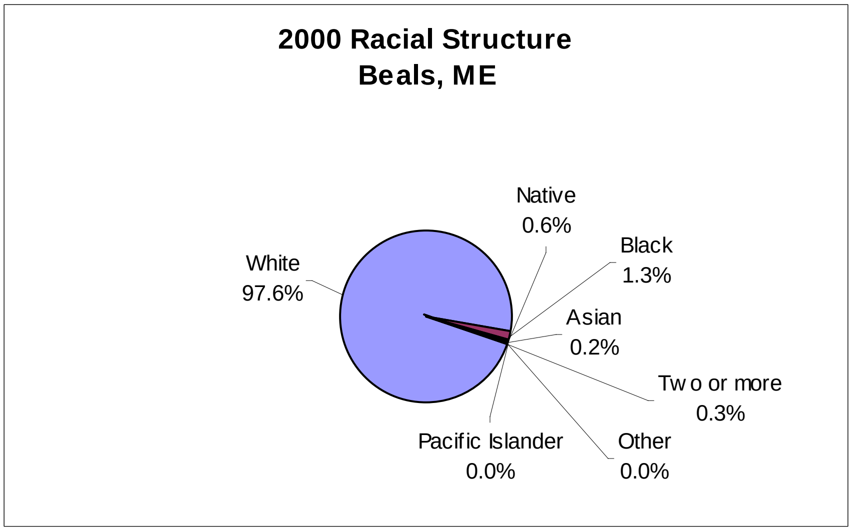
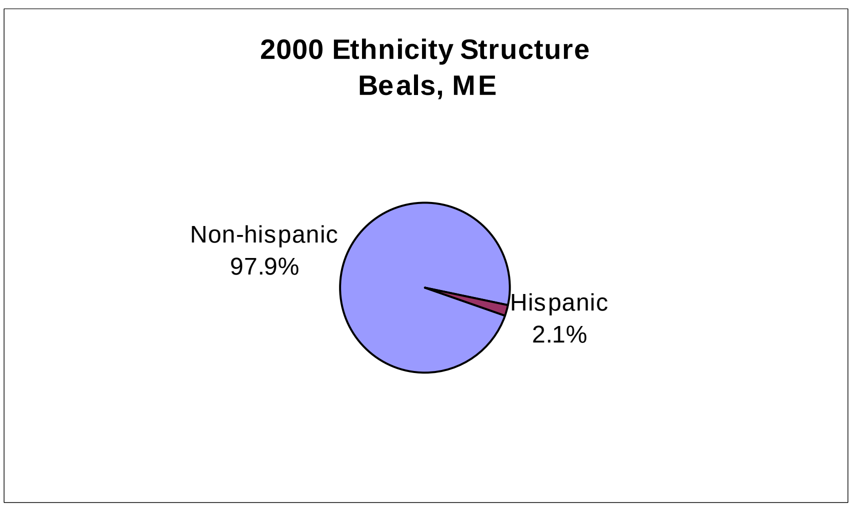


Figure 3. Beals' Ethnic Structure in 2000



For 94.8% of the population 5 years old and higher only English was spoken in the home in 2000, leaving 5.2% in homes where a language other than English was spoken. Of those who spoke other languages, 2.1% of them spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 76.2% were high school graduates or higher and 15.7% had a bachelor's degree or higher. Again of the population 25 years and over, 8.8% did not reach ninth grade, 15% attended some high school but did not graduate, 40.9% completed high school, 15% had some college with no degree, 4.6% received their associate degree, 11.8% earned their bachelor's degree, and 3.9% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Washington County was Catholic with 12 congregations and 4,155 adherents. Other prominent congregations in the county were the United Methodist Church (15 with 1,301 adherents), and the United Church of Christ (9 with 577 adherents). The total number of adherents to any religion was down 3.2% from 1990.

Issues/Processes

No issues of note were identified for Beals, Maine.

Cultural Attributes

There are no annual maritime industry-related celebrations in Beals. Cultural Attributes of this community include the lobster cooperative described in the section below.

2.1.2 Infrastructure

Current Economy

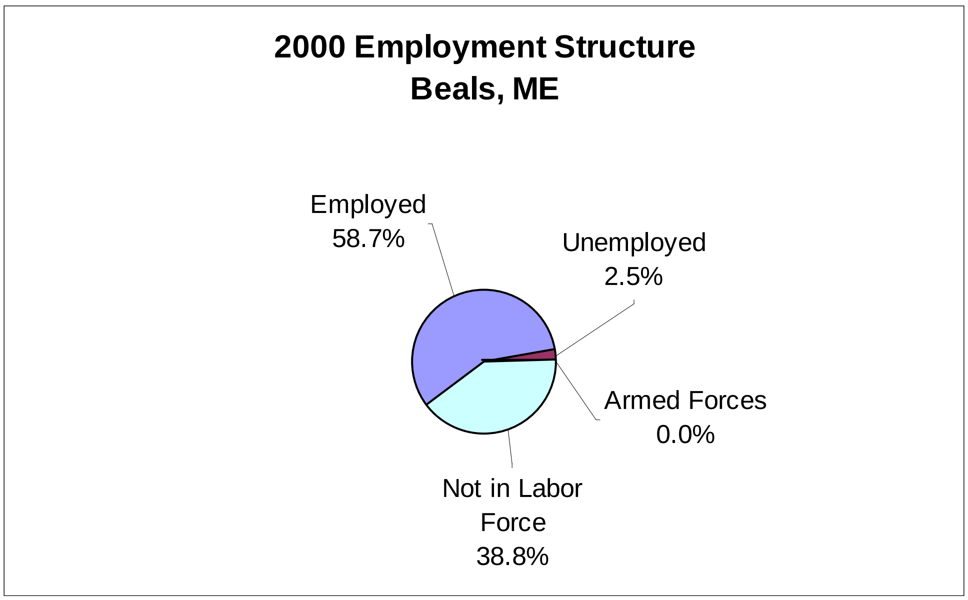
Commercial fishing has dominated the past and current economy of Beals Island. Residents of Beals have been able to rely on fishing because they have had "flexible switching strategies [that] allow small and medium sized boats in particular to adjust their individual business plans to changing ecological and socioeconomic circumstances with relative ease."[3] With recent increased restrictions on gear, permits, and Days At Sea, and declining fish populations, fishermen now depend primarily on lobster. The town has wooden boatbuilding companies[4] and seafood dealers such as Carver Shellfish and Old Salt Seafood[5]. The Beals Island Regional Shellfish Hatchery is the world's only soft-shell clam hatchery and Maine's only public shellfish hatchery.[6] Professor Brian Beal of the University of Maine at Machias founded this hatchery in 1987 and has established a research program for students to learn about mariculture at the facility.[7]

There is no municipal pier in Beals Island, just the breakwater. There is a marina, though it does not have electricity, and there are a lot of private docks.[8] The Barney's Cove Lobster Company provides gas and diesel, freshwater, and marine supplies.[9]

Beals-Jonesport Co-op Inc. in Jonesport is a lobster fisherman's co-op, both wholesale and retail, handling 500,000 to 800,000 pounds of lobster and 200,000-400,000 of live crabs a year. During the winter months scallops are sold, allowing sea urchin fishermen to use the facility at this time. The co-op sells also bait, marine supplies, fuel and gas and wholesale picked crabmeat.[10]

According to the U.S. Census 2000, 61.2% (297 individuals) of the total population 16 years of age and over were in the labor force, of which 2.5% were unemployed and 0% were in the Armed Forces.

Figure 4. Beals' Employment Structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 95 positions or 33.3% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 115 positions or 40.4% of jobs. Educational, health, and social services (19.3%), manufacturing (11.6%) and retail trade (8.8%) were the other primary industries.

Median household income in Beals was $29,375 (up 71.4% from 1990) and median per capita income was $13,133. For full-time year round workers, men made approximately 16.4% more per year than women.

The average family in Beals consisted of 2.85 persons in 2000. With respect to poverty, 10.6% of families (down from 50% in 1990) and 16.7% of individuals earned below the official US Government poverty line, while 61.6% of families in 2000 earned less than $35,000 per year.

In 2000, Beals had a total of 370 housing units of which 64.1% were occupied and 81.6% were detached one unit homes. Approximately one-third (36.7%) of these homes were built before 1940. There were a number of mobile homes/vans/boats in this area, accounting for 16.5% of the total housing units; 91.2% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area was $83,600. Of vacant housing units, 19.2% were used for seasonal, recreational, or occasional use, while of occupied units 16% were renter occupied.

Governmental

Beals' local government is comprised of a Chairperson, and three Selectmen.[11]

Fishery involvement in government
No information has been obtained at this time on fishery involvement in government.

Institutional

Fishing associations
The local fishing associations are the Downeast Lobstermen's Association located in Deer Isle, ME[12] and the Maine Lobstermen's Association which is said to have been founded in Jonesport – Beals Island in 1957.[13]

Fishery assistance centers
Although there are no fishery assistance centers located in Beals, Coastal Enterprises, Inc. provides support to fishing communities including Beals and others throughout Maine. They assist fishermen in getting loans, legal advice, money for research projects, and provide counseling on business questions.[14] The Sunrise County Economic Council also provides assistance for Beals and other Downeast communities.

Other fishing related institutions
Beals-Jonesport Co-op, Inc. is the lobstermen's cooperative, which employs four people and has approximately 75 active members, of which about 50% are residents of Beals Island. There are a few members from Addison and the rest are from Jonesport.[15]

Physical

Beals is accessible via Maine's Route 187, approximately 12 miles south of U.S. Route 1. The closest airports in the area are the Hancock County Bar Harbor airport (BHB) located about 37 miles west of Beals Island in Bar Harbor, Maine and the Bangor International airport (BGR) located approximately 63 miles west of Beals Island in Bangor, Maine.[16]

2.1.3 <u>Involvement in Northeast Fisheries</u>

Commercial

In the past, residents of Beals Island have fished for the following: lobster, groundfish, urchins, shrimp, quahogs, worms, clams, mussels, winkles, herring and scallops. Of these target species, lobster had the highest dollar value of Federally Managed Groups of landing in Beals in 2003. Worms were the second most valuable species in 2003. The value of lobsters in 2003 was significantly less than the 1997-2004 average, and the value of fishing to vessels listing Beals Island as their homeport also saw a dramatic dip in 2003. There was a spike in the value of landings in Beals in 2001 and 2002, but in 2003 this value fell back to previous levels.

From the 1960s to the early 1990s Beals and other Downeast harbors relied on groundfish fishing. As of 2004 no Beals Island residents have groundfish permits, and only one Jonesport resident does. According to information collected by Jennifer Brewer in the Community Panels Project, "many [residents] lost access to the groundfish when regulations required a 'history' of groundfishing in order to obtain a permit".[17]

Landings by Species

Table 4. Dollar value of Federally Managed Groups of landing in Beals

	Average from 1997-2004	2003 only
Lobster	1,774,224	621,094
Surf Clams, Ocean Quahogs	49,135	10,251
Largemesh Groundfish[18]	10,050	0
Scallop	4,355	0
Monkfish	45	0
Other	304,764	480,921

Vessels by Year

Table 5. All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	59	70	208,878	1,167,491
1998	59	70	461,297	1,353,868
1999	58	73	396,058	1,361,703
2000	62	78	546,415	1,622,680
2001	64	79	679,943	4,968,217

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
2002	68	79	857,964	5,554,348
2003	69	76	296,546	1,112,266

Recreational

There is no sport fishing industry in Beals Island.[19]

Subsistence

No information has been obtained at this time on subsistence fishing.

Future

No information has been obtained at this time on views of the future.

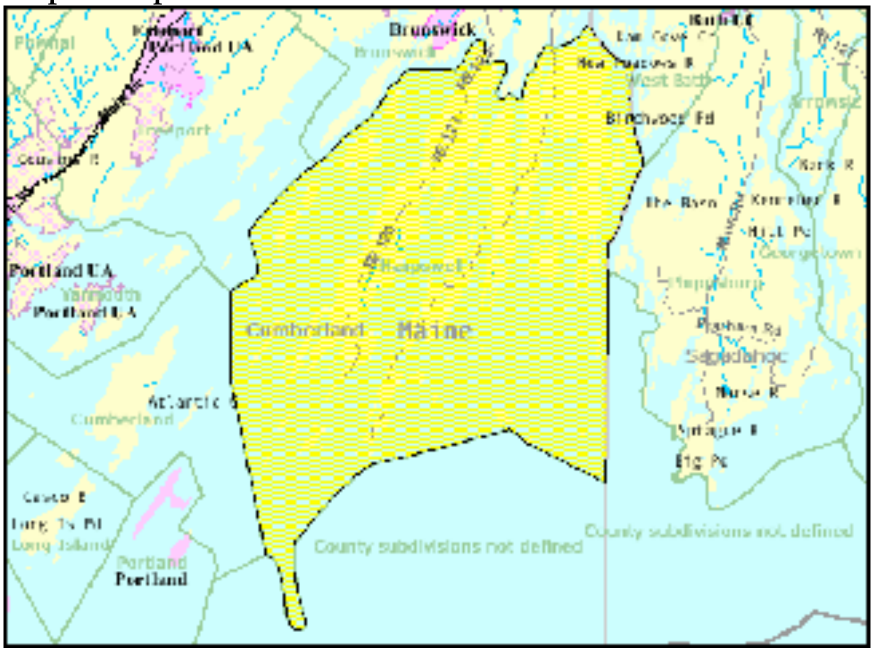
2.2 HARPSWELL, ME

2.2.1 People and Places

Regional Orientation

The town of Harpswell, Maine is located in Cumberland County on Casco Bay. The town of Harpswell is divided into a series of islands and peninsulas separated by bays, including Bailey Island, Great Island, and Orr Island.

Map 2. Harpswell's Location in Maine



Historical/Background Information

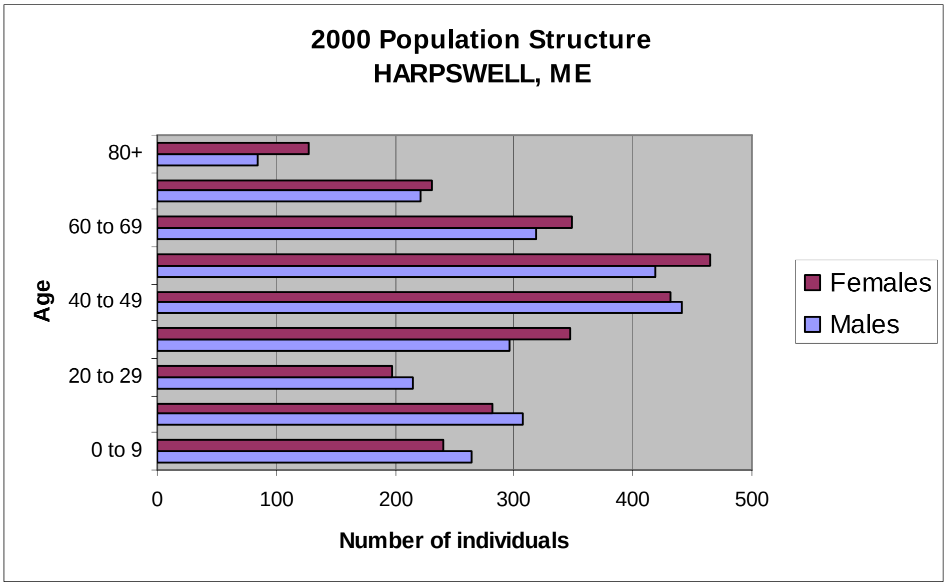
The town of Harpswell is made up of a ten-mile peninsula extending into Casco Bay, consisting of three large islands, Bailey Island, Orr Island, and Great (Sebascodegan) Island, and over 200 small islands, creating over 150 miles of coastline for the town. The town is geographically spread out, and is divided into five main villages: Cundy's Harbor, Harpswell, South Harpswell, Bailey Island and Orr's Island. Cundy's Harbor is the oldest lobstering community in Maine.[20] Harpswell was purchased from the Native Americans in 1659 and settled by Europeans; however, by 1714 only two settlers remained, after the rest were driven off by Indian raids. Harpswell was incorporated as a town in 1758, under what was then the Massachusetts Bay Colony. Many tall ships, sloops, and schooners were built here during the 1800s, and fishing has been an important economic activity for the town for centuries. Harpswell has served as a summer retreat for many famous artists and writers throughout the years, including Harriett Beecher Stowe and Edna St. Vincent Millay.[21]

Demographic Profile

According to Census 2000 data, Harpswell had a total population of 5,239, up from the reported population of 5,012 in 1990. Of this total, 50.9% were female and 49.1% were male. The median age for Harpswell in the year 2000 was 45.3 years and 78.4% of the population was 21 years or older while 23.1% of the population was 62 or older.
The most populous age bracket in Harpswell was between the ages of 50-59, followed closely by the 40-49 age bracket. There were also a number of residents aged 60-69, indicative of a slightly aging population. Like many similar communities, Harpswell

shows a decline in population for residents between 20-29 years of age, as young people leave to go to college or in search of employment elsewhere.

Figure 5. Harpswell's Population Structure in 2000



The majority of the population of Harpswell in 2000 was white (97.8%), with 0.3% Black or African American, 0.6% Native American, 0.7% Asian, and 0% Pacific Islander or Hawaiian. Hispanics/Latinos accounted for 1.3% of the total population. Residents linked their heritage to a number of European ancestries including the following: English (26.5%), Irish (12.9%), French (10.3%), Scottish (7.8%), and French (7.1%).

With regard to region of birth, 54.3% were born in Maine, 40.1% were born in a different state, and 4.2% were born outside of the United States (including 1.3% who were not US citizens).

Figure 6. Harpswell's Racial Structure in 2000

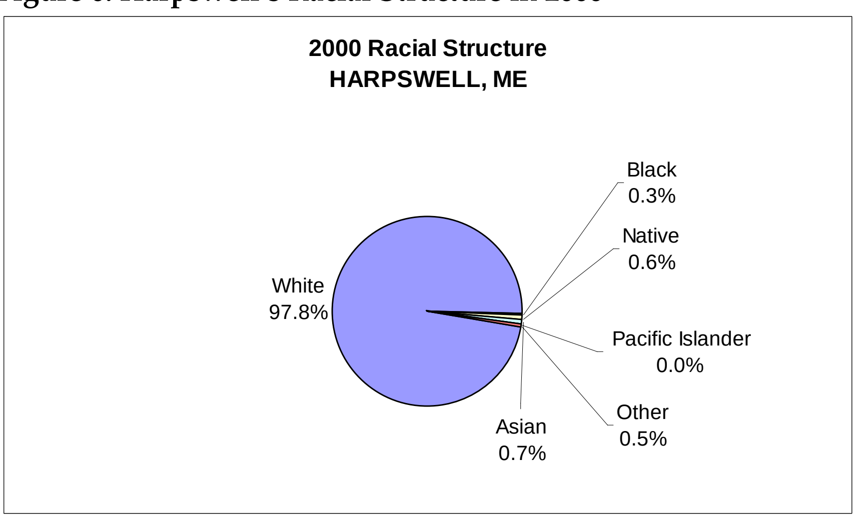
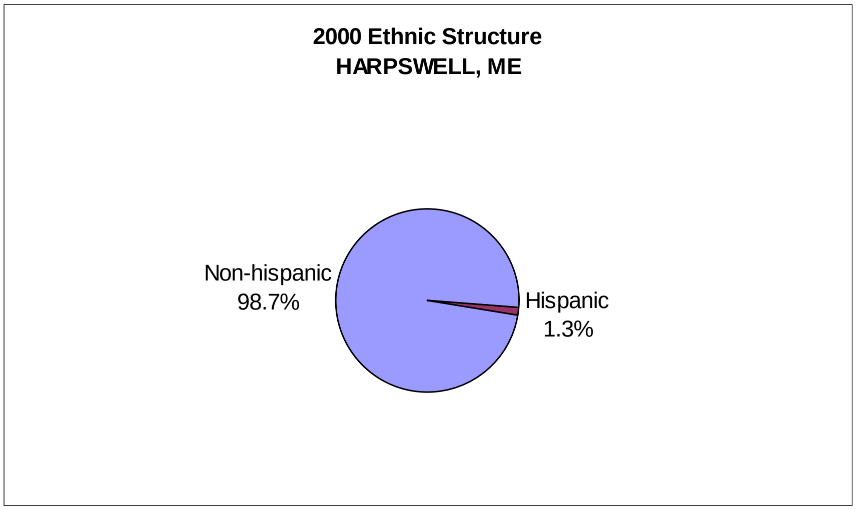


Figure 7. Harpswell's Ethnic Structure in 2000



For 93.1% of the population 5 years old and older in 2000, only English is spoken in the home, leaving 6.9% in homes where a language other than English is spoken, including 2.1% of the population who speak English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 88.9% are high school graduates or higher and 42.2% have a bachelor's degree or higher. Again of the population 25 years and over, 3.9% did not reach ninth grade, 7.2% attended some high school but did not graduate, 23.8% completed high school, 16.6% had some college with no degree, 6.3% received their associate degree, 24.3% earned their bachelor's degree, and 17.9% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Cumberland County was Catholic with 31 congregations and 61,495 adherents. Other prominent congregations in the county were the United Church of Christ (33 with 10,160 adherents), United Methodist Church (26 with 5,590 adherents), Jewish (4 with 6,000 adherents) and the Episcopal Church (11 with 4,577 adherents). The total number of adherents to any religion was up 24.6% from 1990.

Issues/Processes

In 2004 Holbrook's Wharf in Cundy's Harbor, the center of the oldest lobstering community in Maine, was put up for sale. The Trust for Public Land was trying to raise the $1.5 million necessary to preserve this working commercial wharf and historical landmark, and was successful at least in extending the deadline for purchase until November 30, 2006.[22]

Cundy's Harbor is fortunate to have lost little waterfront access, but this danger still exists here. Like many similar communities in Maine, the working waterfront also faces the problems of escalating land values and property taxes, and increased user conflicts among fishing and non-fishing uses. The town of Harpswell has implemented exclusive zoning for commercial fishing activities which may mitigate this threat somewhat.[23]
In the fall of 2005, there were a rash of lobster thefts around Harpswell, which was blamed on desperation of lobstermen brought on by a slower season and lower catch than usual.[24]

Cultural Attributes

The annual Harpswell Festival by the Bay is an old-fashioned celebration of the town, with music and a parade. The Festival has an emphasis on the participation and public awareness of the town's non-profit organizations, businesses, artists, and artisans. In 2005 the festival featured a quahog demonstration and a tidal pool touch tank among other events.[25] Cundy's Harbor has its own celebration, Cundy's Harbor Day, which features a parade and lobster dinner.[26]

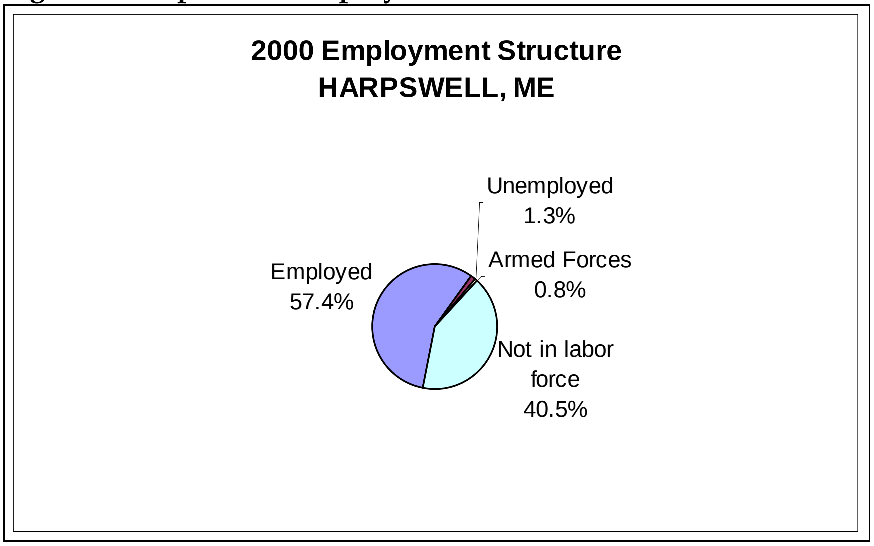
2.2.2 Infrastructure

Current Economy

There are several major employers within a relatively short drive of Harpswell. Bath Iron Works, in Bath, is one of the nation's top ten defense contractors and Maine's largest employer, with 8,500 employees. The Naval Air Station Brunswick, located in neighboring Brunswick, is the city's second largest employer, with 4,710 civilian and military personnel, and provides over $211 million to the local economy. Bowdoin College, also in Brunswick, employs a number of people in the area.[27] Many of the residents also commute to jobs in Portland.

According to the U.S. Census 2000, 59.5% (2,582individuals) of the total population 16 years of age and over were in the labor force, of which 1.3% were unemployed and 0.8% were in the armed forces.

Figure 8. Harpswell's Employment Structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 203 or 8.1% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 582 people or 23.4% of the labor force. Educational, health and social services (21.6%), retail trade (12.9%), construction (10.6%) and manufacturing (10.0%) were major employment categories.

Median household income in Harpswell in 2000 was $40,611 (up 33.4% since 1990 when the median household income was $33,298) and median per capita income was $30,433. For full-time year round workers, men made approximately 13.9% more per year than women.

The average family in Harpswell consisted of 2.69 persons. With respect to poverty, 3.3% of families (up from 3.0% in 1990) and 5.6% of individuals earned below the official U.S. Government poverty line, and 30.8% of families in 2000 earned less than $35,000 per year.

In 2000 Harpswell had a total of 3,701 housing units, of which 63.2% were occupied and 87.7% were detached one unit homes. Just over one quarter (27.7%) of these homes were built before 1940. There were a number of mobile homes in this area, accounting for 7.2% of the total housing units; 89.4% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $162,500. Of vacant housing units, 89.1% were used for seasonal, recreational, or occasional use. Of occupied units, 21.2% were renter occupied.

Governmental

Harpswell is governed by a Town Meeting form of government, as well as a board of three Selectmen, elected to three-year terms. The town was incorporated in 1758.[28] The town offices are located on Great Island.[29]

Fishery involvement in government

Harpswell has more shoreline than any other municipality in Maine, so many of the town's municipal activities relate to the use of the coast, including the management of harbors, the regulation of shellfishing, the placement of moorings, and other relevant activities. The town has a Harbor and Waterfront Committee, a Marine Resources Committee, and a Marine Resources Ordinance, as well as a Shellfish Conservation Warden.[30] The town has also been very active in preserving its working waterfronts, and has implemented exclusive zoning for the commercial fishing industry along the waterfront.[31]

Institutional

Fishing associations

The Maine Fishermen's Cooperative Association is located in Cundy's Harbor.[32] The Association "was initiated in the late 1960s and has a long-standing history of being involved in critical groundfish issues."[33]

Fishery assistance centers

The Maine Fishermen's Wives Association is based in Cundy Harbor.[34] They "advocate for the seafood industry, providing educational programs for schools and communities, and hold a seat on the Maine Fisherman's Forum Board".[35]

Other fishing related institutions

The Harpswell Land Trust is working to preserve public access to the waterfront, and to protect open space in Harpswell, and its mission is "to preserve the natural and cultural heritage of Harpswell through education, conservation, and land owner assistance".[36]

Physical

Harpswell is made up of a long peninsula and over 200 islands, creating a number of coves and harbors throughout the town. Route 24 is the major road running through the town, joining up with Route 1, which runs through Bath, Brunswick, and all along the Maine coast. Harpswell is about 10 miles from Brunswick, 14 miles from Bath, and 36 miles from Portland. The closest airport is the Portland International Jetport.[37] Both Concord Trailways and Greyhound operate bus services that stop in Bath and

Brunswick.[38] Vermont Transit also has buses running from Brunswick.[39] Amtrak offers train service from Portland to Boston and the rest of the eastern seaboard.[40]
Harpswell has a number of deep water harbors; Cundy's Harbor and Mackerel Cove (on Bailey Island) are two harbors/communities where most of the working fishing boats can be found.[41] There are a total of nine commercial wharves in Cundy's Harbor, including Holbrook's, Hawke's, and the Cundy's Harbor Wharf, where the co-op is based. Many residences also have private docks used in small commercial fishing operations.[42] Holbrook's Wharf in Cundy's Harbor has a restaurant, general store, and post office.[43] There is a town landing with a boat ramp off Holbrook Street in Cundy's Harbor.[44] Finestkind Boatyard is located in Basin Cove, Harpswell[45]. Another boatyard can be found on Great Island, which also offers a number of moorings and slips, primarily for recreational vessels.[46] The Dolphin Marina in South Harpswell has a boat launch, dock service, and fuel, ice, and water.[47]

2.2.3 Involvement in Northeast Fisheries

Commercial

Much of the commercial fishing industry is in Cundy's Harbor.[48] The nine commercial wharves here include Cundy's Harbor, Holbrook's, Hawkes, Mill's Ledge Seafood, Watson's, and Oakhurst Island; all of these offer loading and unloading, ice, and docking, and some also have fuel facilities. These businesses all serve as seafood wholesalers as well to sell the catch. Some nearby businesses offer bait.[49] A small number of commercial vessels are also present in South Harpswell.[50]

Like many other fishing communities in Maine, lobster is by far the most valuable species landed in Harpswell. The value of lobster landings in 2003 was close to $7 million, considerably higher than the average landed value for 1997-2004. In 2003 the second most valuable species in Harpswell was soft clam, worth just under $1 million ($963,049), followed by rockweed ($36,172), both of which would be found in the "other" category. The value of the "other" category in 2003 was also approximately three times the average eight-year value. Harpswell has a large number of home ported vessels, which increased over the seven-year period to a high of 59 in 2003. There are an even larger number of vessel owners present in Harpswell. The level of fishing for home ported vessels was relatively consistent from 1997-2003; however, the landings values varied widely. There were no landings reported for 1997-1999, and then more than $10 million in landings in 2002.

Landings by Species

Table 6. Dollar value by Federally Managed Groups of Landings in Harpswell

	Average from 1997-2004	2003 only
Lobster	2,102,345	6,865,675

Other	331,557	1,015,534
Largemesh Groundfish	18,104	32,226
Herring	841	0
Monkfish	557	364
Scallop	21	168
Skate	1	0
Smallmesh Groundfish	1	0

Vessels by Year

Table 7. All columns represent Federal Vessels Permits or Landings Value combined between 1997-2003 for Harpswell

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	46	30	436,714	0
1998	46	32	439,059	0
1999	51	41	404,231	0
2000	52	59	410,451	13,006
2001	53	64	360,501	1,615,179
2002	59	74	367,919	10,084,259
2003	59	73	469,363	7,913,967

Recreational

The town of Harpswell has both commercial and recreational shellfishing managed through the Marine Resources Committee.[51] Captain Jay McGowen's Sport Fishing Charters leave from Orr Island in Harpswell.[52]

Subsistence

Information on subsistence fishing in Harpswell is either unavailable through secondary data collection or the practice does not exist.

Future

Harpswell is currently in the process of implementing a comprehensive plan for the town which will encourage smarter growth within the town by focusing development within designated village areas.[53] If the Trust for Public Land is successful in purchasing Holbrook's Wharf in Cundy's Harbor, ownership of the wharf would transfer to a community non-profit organization who would manage the wharf to preserve its commercial use.[54]

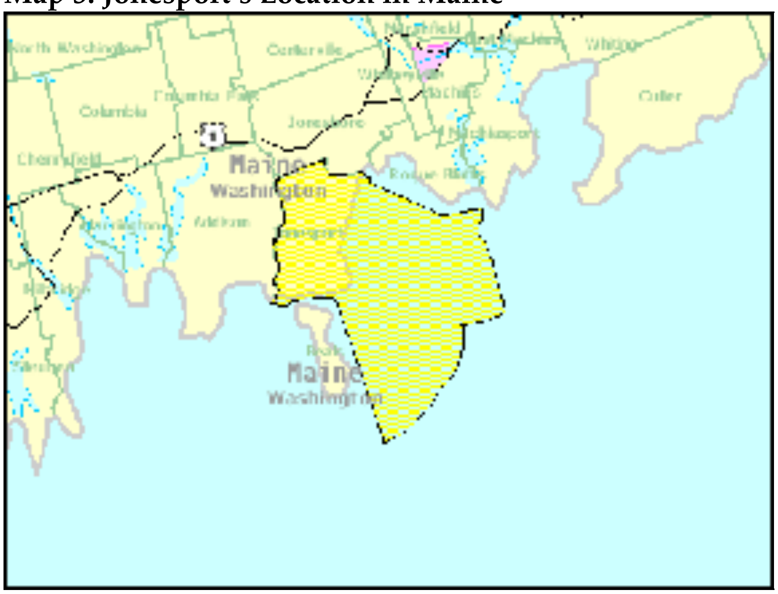
2.3 JONESPORT, ME

2.3.1 People and Places

Regional orientation

The city of Jonesport, Maine (44:37:17°N, 67:30:54°W) is located in the Washington County. West Jonesport is connected to Beals Island by a bridge. Jonesport is 73.67 miles from Bar Harbor, 121.02 miles from Rockland, and 159.88 miles from Augusta. Jonesport contains 24.3 square miles of land area.[55]

Map 3. Jonesport's Location in Maine



Historical/Background information

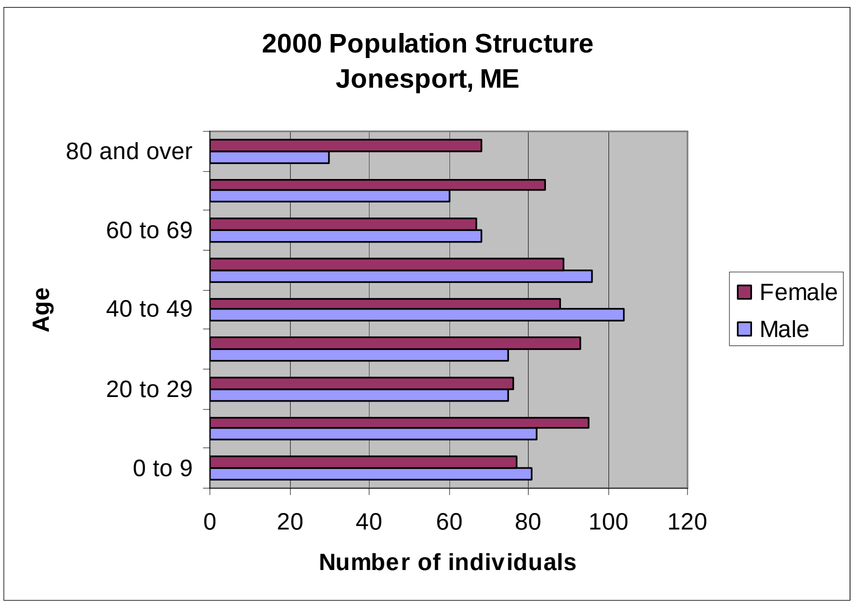
Jonesport, like Beals Island across Moosabec Reach, is a fishing town. The shores are lined with docks piled with lobster gear, and lobster boats are moored in every cove.[56] In Jonesport and Beals Island, 50-75% of the population depends directly on fishing and, as in many other Downeast communities, there is relatively little non-fishing related employment. There were three sardine canneries in Jonesport in the past. Today, lobster fishing is the dominant fishery, but community members point out that their industry has a history of fishing a multiplicity of species. The only income apart from fishing-related business is seasonal tourism. The survival of the entire community depends on access to sustainable resources.[57]

Demographic Profile

According to Census 2000 data, Jonesport had a total population of 1,408, down 7.6% from the reported population in 1990. Of this total in 2000, 52.3% were female and 47.7% were male. The median age was 42.7 years and 74.6% of the population was 21 years or older while 25.5% were 62 or older.

Jonesport's age structure shows a preponderance of the 40-59 years age group. The 20-29 age group is smaller than both the 10-19 year group and the 30-39 year age group, showing that young people are apparently leaving the community after high school. Among the 10-19 years and the 30-39 years age groups the number of young females is dominant, indicating that the trend toward leaving is strongest among young men.

Figure 9. Jonesport's Population Structure in 2000



The majority of the population of Jonesport in 2000 was white (97.8%), with 0.3% of residents Black or African American, 0.7% Native American, 0.1% Asian, and 0.0% Pacific Islander or Hawaiian. Only 0.4% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: English (28%), Irish (12.9%), French (7.1%) and Scottish (5.6%). With regard to region of birth, 77.7% were born in Maine, 20.9% were born in a different state and 0.4% was born outside of the U.S. (including 0.1% who were not United States citizens).

Figure 10. Jonesport's Racial Structure in 2000

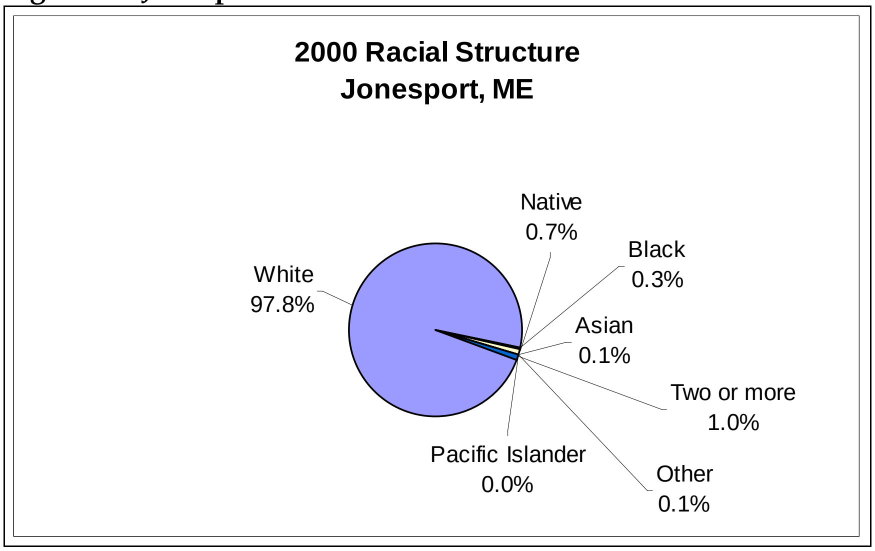
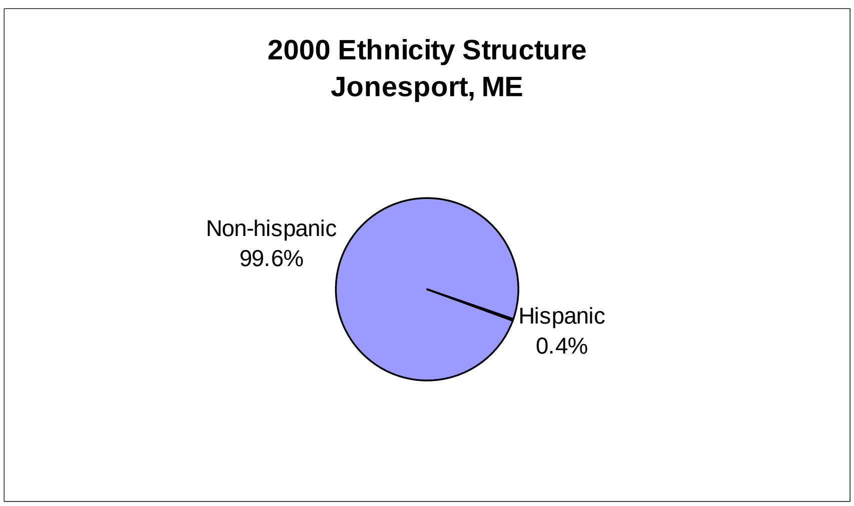


Figure 11. Jonesport's Ethnic Structure in 2000



For 97.8% of the population 5 years old and higher in 2000 only English was spoken in the home, leaving 2.2% in homes where a language other than English was spoken. Of those who spoke other languages, 0.2% of them spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 77.4% were high school graduates or higher and 14.6% had a bachelor's degree or higher. Of the population 25 years and over, 11% did not reach ninth grade, 11.6% attended some high school but did not graduate, 40.8% completed high school, 19% had some college with no degree, 3.1% received their associate degree, 9.7% earned their bachelor's degree, and 4.9% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Washington County was Catholic with 12 congregations and 4,155 adherents. Other prominent congregations in the county were the United Methodist Church (15 with 1,301 adherents), and the United Church of Christ (9 with 577 adherents). The total number of adherents to any religion was down 3.2% from 1990.

Issues/Processes

No information was available at this time on issues or processes in Jonesport.

Cultural Attributes

The World's Fastest Lobster Boat Race takes place annually in Jonesport in July.[58] Cultural Attributes of this community also include the lobster cooperative described in the section below.

2.3.2 Infrastructure

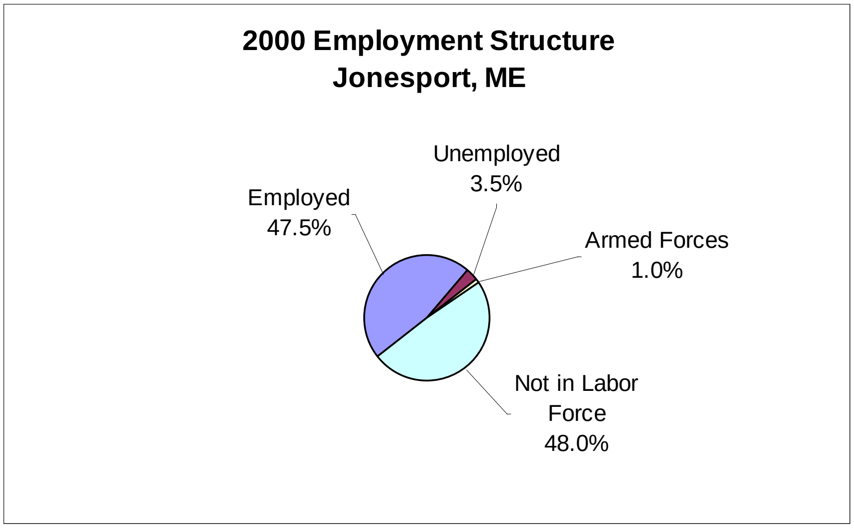
Current Economy

The economy of Jonesport is dominated by commercial fishing. The town has several bait dealers and seafood wholesalers, such as Smith's Lobster, O W Look and Son, and Look's Live Lobster specializing in lobster[59], and Moosabec Mussels, Inc.[60] Jonesport also has a lobster fisherman's cooperative which includes Beals fishermen as well. The Beals-Jonesport Co-op Inc. both wholesales and retails, handling 500,000 to 800,000 pounds of lobster and 200,000-400,000 of live crabs a year. During the winter months scallops are sold, allowing sea urchin fishermen to use the facility at this time. The co-op sells also bait, marine supplies, fuel and gas and wholesale picked crabmeat.[61]

Jonesport has a harbor in Sawyer Cove behind a 1,200-foot steel and a stone breakwater that extends across the mouth from the east. The town marina consists of the recently rebuilt and enlarged town wharf and floats and a launching ramp and parking. The first, southernmost float is for commercial vessels only. The other float, to the north, is for the limited docking of recreational boats. Despite the longer wharf, each float has only about 3 feet of depth at low tide. Jonesport Shipyard is located east of the town on floats near the head of the harbor. Boats up to 17 tons or 45 feet can be hauled and repaired there, and showers, laundry, and ice are provided. Look Lobster's floats and buildings are opposite the west end of the breakwater. Gas is available at the floats, and diesel is available halfway up the dock. Look's also sells ice and frozen crabmeat.
[62]

According to the U.S. Census 2000, 52% (1,143 individuals) of the total population 16 years of age and over are in the labor force, of which 3.5% are unemployed and 1.0% is in the Armed Forces.

Figure 12. Jonesport's Employment Structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 134 positions or 24.7% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 137 positions or 25.2% of jobs. Educational, health and social services (24.1%), retail trade (12.7%), and public administration (5.7%) were the other primary industries.

Median household income in Jonesport in 2000 was $23,224 (up 49.1% from 1990[63]) and median per capita income was $14,135. For full-time year round workers, men made approximately 43.9% more per year than women.

The average family in Jonesport consisted of 2.79 persons. With respect to poverty, 14.7% of families (down from 41.2% in 1990) and 19.8% of individuals earned below the official U.S. Government poverty line, while 58.4% of families in 2000 earned less than $35,000 per year.

In 2000, Jonesport had a total of 877 housing units, of which 68.1% were occupied and 82.5% were detached one unit homes. Close to one-half (45.6%) of these homes were built before 1940. There were a number of mobile homes/vans/boats in this area, accounting for 9.3% of the total housing units; 89.1% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $75,600. Of vacant housing units, 20.4% were used for seasonal, recreational, or occasional use, while of occupied units 18.3% were renter occupied.

Governmental

Jonesport's local government is comprised of a Chairperson, and three Selectmen. It was incorporated as a town in 1832.[64]

Fishery involvement in government

No information has been obtained at this time on fishery involvement in Jonesport's government.

Institutional

Fishing associations

The local fishing associations are the Downeast Lobstermen's Association located in Deer Isle, ME[65] and the Maine Lobstermen's Association which is said to have been founded in Jonesport – Beals Island in 1957.[66]

Fishery assistance centers

Coastal Enterprises Inc. (CEI) in Maine is a private, nonprofit Community Development Corporation (CDC) and Community Development Financial Institution (CDFI) with roots in the civil rights movement. Founded in 1977, the organization provides capital and support in the development of job-creating small businesses, natural resources industries, community facilities, and affordable housing.[67] Also, the Sunrise County Economic Council, located in Machias, has worked with fishermen in Jonesport to develop a grant program to help the small home-based crab pickers. This Council is also available to provide assistance to other sectors of the fishing industry in Downeast, Maine.[68]

Other fishing related institutions

There is no information on other fishing related institutions than those described in previous sections.

Physical

Jonesport is accessible via Maine's Route 187, approximately 12 miles south of U.S. Route 1. The closest airports in the area are the Hancock County Bar Harbor airport (BHB) located about 75 miles west of Jonesport in Bar Harbor, Maine and the Bangor International airport (BGR) located approximately 80 miles west of Jonesport in Bangor, Maine.[69]

2.3.3 Involvement in Northeast Fisheries

Commercial

As with Beals Island, commercial fishing has dominated the past and current economy of Jonesport. Residents of Jonesport have been able to rely on fishing because they have had "flexible switching strategies [that] allow small and medium sized boats in particular to adjust their individual business plans to changing ecological and socioeconomic circumstances with relative ease."[70] With recent increased restrictions on gear, permits, and Days At Sea, and declining fish populations, fishermen now depend primarily on lobster. The town has wooden boatbuilding companies[71] and seafood dealers such as Carver Shellfish and Old Salt Seafood[72].

In the past, residents of Jonesport Island have fished for the following: lobster, groundfish, urchins, shrimp, quahogs, worms, clams, mussels, winkles, herring and scallops. Of these target species, lobster had the highest dollar value of Federally Managed Groups of landing in Jonesport in 2003.

From the 1960s to the early 1990s Beals and other Downeast harbors relied on groundfish fishing. As of 2004 only one Jonesport resident has a groundfish permit, and no Beals Island residents do.

In 2003 lobster was by far the most valuable species, worth over $11 million, which was considerably higher than the 8-year average taken. Also valuable in 2003 were ocean quahogs ($2,618,245), and mussels ($1,188,607). Overall the value of both landings in Jonesport and of fish landed by vessels listing Jonesport as their home port had increased in the 1997-2003 period, as had the number of vessels using Jonesport as their home port, and the number of vessels registered to residents here.

Beals-Jonesport Co-op Inc. in Jonesport is a lobster fisherman's co-op, both wholesale and retail, handling 500,000 to 800,000 pounds of lobster and 200,000-400,000 of live crabs a year. During the winter months scallops are sold, allowing sea urchin fishermen to use the facility at this time. The co-op sells also bait, marine supplies, fuel and gas and wholesale picked crabmeat.[73]

Landings by Species

Table 8. Dollar value of Federally Managed Groups of landing in Jonesport

	Average from 1997-2004	2003 only
Lobster	5,953,942	11,400,801
Surf Clams, Ocean Quahogs	1,723,276	2,618,245

Scallop	182,619	115,463
Largemesh Groundfish	9,662	0
Monkfish	44	0
Other	1,606,438	2,250,136

.

Vessels by Year

Table 9. All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	50	32	1,369,931	8,274,554
1998	50	29	871,583	6,480,955
1999	54	30	1,235,018	7,002,863
2000	59	29	1,872,287	9,080,978
2001	61	33	1,753,357	12,464,464
2002	67	40	2,457,735	16,080,804
2003	69	44	2,281,340	16,384,645

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Recreational

No information has been found for recreational fishing in Jonesport, however, there is one business that does Puffin tours out of the town.

Subsistence

No information has yet been found on subsistence fishing.

Future

No information on future plans or expectations has yet been found.

2.4 STONINGTON, ME

2.4.1 People and Places

Regional orientation

The city of Stonington (44.156°N, 68.667°W) is located in Hancock County on Deer Isle in Downeast Maine. It is 103 miles northeast of Augusta, ME, and 159 miles northeast of Portland, ME, and 265 miles northeast of Boston, MA.

Map 4. Stonington's Location in Maine

Historical/Background information

Stonington promotes itself as a town known for high quality fish. An influx of nutrients from the Gulf of Maine along with upwelling make this area a good habitat for lobsters, crabs, scallops, and mussels as well as native species of finfish like halibut, mackerel, cod and haddock.[74]

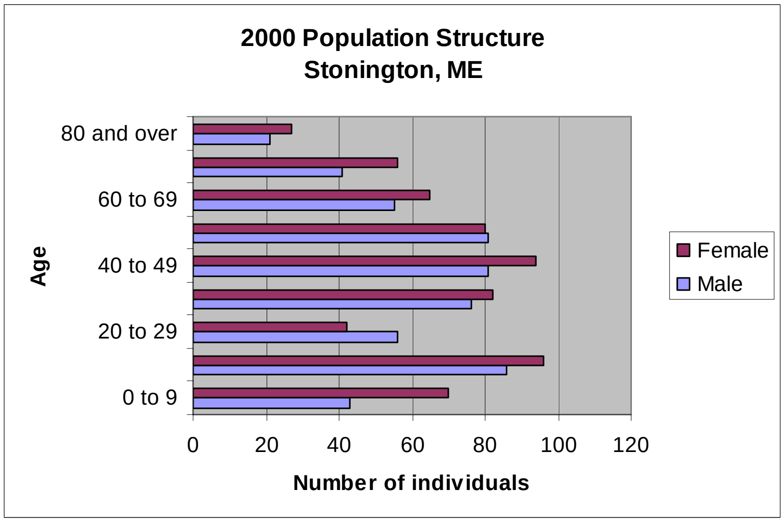
Originally Stonington's economy revolved around its high quality granite rather than fishing. Between 1870 and 1925, enormous quantities of granite were produced from quarries in Stonington and on Crotch Island. Stonington, originally known as Green's Landing, earned its new name because of this granite industry. In 1899, Stonington separated from Deer Isle Town. Stonington granite can be found in the structures of Rockefeller Center, the Smithsonian Institution, Boston's Museum of Fine Arts, and several New York City bridges, including the George Washington and the Triboro. But the granite industry declined and the quarries closed, and fishing became Stonington's most important industry.[75] Currently, clams, mussel and lobster fishing activities have replaced the urchin fishing activity which was carrying Stonington's Pier in the 1990s.[76]

Demographic Profile

According to the Census 2000 data, the city had a population of 1,152, down from the reported population of 1,252 in 1990. Of this 2000 total, 46.9% were male and 53.1% were

female. The median age was 41.6 years and 73.3% of the population was 21 years or older while 21.5% of the population was 62 or older.
Stonington's age structure showed a dip in population within the 20-29 year age group, similar to many small fishing communities, and then an increase -- with the highest percentage between 40-49 years.

Figure 13. Stonington's Population Structure by Sex in 2000



The majority of the population of Stonington in 2000 was white (96.8%), with 0.6 Black or African American and 0.4% Asian. Of the total population, 0.9% identified themselves as Hispanic/Latino. In addition, residents linked their heritage to a number of European ancestries including: English (25.8%), Irish (9.2%), French (7.1%), German (4.1%), and Scottish (3.4%). With regard to region of birth, 79.3% were born in Maine, 17.4% were born in a different state and 2.1% were born outside the U.S (including 0.4% who were not US citizens).

Figure 14. Stonington's Racial Structure in 2000

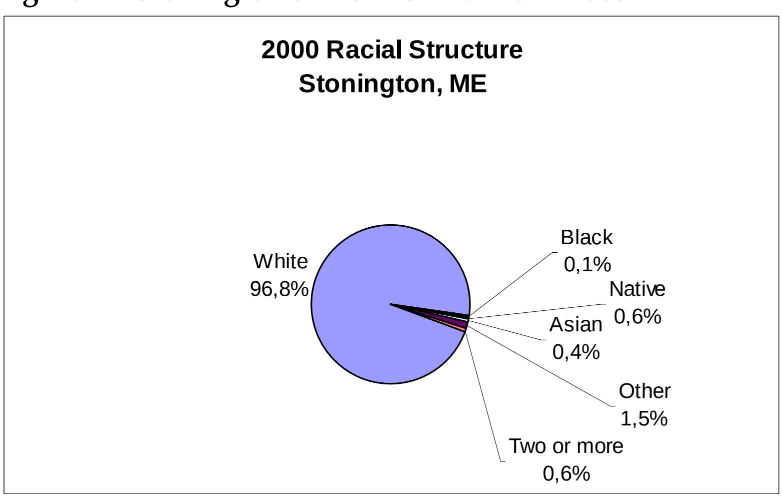
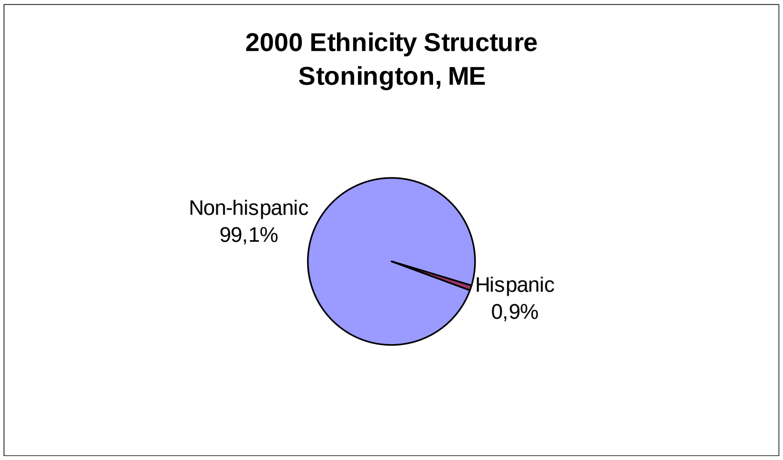


Figure 15. Stonington's Ethnic Structure in 2000



For 96.8% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 3.2% in homes where a language other than English was spoken, including 0.3 % of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over in 2000, 76.7% were high school graduates or higher and 15.6% had a bachelor's degree or higher. Again of the population 25 years and over, 8.3% did not reach ninth grade, 15% attended some high school but did not graduate, 42.9% completed high school, 14% had some college with no degree, 4.1% received their associate degree, 10.3% earned their bachelor's degree, and 5.3% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data in 2000 the religions with the highest number of congregations in Hancock County included Catholic (10 with 6,292 adherents), United Church of Christ (19 with 1,957 adherents), American Baptist Churches USA (17 with 1,774 adherents), and United Methodist (17 with1,074 adherents). The total number of adherents to any religion was up 25.2% from 1990.

Issues/Processes

Stonington is one of the few Maine fishing communities that has secured waterfront access for commercial fishing. This is largely due to the fact that Stonington has not yet witnessed the rise in property values that southern and midcoast Maine have experienced.[77] Steve Johnson of the Stonington Fish Pier pointed out that there aren't any problems other than dealers in Stonington. Allegedly, dealers will not sell gas or bait to fishermen if they sell their catch to the Stonington Pier.[78]

Cultural Attributes

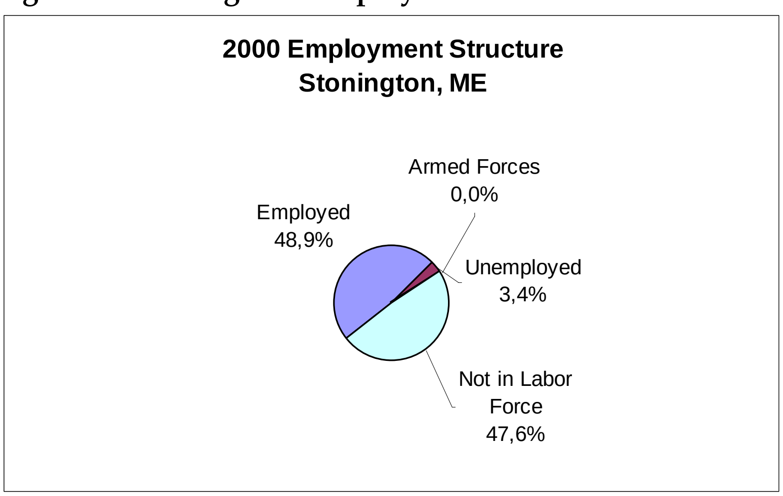
Two of the major events held each summer are the Fourth of July parade and Fisherman's Day. Early in the morning of the Fourth of July Events are the 6K Road Race and Fun Run in Downtown Stonington. The parade is later in the morning in Deer Isle Village. The 3rd of July of each year, the Fish & Fritter Fry starts in the late afternoon on the Stonington Fish Pier followed by fireworks over Stonington Harbor at nightfall. The 18th of July the annual Lobster Boat Race takes place. The 25th of July is the annual Fishermen's Day celebration. It has become a popular event with a wide variety of activities for the whole family on and around the Stonington Fish Pier. These range from Coast Guard demonstrations to Wacky Rowboat Races to a very spirited Codfish Relay Race. The 30th of August the "Flash In The Pans" takes place at the Stonington Fish Pier to benefit Island Fishermen's Wives and the Island Community Center. [79]

2.4.2 Infrastructure

Current Economy

Greenhead Lobster LLC opened in 1997 at its shorefront buying station in Stonington. It supplies over a million pounds of Penobscot Bay lobsters to the national market each year. These lobsters are purchased daily from independent lobstermen. GreenHead Lobster LLC has a chilled, aerated lobster holding tank with bio-bed filtration, capable of holding 8,000 pounds of live lobster. Federal Express and refrigerated trucks ensure the lobster delivery.[80] Stonington Lobster Cooperative is another wholesale and retail vendor of seafood in Stonington.[81] There are four shellfish dealers in Stonington: Carter's Seafood, Ingrid Bengis Seafood, Morning Star Seafood and Oceanville seafood.[82] According to the US Census 2000, 52.4 % (928 individuals) of the total population over 16 years of age and over were in the labor force, of which 3.4% were unemployed and 0.0% were in the Armed Forces. The biggest employer on the island is Billings Diesel and Marine Services, Inc. with 60 people located in Stonington.[83]

Figure 16. Stonington's Employment Structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 104 or 22.9% of all jobs. Self employed workers, a category where fishermen might be found, accounts for 177 or 39.0% of the labor force. Retail trade (15.2%), educational health and social services (10.8 %), and arts, entertainment, recreation, accommodation and food services (10.3%) were the other primary industries.

Median household income in Stonington in 2000 was $28,894 (a considerable increase since 1990 when the median household income was $19,038) and median per capita income in 2000 was $15,634. For full-time year round workers, men made approximately $8,437 more per year than women.

The average family in Stonington in 2000 consisted of 2.78 persons. With respect to poverty, 9.6% of families (down from 13.2% in 1990) and 12.7% of individuals earned below the official US Government poverty line, and 51.1% of families in 2000 earned less than $35,000 per year.

In 2000, Stonington had a total of 911 housing units, of which 55.2% were occupied and 81.0% were detached one unit homes. Fewer than half (43%) of these homes were built before 1940. There were a number of mobile homes and some boats in this area, accounting together for 10.6% of the total housing units; 94.5% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $96,300. Of vacant housing units, 83.0% were used for seasonal, recreational, or occasional use. Of occupied units, 23.3% were renter occupied.

Governmental

Stonington has a Board of Selectmen (5 individuals) and a town manager.[84]

Fishery involvement in government

Information on fishery involvement in government in Stonington is unavailable through secondary data collection methods or does not exist.

Institutional

Fishing associations

Stonington Fisheries Alliance includes 44 participants from 6 ports in Maine. The association is a member of the Northwest Atlantic Marine Alliance (NAMA).[85]
Other associations are Stonington Lobster Cooperative, Downeast Lobstermen's Association in Deer Isle, Deer Isle-Stonington Shellfish Committee, Island Fishermen's Wives Association and Maine Gillnetters Association in Stonington.[86]

Fishery assistance centers

The Island Fishermen's Wives Association supports the fishing community in many ways, including through school programs and scholarships, emergency financial assistance to fishing people and their families, and survival and safety education with help from the U.S. Coast Guard. The Association is committed to preserving the fishing heritage of the island and to educating the public about the industry.[87]

Other fishing related institutions

The Maine Sea Grant Program, the School of Marine Sciences, and the Lobster Institute, all located in Orono, ME, are involved in Stonington fisheries.[88] The Commercial Fisheries News, the premiere monthly fishing industry newspaper for the Atlantic coast, is located in Stonington.[89] The Lobster Zone Council (for Zone C) is empowered by the state legislature to set trap limits and otherwise manage the lobster fishery on a zone-by-zone basis, subject to approval by the state's Department of Marine Resources.[90]

Physical

At the southern end of Deer Isle, Stonington is accessible via Maine's meandering Route 15, 36 miles south of the intersection of Route 15 with U.S. Route 1. Stonington has a general aviation airport. Bar Harbor in Hancock County, ME (52 miles from Stonington), has a national airport.[91] The city of Bangor in Penobscot County, ME (58 miles from Stonington), has an international airport.[92] The Isle au Haut mailboat provides service between Stonington, ME and the town landing at Isle au Haut, with summer service to the Acadia National Park campground at Duck Harbor. Downeast Transportation operates bus services to Ellsworth from Stonington, Bucksport, Otis, and Winter Harbor.[93]

Stonington's fish pier, built with federal funds in 1984 at a cost of approximately $3 million to support commercial fishing, maintains public space for fishermen to keep skiffs, park trucks and unload their catch. It has space for about 80 punts, and parking for 58 trucks. The fish pier serves as a place for lobstermen, urchin divers and mussel harvesters to haul out their catch. Few groundfish boats are still working out of Stonington, mostly because of a combination of federal regulations and groundfish scarcity. [94] However, the waterfront counts 380 fishing vessels.[95]

2.4.3 Involvement in Northeast Fisheries

Commercial

In 2002 recorded annual landings for the state of Maine totaled 197 million pounds with a landed value of $279.4 million.[96] Stonington's annual landed value for 2003 was $20.5 million including an annual lobster landed value of $18.5 million. Herring was an important species, worth close to $1 million in 2003, more than twice the average value

for 1997-2004, and rock crab was also important, worth $505,710. Between 1997 and 2003 the number of vessels considerably increased.
The Maine purse seine fleet consists of five vessels with principal ports of Addison, Prospect Harbor, Rockland, and Stonington. This sector made 340 trips and landed 20,256 mt of herring in 2003. The majority of the landings were from vessels with a port designation of Rockland or Stonington. Ninety five percent of the landings by this sector came from Area 1A (adjacent to Stonington) in 2003. Eighty two percent of the total revenues for this sector came from Atlantic herring in 2003. Maine had the highest reported landings (46%) in 2003, followed by Massachusetts (38%), New Hampshire (8%), and Rhode Island (7%).[97]

Landings by Species

Table 10. Dollar Value by Federally Managed Groups of Landings in Stonington

	Average from 1997-2004	2003 only
Lobster	11,775,214	18,555,192
Herring	374,666	952,374
Scallop	218,460	109,350
Largemesh Groundfish	122,628	111,776
Monkfish	5,503	8,670
Skate	142	87
Smallmesh Groundfish	31	0
Squid, Mackerel, Butterfish	24	0
Other	943,278	817,379

Vessels by year

Table 11. All columns represent Federal Vessels Permits or Landings Value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Home port value ($)	Landed port value ($)
11997	44	36	653,135	10,718,821
11998	44	33	506,533	9,739,864
11999	46	33	270,941	9,123,045
22000	49	35	234,698	18,003,137
22001	52	33	509,830	16,616,914

22002	59	40	429,571	21,733,899
22003	65	44	413,737	20,544,254

.

Recreational

One company specializing in kayak rentals also runs eco-tours from a lobster boat which includes pulling traps and selling the lobsters to passengers.[98]

Subsistence

Information on subsistence fishing in Stonington is either unavailable through secondary data collection or the practice does not exist.

Future

Currently there are plans for a community marine resource center in Stonington. It will serve fishermen in the Lobster Zone C area, including North Haven, Vinalhaven, Matinicus Island, Isle au Haut, Deer Isle and the Blue Hill peninsula.[99] Also in the works is a lobster hatchery which is estimated to produce as many 150,000 lobsters to be distributed evenly throughout the area.[100]

Many lobstermen in 2004 believe economic conditions will worsen due to more stringent regulations. However, many have accepted regulations and note little if any ill effect on their own economic condition.[101] The main concern of Stonington fishermen is the threat of the lobster fishery crashing. This is pronounced in Stonington because the community's future is completely dependant on the recent record-setting lobster catches. Many fear that a loss of this dependence on the lobster fishery will force Stonington to transform from a working fishing community to a summer resort or retirement community.[102]

2.5 VINALHAVEN, ME

2.5.1 People and Places

Regional Orientation

The island town of Vinalhaven, Maine is located in Knox County (W 68:50:10, N 44:04:30). The area encompasses 22.1 square miles of territory.

Map 5. Location of Vinalhaven Maine

Historical/Background Information

Traditionally the economy of Vinalhaven has relied upon fishing, farming, logging, boat building and, for women, the knitting of fish nets. In 1826 however the high quality of Vinalhaven's granite was discovered and it became one of Maine's largest quarrying centers. This attracted workers from surrounding states and later from the British Isles and Scandinavia. By 1919 the largest granite company had closed with the advent of structural steel and concrete as building materials. However, the paving block industry functioned until the late 1930's.[103]

Fishing has also been a major part of Vinalhaven's economy as the island has always been a major supplier of seafood to markets in Portland, Boston and New York; first as salted and dried fish, then canned lobster, canned fish, fish glue, cut and packed fresh fin fish, canned herring, fresh lobsters, scallops, shrimp and sea urchins. During the 1800's and into the mid- 1900's the Island had a large fleet of fishing vessels, some bringing home catches of 10,000 pounds or more. Currently lobsters are being frozen for shipment to U.S. and world-wide Markets. Not unlike most fishing ports, Vinalhaven's finfishing fleet has declined with the declining stocks.[104] Nonetheless, Vinalhaven has had a healthy fishing economy based on the size of the catch of its large lobster fishing fleet.

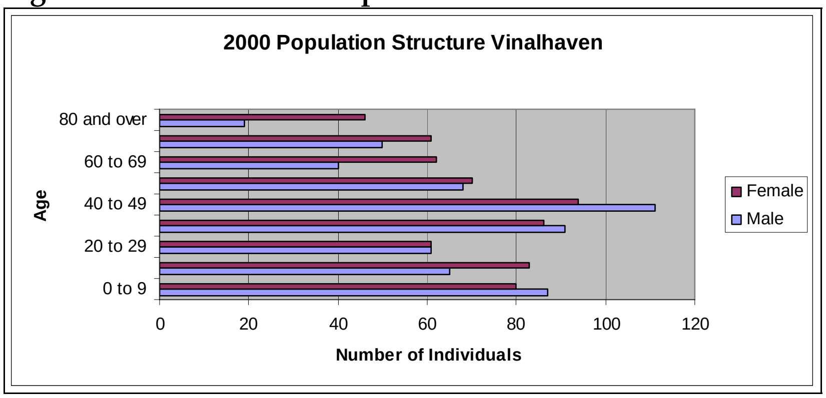
Demographic Profile

According to Census 2000 data, Vinalhaven had a total population of 1,235, up from the reported population of 1,072 in 1990. Of this total in 2000, 52.1% were female and 47.9%

were male. The median age for Vinalhaven in the year 2000 was 40.2 years and 73.7% of the population was 21 years or older while 20.9% of the population was 62 or older.

Vinalhaven's age structure showed a dip in the bracket of ages 20 to 29, common in many small fishing towns. But by ages 40-49 the population almost doubled from this low point. This may indicate young people leaving for school and other work, but then returning to Vinalhaven to live.

Figure 17. Vinalhaven's Population Structure in 2000



The majority of the population of Vinalhaven in 2000 was white (98.1%), with 0.3% Native American and 0.3% Asian. No Blacks or African Americans nor Hispanic/Latino residents were reported. Residents linked their heritage to a number of European ancestries including: English (29.6%), Irish (11.7%), French (8.2%) and Swedish (6.4%). With regard to region of birth, 74.7% were born in Maine, 23.7% were born in a different state and no residents of Vinalhaven were born outside the U.S.

Figure 18. Vinalhaven's Racial Structure in 2000

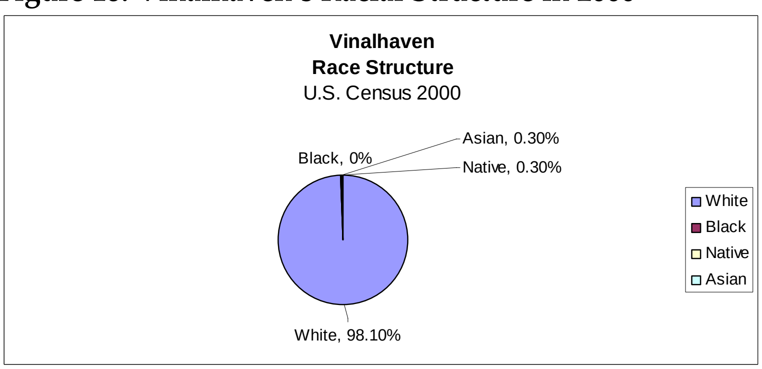
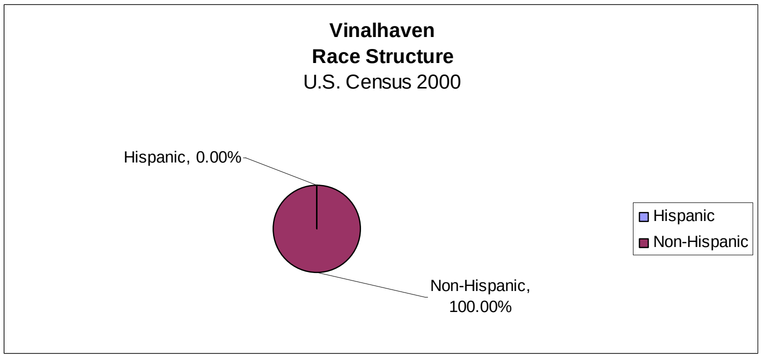


Figure 19. Vinalhaven's Ethnic Structure in 2000



For 96.0% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 4.0% in homes where a language other than English was spoken, including 0.6% of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over in 2000, 80.2% were high school graduates or higher and 20.4% had a bachelor's degree or higher. Again of the population 25 years and over, 3.8% did not reach ninth grade, 16% attended some high school but did not graduate, 44.3% completed high school, 12.9% had some college with no degree, 2.6% received their associate degree, 15% earned their bachelor's degree, and 5.4% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religions with the highest number of congregations in Knox County were American Baptist USA (11 with 1,490 adherents), United Methodist (7 with 1,138 adherents) and Catholic (5 with 4,274 adherents). The total number of adherents to any religion was down 1.0% from 1990.

Issues/Processes

In addition to depletion of fin-fishing and the increase in stringent regulation, Vinalhaven like so many other ports struggles for waterfront access. Primarily, the fishing industry falls prey to development pressure, competition with tourism and recreation and rising property values.[105]

Cultural Attributes

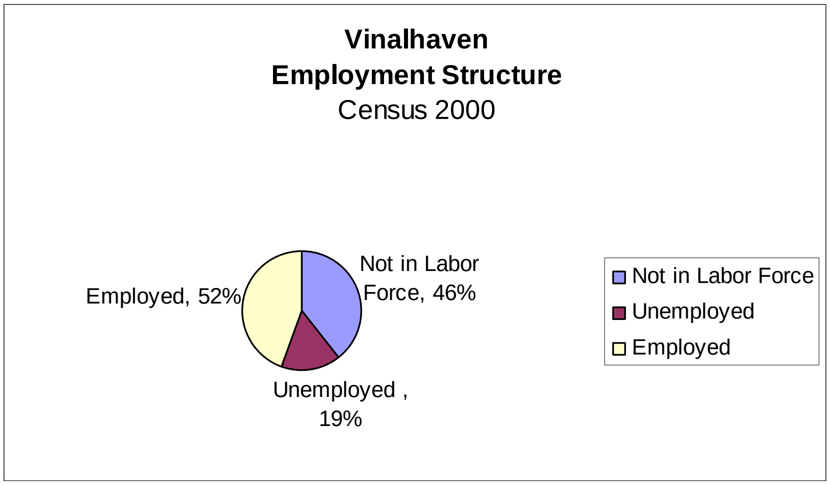
No information was collected regarding cultural attributes in Vinalhaven.

2.5.2 <u>Infrastructure</u>

Current Economy

According to the U.S. Census 2000, 53.9% (523 individuals) of the total population 16 years of age and over were in the labor force, of which 2.0% were unemployed and 0.0% were in the Armed Forces.

Figure 20. Vinalhaven's Employment Structure in 2000



Median household income in Vinalhaven in 2000 was $34,087 (a considerable since 1990 when the median household income was $19,706) and median per capita income was $21,287. For full-time year round workers, men made approximately $18,443 more per year than women.

According to the U.S. Census 2000, jobs with agriculture, forestry, fishing and hunting accounted for 128 or 25.4% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 195 or 38.7% of the labor force. Construction (16.3%), educational, health and social services (14.5%) and entertainment, recreation, accommodation and food services (9.7%) were other primary industries.

The average family in Vinalhaven in 2000 consisted of 2.82 persons. With respect to poverty, 5.7% of families (down considerably from 14.7% in 1990) and 9.0% of individuals earned below the official US Government poverty line, and 16.4% of families in 2000 earned less than $35,000 per year.

In 2000, Vinalhaven had a total of 1,225 housing units of which 44.8% were occupied and 89.6% were detached one unit homes. Slightly over half (58.8%) of these homes were built before 1940. Mobile homes and boats accounted for 2.8% of the total housing units; 91.5% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $115,800. Of vacant housing units, 90.4% were used for seasonal, recreational, or occasional use. Of occupied units, 24.4% were renter occupied.

Governmental

Vinalhaven has a 5 member Board of Selectmen, meeting biweekly Full time and a Town Manager.[106]

Fishery Involvement in Government

No secondary information has been found on fishery involvement in government.

Institutional

Fishing Associations

Both wholesale lobster companies in Vinalhaven, Inland Seafood and Alfred Osgood, are members of The Maine Lobstermen's Association.[107]

Fishery Assistance Centers

Coastal Enterprises Inc.: A notable development in 2004 has been the creation of the Working Waterfront Investment Initiative, an action group that provides financing, pre-development costs, business planning, publicity and legal advice to commercial fishermen. According to Elizabeth Sheehan and Hugh Cowperthwaite at CEI, technical assistance and funding have been provided to 18 projects seeking to improve access to the ocean. To date, the group has responded to over 40 inquiries[108]

The Working Waterfront Coalition, a statewide advocacy group convened by the planning office's Coastal Program, is working on a tool to address the investment gap. Discussion at a recent coalition meeting focused on the creation of a grant and investment program to support businesses and communities that are committed to securing the future access needs of their fishing industry. The coalition recognizes that in order for a grant and investment program to be helpful, it must be responsive to the speed of the real estate market and robust enough to support numerous six-figure waterfront purchases. The Coalition intends to reach out to farming and forestry groups to ensure that its approach complements similar efforts elsewhere in Maine. The Working Waterfront Coalition has grown from twelve to over 100 members since its inception in March of 2003.[109]

The Island Fishermen's Wives Association supports the fishing community in many ways: school programs and scholarships, emergency financial assistance to fishing people and their families; ongoing commitment to preserve the fishing heritage and educating the public about the industry; survival and safety education with help from the U.S. Coast Guard.[110]

Other Fishing Related Institutions

No secondary data has been found on other fishing related institutions.

Physical

Vinalhaven is served daily by a ferry, operated by the Maine State Ferry Service, that departs from Rockland. Two boats, making several trips each day between Vinalhaven and Rockland, carry passengers, cars, bicycles and cargo trucks. Each ferry carries about 16 cars, or the equivalent. Foot passengers and bicyclists will almost always find space available on any ferry run, but the procedure by which one gets a car on the ferry can be confusing. There is no public transportation on the island. [111]

2.5.3 Involvement in Northeast Fisheries

Commercial

The majority of landings in Vinalhaven are lobster. There are 60 vessels that use Vinalhaven as their home port.[112] Maine's Department of Marine Resources reported in 2003 that 19,758,705 pounds of lobster were landed in Knox County. Two purse seiners land herring for bait in Vinalhaven.[113] There is also some shrimp and scallop fishing but no finfishing.[114] In 2003, the value of lobster landed was significantly higher than the average for 1997-2004, as was the catch of herring, the second most valuable species. Also important to the Vihalhaven fishery was the rock crab fishery, worth $326,226 in 2003.

The number of vessels home-ported has increased slightly from 1997 to 2003. Since 1997 the home port value has decreased by more than half while the landed port value has increased from $13 million in 1997 to $22 million in 2003. However, a significant reduction can be seen in 1998 and 1999.

There are no processing plants in Vinalhaven in 2004, however the town previously had a processing plant that they leased out to a private company known as "Claw Island"; it had 70 employees, and ran three 8-hour shifts which processed crabs or shrimp in winter, and lobster in summer. In 2000, Claw Island was bought out and after encountering too many problems operating the processing plant on the island, it moved to South Portland.[115]

Vinalhaven has several packaging companies that ship lobster to Portland and other inland locations for processing and distribution.[116] They include Vinalhaven Lobster Co. which packages lobster and ships inland to Portland for processing and Vinalhaven Fishermen's Co-op which operates as a wholesale lobster distributor.[117] Vinalhaven has two wholesale companies: Inland Seafood and Alfred Osgood.[118]

Landings by Species

Table 12. Dollar value of Federally Managed Groups of landings in Vinalhaven

	Average from 1997-2004	2003 only
Lobster	12,349,581	20,814,588
Herring	336,957	1,031,529
Scallop	20,971	0
Monkfish	269	0
Large Mesh Groundfish	227	0
Other	356,448	639,115

Vessels by Year

Table 13. All columns represent vessel permits or landings value combined between 1997 and 2003

Year	# vessels homeported	# vessels (owner's city)	Home port value ($)	Landed port value ($)
1997	55	58	2,003,337	13,016,421
1998	54	56	1,183,363	7,320,734
1999	59	60	1,572,567	9,273,123
2000	59	58	1,766,609	12,379,840
2001	58	60	1,036,243	18,571,121
2002	62	65	644,067	21,322,045
2003	60	60	763,276	22,055,061

Recreational

Information on recreational fishing in Vinalhaven is either unavailable through secondary data collection or the practice does not exist. [119]

Subsistence

Information on subsistence fishing in Vinalhaven is either unavailable through secondary data collection or the practice does not exist.

Future

A 2004 study, "Tracking Commercial Fishing Access," produced by Coastal Enterprises Inc. (CEI) for the State Planning Office's Coastal Program, suggests that the gap between the market value of working waterfronts and what can be financed by cooperatives and municipalities is likely to grow. The study indicates that midcoast Maine has the highest degree of vulnerability to waterfront access loss. Development pressure, competition with tourism and recreation and rising property values (an average of 58 percent coastwide between 2000 and 2004) are listed as the top causes of working waterfront loss.[120]

Following a boom in lobster catches in 2001, "virtually everyone, from biologists to old-time fishermen, expects the catches to drop again. But for now, Maine lobstermen are enjoying that rarest of modern maritime tales: a fisheries success story."[121] The perspective is that the lobster fishery in Vinalhaven will survive; however, fishermen see signs that the number of young people interested in becoming fishermen is dropping.[122] However, lobstermen are concerned with rising gas prices and property taxes.

Additionally, the boom in second homes sends gentrification creeping along the coast. "People move into Maine from out of state who do not understand the value of a working waterfront," says Patrice McCarron, executive director of the Maine Lobstermen's Association, a commercial-fishing industry group. Many newcomers "want more mooring for sailing, but not [the smell of] bait and engines running at 4 a.m. But this is part of our identity."[123]

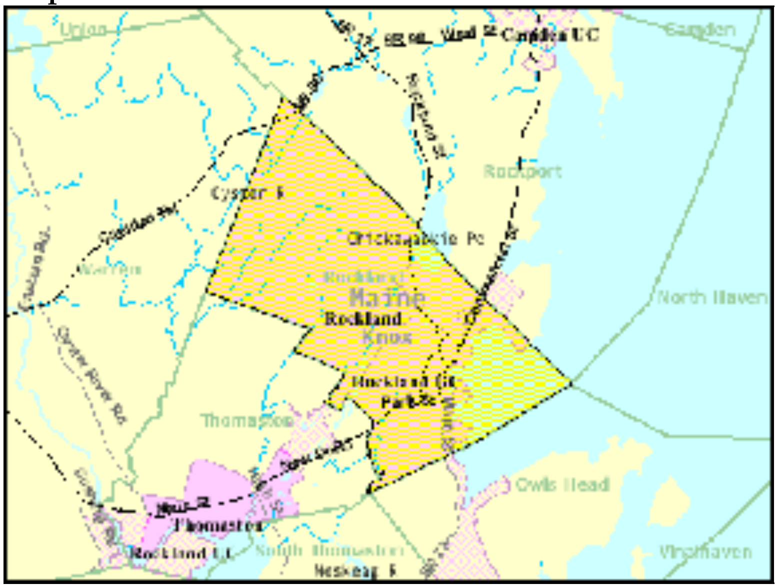
2.6 ROCKLAND, ME

2.6.1 People and Places

Regional orientation

Rockland (44.1°N, 69.1°W) is located in Mid-Coast Maine on Penobscot Bay in Knox County. The area encompasses approximately 12 square miles of territory and has approximately 7.5 miles of coastline.[124] It is 44 miles from Augusta and 54 miles from Brunswick, 82 miles from Portland, and 189 miles to Boston. The nearest cities include Camden, Thomaston, Waldoboro, Belfast, and Seaport.[125]

Map 6. Rockland's Location in Maine



Historical/Background Information

Rockland's economic history includes shipbuilding, commercial fishing, lime kilns, and granite quarries, the last of which are what the city is named for. "Throughout the historic period, a series of single industries have dominated Rockland's economy while its population has remained remarkably stable. Lime production, for mortar and plaster, was first, beginning with the earliest Europeans in the area in the eighteenth century and coming to its end in the 1930s. Shipping and shipbuilding were important outgrowths of the lime industry but shipbuilding ended by the early 1920s with the change from wood to steel as the favored material for shipbuilding.

Commercial fishing and fish processing followed lime as the main industry. Dominance by fishing was not nearly as long-lived as lime production; in Rockland, as elsewhere in New England, the collapse of commercial fishing took a great toll beginning in the 1980s; Rockland's fishing industry virtually ended by 1990. After a relatively brief period of decline and depression, residents and outside interests have been able to transform Rockland into a tourist destination and fine arts center. In addition, manufacturing and service (outside of tourist-related service) are important, but smaller, components of the city's economy today."[126]

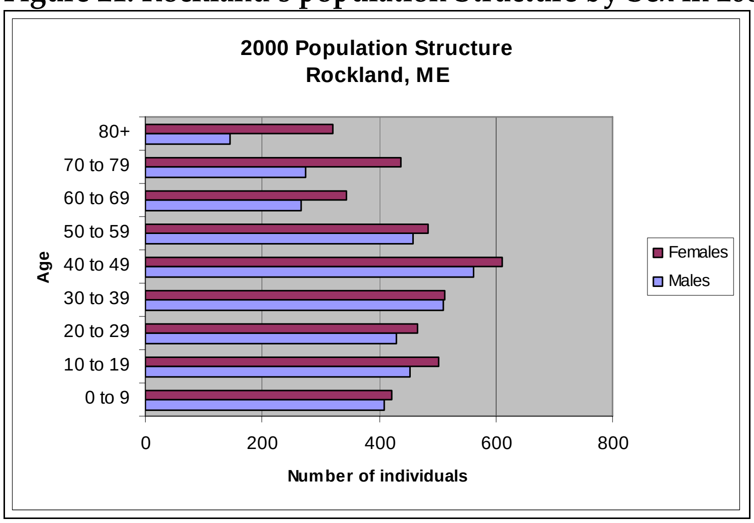
Newspaper and internet sources do not state when the fishing industry became a significant part of Rockland's economy. Fishermen have probably caught lobster off of Rockland Harbor for the past century, but the groundfish catches were not significant until much later. "Two offshore fleets based here (O'Hara and National Sea Products) fished in Canadian water until 1984 when the Hague Line, the international boundary established by the International Court of Justice in The Hague, Netherlands, led to the exclusion of U.S. fishermen from Canadian fishing grounds. Groundfish processing plants that relied primarily on Canadian fish continued producing product for U.S. government contracts until the early 1990s. In the 1970's the city also had a major shrimp plant and served as a primary herring-processing center with two sardine plants, the last one of which closed about 12 years ago [quote from 2001]."[127]

Demographics

According to Census 2000 data, Rockland City had a total population of 7,609, down from the reported population of 7,972 in 1990. Of this total, 53.9% were female and 46.1% were male. The median age was 40.9 years and 75% of the population was 21 years or older, while 21.8% of the population was 62 or older.

Rockland had a similar age structure to many other small fishing towns in that there was a dip in population within the 20-29 year age group.

Figure 21. Rockland's population Structure by Sex in 2000



The vast majority of the population of Rockland in 2000 was white (97.9%) with only 0.6% of residents Black or African American, and 0.2% American Indian. In addition, Hispanics/Latinos make up 0.6% of the population. Residents linked their heritage to a number of ancestries including: English (21.8%), Irish (13.6%), Scottish (5.3%), American (10.3%) and other (14.9%). With regard to region of birth, 73.0% were born in Maine, 24.6% were born in a different state and 1.6% were born outside of the U.S. (including 0.7% who were not United States citizens).

Figure 22. Rockland's Racial Structure in 2000

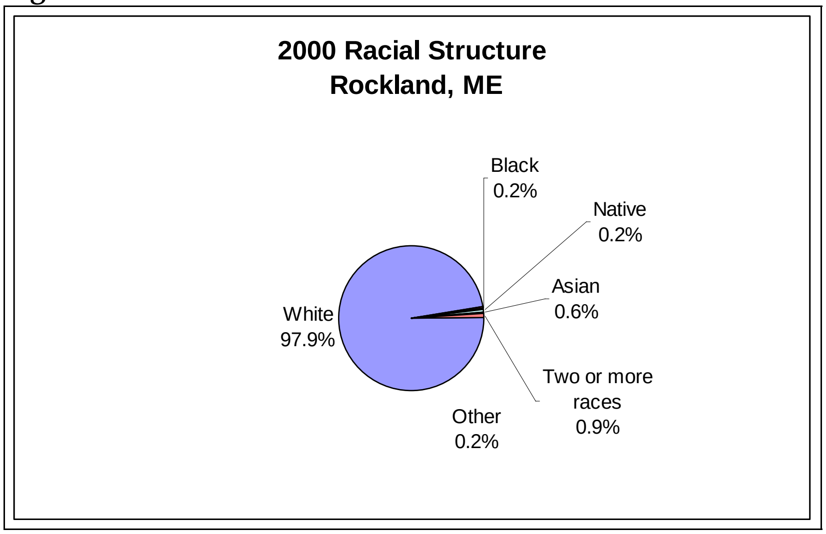
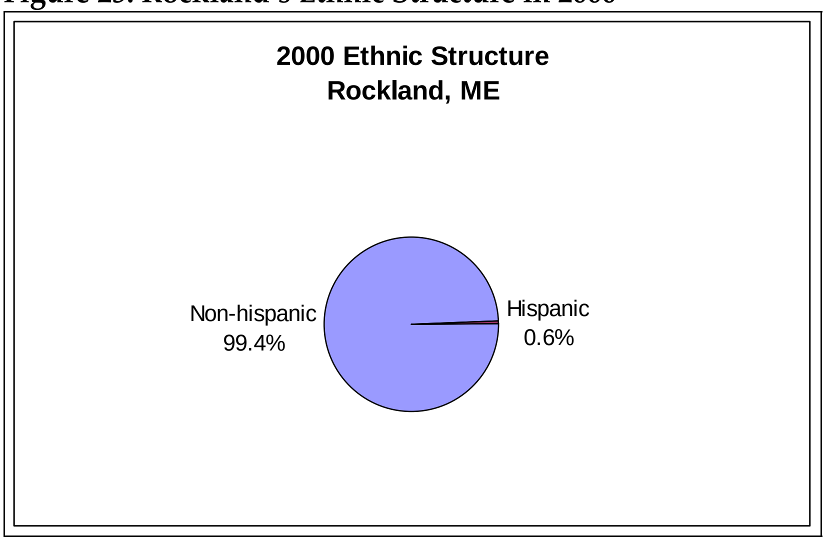


Figure 23. Rockland's Ethnic Structure in 2000



For 96.3% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 3.7% in homes where a language other than English was spoken, including 0.3% of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 83.3% were high school graduates or higher and 20.4% had a bachelor's degree or higher. Again of the population 25 years and over, 4.7% did not reach ninth grade, 12% attended some high school but did not graduate, 38.3% completed high school, 20.0% had some college with no degree, 4.6% received their associate degree, 13.5% earned their bachelor's degree, and 6.9% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive in 2000 the religions with the highest number of congregations in Knox County included American Baptist Churches (11 with 1,490 adherents), Catholic (5 with 4,274 adherents) and United Methodist (7 with 1,138 adherents). The total number of adherents to any religion was down 1.0% from 1990.

Issues/Processes

Like other fishing communities in the Northeast, Amendment 13 brought significant changes to the local fishing industry. However, this groundfish recovery act may have had less economic impact on Rockland than on communities farther east in Maine because other fisheries such as herring and lobster have played a larger role in Rockland's economy.[128] The following excerpt, from "The Future of the Rockland Fish Pier" conducted by Coastal Enterprises in 2003, summarizes the main fisheries issues that the city of Rockland currently faces: "With the end of large-scale fish processing in Rockland, the City has become simply one of a score of ports in the midcoast-Pen Bay region where fish and shellfish may be landed and sold, or trucked to Portland for auction at the Portland Fish Exchange. Unlike herring, where there is a critical mass of vessels and bait dealers operating at the port, Rockland has no significant competitive advantage in other fisheries. In groundfish it plays a secondary role in the region to Port Clyde; in lobsters, to Stonington, Friendship and Spruce Head; in urchins, it shares a sharply declining catch with a dozen ports. What is significant about Rockland, though, is the fact that the Fish Pier provides open, public water access - either primary or alternate - for participants in several fisheries.

"A further element in the herring fishery was the emergence and then the disappearance of foreign processing vessels buying herring caught in U.S. waters. The years 1996 and 1997 saw purchases of significant tonnage in Rockland harbor, but this has not been repeated. The 1990s saw Rockland emerge as the hub of herring landings for Maine, and the point from which bait was distributed throughout the region from Casco Bay to the Canadian border. The presence of foreign processing vessels saw landings in Rockland peak in 1996 at 36,886 metric tons."[129]

Cultural Attributes

August 2004 marked the 57th annual celebration of the Maine Lobster Festival. Presented by the Rockland Festival Corp., this festival celebrates the importance of lobster to Rockland and the surrounding area with entertainment and seafood.[130]

2.6.2 <u>Infrastructure</u>

Current Economy

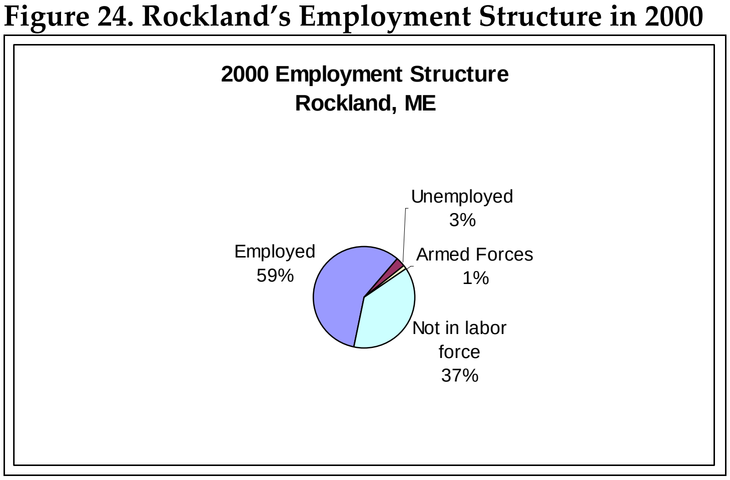
Other than fishing, and boat building and repair, Rockland City has other more recent industries stabilizing its economy such as furniture and playground equipment manufacturing, biotechnology industries, wholesale distribution, marine-related businesses, seaweed processing, metal fabricating, and food related industries. "The structure of the economy in the Rockland LMA [Labor Market Area] has been shifting from manufacturing to services, retailing, and construction for many decades."[131] "The City continues to attract new industries to broaden its industrial base while retaining traditional industries such as ship and boat building and repair. The relatively broad base has made the city less vulnerable to economic fluctuations in any single industry or product line."[132]

The major employers of Rockland include medical centers, banks, food distributors, schools, and government facilities. Other private industries demonstrate the diversity of Rockland's economy. They include the following companies with the range of employees in parentheses: MBNA Marketing Systems Inc, a banking corporation (701-800); Samorock LLC, a hotel resort company part of a Florida-based group; Fisher engineering, snow and ice control equipment company (151-200); Maritime Energy, started in 1939, provides heating oil and other energy products to residents and businesses of the region (151-200); Osram Sylvania Products Inc, a lighting products company (126-150); Tibbetts Industries Inc, a medical electronic supplier (101-125); and Dragon Products, the largest supplier of ready-mix concrete in Maine (101-125).

According to the U.S. Census 2000, 63% (3,876 individuals) of the total population 16 years of age and over were in the labor force, of which 3.0% were unemployed and 1.0% were in the Armed Forces.

Major manufacture employers in Knox County in 2002 included companies producing the following: snow plows, seaweed extractives, newspapers, bio-medical products, and bituminous concrete (see footnote 127).

Figure 24. Rockland's Employment Structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 119 or 3.3% of available jobs. Self employed workers, a category where fishermen might be found, accounts for 502 or 13.8% of the labor force. Educational, health and social services (18.9%), retail trade (14.1%) and arts, entertainment, recreation, accommodation and food services (13.3%) were the primary industries.

Median household income in Rockland City in 2000 was $30,209 (a considerable increase since 1990 when the median household income was $22,006) and median per capita income was $16,659. On average, male full-time year round workers make approximately $7,000 more per year than their female counterparts.

The average family in 2000 consisted of 2.78 persons. With respect to poverty, 10.4% of families (down from 12.6% in 1990) and 15.9% of individuals earned below the official US Government poverty line, and 46.9% of families in 2000 earned less than $35,000 per year.

In 2000 Rockland City had a total of 3,752 housing units of which 91.5% were occupied and approximately half (52.7%) were detached single unit homes. Over fifty percent (51.1%) of these homes were built before 1940. There were a number of mobile homes in this area, accounting for 4.9% of the total housing units; 92.3% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $82,400, which is almost $30,000 less than the county average. Of vacant housing units, 25.2% were used for seasonal, recreational, or occasional use. Of occupied units, 45.8% were renter occupied.

Governmental

The city of Rockland's governance is by the City Council and a City Manager. The city operates under the City Charter and the Rockland Code.[133]

<u>Fisheries involvement in the government</u>

Fisheries involvement in the government was not identified in this research.

Institutional

<u>Fishing associations</u>

No active fishing associations were identified for Rockland.

<u>Other fishing-related organizations</u>

The Island Institute, located in Rockland, promotes ecological research to help conservation efforts of 15 Maine island communities, which includes research on fisheries, especially that of lobster fisheries.[18] Until mid 2004 the Conservation Law Foundation (CLF) had an office based in Rockland, but it is now located Brunswick.

Physical

There is transportation access to and within the city of Rockland. It has both an interstate and state highway system, and Amtrak will soon reach Rockland. It has one municipal airport. Larger airports near Rockland are Bangor International (52 miles), Brunswick NAS (59 miles), and Portland International (89 miles). There are no hospitals within the limits of Rockland, but the three most accessible are Penoboscot Bay Medical Center in Rockport (approx. 6 miles), Waldo County General Hospital in Belfast (approx. 24 miles), and Miles Memorial Hospital in Damariscotta (approx. 27 miles). There are two public high schools in Rockland, three public and one private primary/middle school.[19] Rockland has a municipally-owned pier designated to fishing, which was built after the Magnuson Act to promote the fishing industry during the Fish Pier Program. This provides off loading facilities and ice. Landings are then trucked to Portland for processing since the sardine canneries have all closed in Rockland.

2.6.3 Involvement in Northeast Fisheries

Commercial

According to the landings data collected on federally managed species, Rockland's commercial fishery is primarily based on the herring and lobster fisheries. Landings in 2003 were slightly higher than the average landings for herring for the period of 1997-2004, and slightly lower for lobster for the same period. The landings of largemesh groundfish species and of monkfish also slightly exceeded the 1997-2004 averages in 2003.

As of 2004 there were a total of 675 moorings, berthings, slips, and tie ups for commercial and recreational fishermen, of which 4% are used by commercial fishermen in Rockland. The city has 21 commercial private and public waterfront facilities, of which two are dedicated to commercial fishing use. Commercial fishing access is not perceived as a problem, but both issues of development pressures and the decline in the commercial fishing industry are reported as current threats to the commercial fishing access. [20]

Landings by species

Table 14. Dollar value by Federally Managed Groups of landings in Rockland

Species	Average from 1997-2004	2003 only
Herring	1,899,206	2,247,792
Lobster	1,815,151	1,748,842
Largemesh Groundfish	142,602	159,219
Scallop	91,164	30,123
Monkfish	87,429	101,675
Redcrab	3,324	0
Skate	634	108
Squid, Mackerel, Butterfish	72	0
Other	1,095,180	112,453

Vessels by year

Table 15. All columns represent vessel permits or total landings value annually between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port (in $100,000)	Level of fishing landed port (in $100,000)
1997	42	17	29.6	72.7
1998	32	16	13.3	64.4
1999	28	14	14.3	39.1
2000	29	14	10.6	82.1
2001	32	15	9.8	64.2
2002	30	13	9.1	43
2003	26	15	14.3	40.8

Recreational

There are a number of recreational fishing companies that are based in Rockland.[134] These include Big A Charters[135] and Holy Mackerel Charters.[136]

Subsistence

No information has been obtained at this time on subsistence fishing.

Future

A ferry terminal has been proposed for Rockland Harbor to provide service to Portland, Bar Harbor, and perhaps other ports within the Penobscot Bay region. The existing rail line between Brunswick and Rockland is in the process of being improved to allow passenger service to the ferry terminal. These changes would likely turn Rockland into a major port and would likely significantly increase both the number of tourists traveling to the area and the commercial use of the harbor area. Goals within the city's comprehensive plan include increasing public facilities for commercial fishing as needed and providing space for the commercial fishing industry along the proposed ferry dock if possible. At the same time, the city is also attempting to increase tourism to the harbor.[137]

Currently, lobster stations, herring vessels, and coastal tankers respectively reap the highest revenue for the Rockland Fish Pier. Some suggest that if groundfish stocks do recover as projected within the next five years, the fishing industry of Rockland will rejuvenate. While Rockland would benefit from the predicted increase in groundfish landings, the city's fishing industry has primarily depended on herring landings (used for lobster bait), all of which are now taken to the Portland for sale and processing.[138] No matter what happens with the fishing industry, it appears that Rockland is attracting more people as a tourist destination similar to many other areas in Maine.[139]

2.7 PORTLAND, ME

2.7.1 People and Places

Regional orientation

The city of Portland, Maine (43.66 N, 70.2 W) has 56.92 miles of coastline,[140] a terrestrial area of 54.9 square miles, and 31.4 square miles of water. It is located in Cumberland County on Casco Bay, and is adjacent to South Portland, Westbrook, and Falmouth. Portsmouth and Manchester, New Hampshire are the closest large cities.[141]

Map 7. Location of Portland City in Maine

Historical/Background information

Prior to English settlement in 1632, resident Native Americans referred to this region as *Machigonne*, meaning "Great Neck." This fishing and trading settlement changed names several times before it became Portland in 1786. The city was destroyed four times by various sources including Native American attacks, the British Navy during the American Revolution, and a fire. Each time it was rebuilt and now it is well-known for its preservation of Victorian-style architecture.

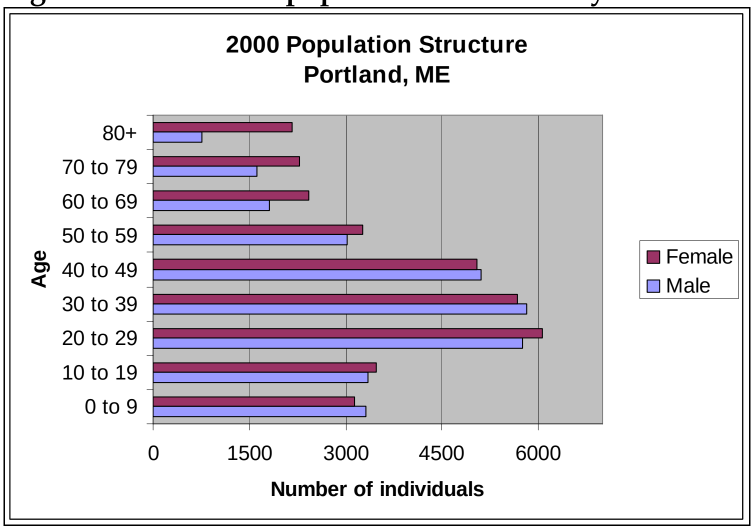
The city's port industries have driven its economy since its settlement. From the mid 1800s until World War I, Portland provided the only port for Montreal, Canada. Railroads from the south to the north fed through the city, facilitating trade and travel. Although Canada developed its own ports, and other cities in southern New England states built larger ports, the city remained tied to its maritime roots by depending on the fishing industry. More recently, it has become a popular cruise ship destination. Although tourism plays a major role in the city's economy, Portland functions as the second largest oil port on the east coast of the U.S., and as valuable fishing port.[142] For a more detailed history of Portland and the surrounding fishing communities, refer to Hall Arber et al. (2001)[143].

Demographic Profile

Portland is the largest city in Maine and has the highest population in New England north of Boston. According to Census 2000 data, Portland City has a total population of 64,257, down from a reported population of 64,358 in 1990. Of total population, 52.1% are female and 47.9% are male, which is very similar to the U.S. average percentage of males and females. The median age in 2000 is 35.7 years and 77.4% of the population is 21 years or older, while 15.7% of the population is 62 or older.

Portland's age structure varies from smaller fishing cities in that the age groups with the highest population in Portland are 20-29 years, 30-39 years and 40-49, while smaller fishing towns often had a much lower portion of its population between 20-29 years and higher between 0-19 years than Portland. This difference in age structure may be because Portland offers employment opportunities to 20-29 year olds (recent high school or college graduates) that smaller cities or rural towns cannot offer, especially in Maine.

Figure 25. Portland's population Structure by Sex in 2000



The vast majority of the population in 2000 (91.3%) was white, with 2.6% Black or African American, 0.5% Native American, 3.1% Asian, 0.1% Pacific Islander or Native Hawaiian, 0.7% "other", and 1.9% two more races. Of the total population, 1.5% regarded themselves as Latino or Hispanic. Residents linked their heritage to a number of European ancestries including the following: English (19.2%), French (10.5%), French Canadian (4.9%), German (6.9%) and Irish (21.2%). With regard to region of birth, 59.1% of residents were born in Maine, 32.4% were born in a different state and 7.6% were born outside the U.S. (including 5.0% who were not US citizens).

Figure 26. Portland's Racial Structure in 2000

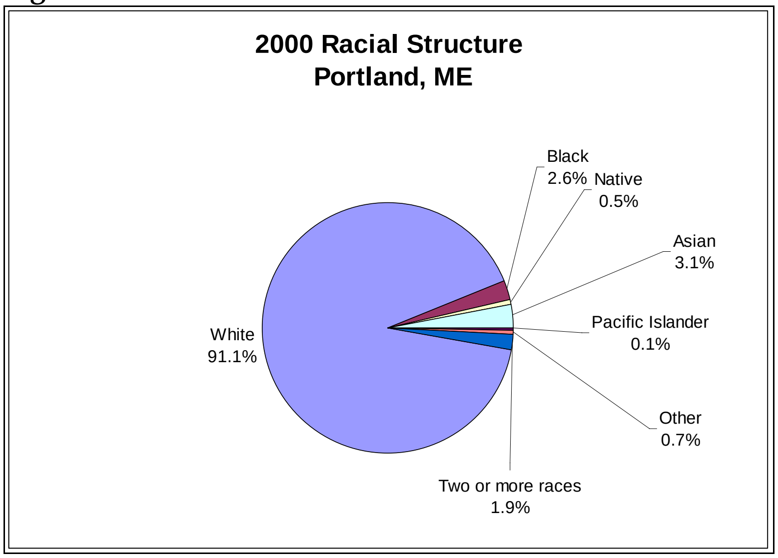
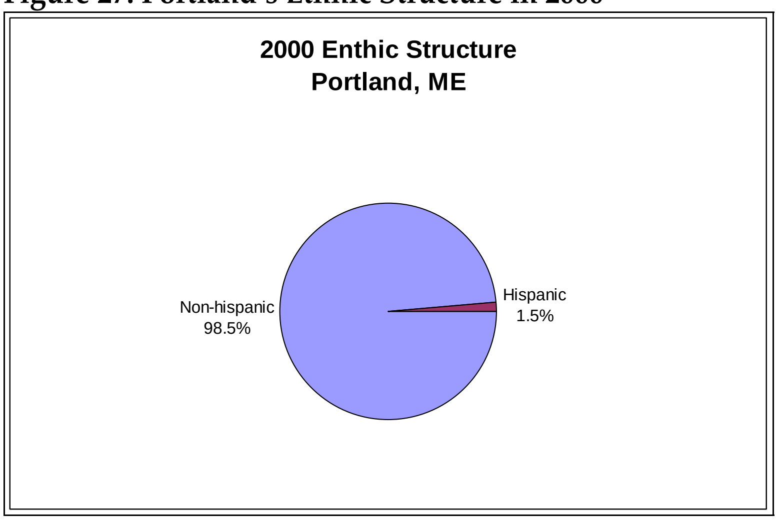


Figure 27. Portland's Ethnic Structure in 2000



For 90.1% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 9.9% in homes where a language other than English was spoken, including 3.8% of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 88.3% were high school graduates or higher and 36.4% had a bachelor's degree or higher. Again of the population 25 years and over, 4.3% did not reach ninth grade, 7.5% attended some high school but did not graduate, 25.9% completed high school, 19.3% had some college with no degree, 6.7% received their associate degree, 23.4% earned their bachelor's degree, and 13% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive in 2000 the religions with the highest number of congregations in the metro area of Portland included United Church of Christ (33 with 10,160 adherents), Catholic (31 with 61,495 adherents), United Methodist (26 with 5,690 adherents), Baptist (15 with 2,446 adherents), and Episcopal (11 with 4,577). The total number of adherents to any religion was up 24.6% from 1990.

Issues/Processes

Many newspaper articles in February-August 2004 discuss impacts of Amendment 13 on the fishermen of Portland and surrounding fishing communities. Amendment 13 limited fishermen's Days at Sea throughout the Northeast, but Maine fishermen feel they were put at more of a disadvantage than Southern New England because Maine is farther from George's Bank, which requires fishermen to use more of their allowed Days at Sea for travel rather than fishing.

Another issue in newspapers during this same time period is the question of how Portland's land-based fishing industry infrastructure will remain in business if landings become more sporadic. For example, if the Portland Fish Exchange were to go out of business, fishermen would have to travel to other large ports to sell their landings. To avoid this disaster, the federal government implemented a program to keep the Fish Exchange afloat during the current strict groundfish regulations.

The main issue of worry for the fishing community in Portland and other towns in Maine is whether the fishing infrastructure can be maintained as Days at Sea and catches are limited. Most recently, there has been concern that herring fishing is threatening groundfish stocks.[144]

Cultural Attributes

In 2004, Portland's annual Blessing of the Fleet, coordinated by the Maine Fishermen's Wives Association[145] and the Seafarer's Friends Society,[146] was celebrated in mid-June.

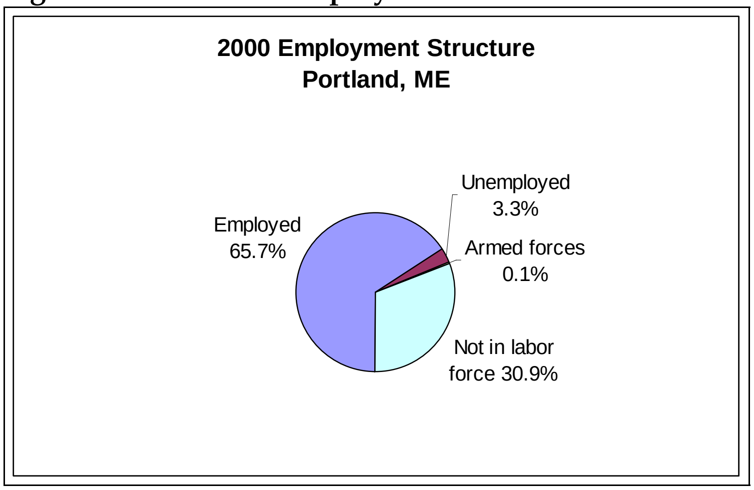
2.7.2 Infrastructure

Current Economy

Portland's waterfront provides most of the community's fishing industry infrastructure (e.g., Portland Fish Exchange). However, it also is the site of many other industries: recreation, tourism, light industry, transportation, cargo, and marine-related research, many of which compete for space with the fishing industry. The future of the waterfront depends on the next large scale project that the city passes in 2004-2005[147]. Potential additions to the waterfront property include the building of two large drill rigs, the additions of commercial businesses, or strengthening the current fishing industry infrastructure so that it can deal with predicted increases in groundfish stocks.[148]

According to the U.S. Census 2000, 70.1% (15,266 individuals) of the total population 16 years of age and over are in the labor force, of which 3.3% are unemployed and 0.1% are in the Armed Forces.

Figure 28. Portland's Employment Structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 144 or 0.4% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 2,512 or 7.1% of the labor force.
The major employers of Portland include L.L. Bean, public facilities (i.e., medical facilities, schools, post office) and private industry (i.e., phone, food, newspaper companies, and WalMart). A full list is below.[149] According to the Census, in 2000 major industries were Retail trade (13.5%); Professional, scientific, management, administrative, and waste management services (11.2%) and Finance, insurance, real estate, and rental and leasing (10.6%).

Table 16. Portland's top 25 employers in 2004

	Employer	Emp Range
1	Maine Medical Center	5101-5300
2	L L Bean Inc	4101-4300
3	Unum Provident	3401-3600
4	Hannaford Bros Co	2401-2600
5	University Of Southern Maine	2001-2200
6	Portland City Of	1401-1600
7	Us Post Office	1401-1600
8	Portland Public Schools	1401-1600
9	Mercy Hospital	1201-1400

	Employer	Emp Range
10	Anthem Health Systems	1201-1400
11	Fairchild Semiconductor Corp	1001-1200
12	Shaws Supermarkets Inc	1001-1200
13	Banknorth N A	1001-1200
14	Attendant Services Inc	901-100
15	Wal Mart Associates Inc	801-900
16	Standish Schools	701-800
17	Verizon New England Inc.	701-800
18	Barber Foods	701-800
19	South Portland School Dept	601-700
20	National Semiconductor Corp	601-700
21	Goodwill Of Maine Inc	501-600
22	Scarborough School Dept	501-600
23	Windham School Dept	501-600
24	Maine Turnpike Authority	501-600
25	The Portland Newspapers	501-600

Median household income in Portland in 2000 was $48,763 (a considerable increase since 1990 when the median household income was $26,576) and median per capita income was $22,698. For full-time year round workers, men made approximately $3,655 more per year than women.

The average family in 2000 consisted of 2.83 persons. With respect to poverty, 9.2% of families (down from 10.3% in 1990) and 14.1% of individuals earned below the official US Government poverty line, and 33.4% of families in 2000 earned less than $35,000 per year.

In 2000, Portland had a total of 31,862 housing units of which 93.3% were occupied and 35.1% were detached one unit homes. Just less than fifty percent (49%) of these homes were built before 1940. Almost 0.2 percent of the population lived in mobile homes and none were recorded living on boats; 29.6% of detached housing units had between 2 and 9 units. In 2000, the median cost for a home in this area was $121,200. Of vacant housing units, 44.2% were used for seasonal, recreational, or occasional use while 57.5% of occupied housing units were renter occupied.

Governmental

Portland's city governance is by an elected mayor and city council. However, unique to many communities, city development is controlled by public forum rather than city government.

Fisheries involvement in government

No information was found in secondary sources at this time for the involvement of fisheries in the government in Portland.

Institutional

Fishing associations

One of the most important fishing associations in Portland is the Portland Fish Exchange. It was the first open display fish auction in the United States, and remains economically strong. According to the Fish Exchange website, it offloads and auctions approximately 90% of Maine's annual regulated groundfish catch.[150] Currently the auction receives landings in the mornings and auctions the fish at noon Sunday through Thursday.

Other fishing associations in Portland include Maine Urchin Harvesters Association, and the Associated Fisheries of Maine (AFM).

Fishing assistance centers

Information on fishing assistance centers in Portland is either unavailable through secondary data collection or it does not exist.

Other fishing related institutions

Seafarers Friend is a non-denominational Christian organization that assists fishermen and other seafarers at three New England ports: Boston, Portsmouth, and Portland.[151] Recently the Portland Fishermen's Monument Commission was established to increase awareness of the fishing industry by building a monument once they have raised necessary funds.[152]

Physical

The city of Portland has infrastructure that provides full access to and within the city. Portland has its own international airport, and it has several transportation options within and to the city. Amtrak, public buses, and interstate and state highway systems provide public access to the city. Public transit within the city includes a bus and a street car system.

2.7.3 Involvement in Northeast Fisheries

Commercial

Portland's landings come primarily from the large mesh groundfish species and from lobster. Monkfish and herring are also important species; monkfish landings in 2003 were higher than those of lobster.

In 2004 there are a total of 500 moorings, berthings, slips, and tie ups for commercial and recreational fishermen, of which 30% were used by commercial fishermen in Portland. A 2002 report by Coastal Enterprises, Inc. to the Maine State Planning Commission recorded 271 commercial harvesters. Portland has 22 commercial private and public waterfront facilities, of which nine are dedicated to commercial fishing use. Further, commercial fishing access is perceived as a problem, and issues of development pressures, increased competition from tourism/recreational use, and deterioration of infrastructure are reported as current threats to the commercial fishing access.[153]
Both the number of vessels home-ported and number of vessels registered with owner's living in Portland slightly decreased between 1997 and 2003. The dollar value of landings remained relatively stable, while the level of fishing by landed port in Portland significantly dropped in 2003 relative to the six years prior.

Landings by Species

Table 17. Dollar value by Federally Managed Groups of landings in Portland

	Average from 1997-2004	2003 only
Largemesh Groundfish	13,977,332	13,612,499
Lobster	11,865,929	4,437,470
Monkfish	4,654,339	6,524,417
Herring	1,855,238	2,686,168
Scallop	69,016	14,336
Smallmesh Groundfish	55,954	1,048
Skate	54,996	31,489
Squid, Mackerel, Butterfish	15,446	21,141
Dogfish	13,291	0
Summer Flounder, Scup, Black Sea Bass	12,919	0
Tilefish	1,983	6,165
Bluefish	172	254
Other	2,304,305	1,557,987

Vessels by Year

Table 18. All columns represent vessel permits or landings value combined between 1997-2003

Year	# vessels home ported	# vessels (owner's city)	Home port value (in millions of $)	Landed port value (in millions of $)
1997	123	49	14	43
1998	104	43	12	35
1999	116	47	15	42
2000	115	43	16	45
2001	109	39	15	34
2002	107	40	15	40
2003	114	40	15	27

Recreational

Portland contains a number of recreational fishing companies.[154] Go Fish Charters, Olde Port Mariner & Trolley Fleet, Indian II Deep Sea/Bay Fishing, and Maine Fishing & Diving are the recreational fishing companies out of Portland.[155] They offer boat charters and fishing excursions.[156]

Subsistence

Information on subsistence fishing in Portland is either unavailable through secondary data collection or the practice does not exist.

Future

Currently, in 2004, there is a heated conflict regarding the future use of the waterfront property. There are only three miles of waterfront and several industries are trying to expand, including private real estate development, commercial fisheries, cruise ship industry, and tourism and entertainment industries.[157,158]

Information on people's perception of the future has not been collected at this time.

3.0 NEW HAMPSHIRE

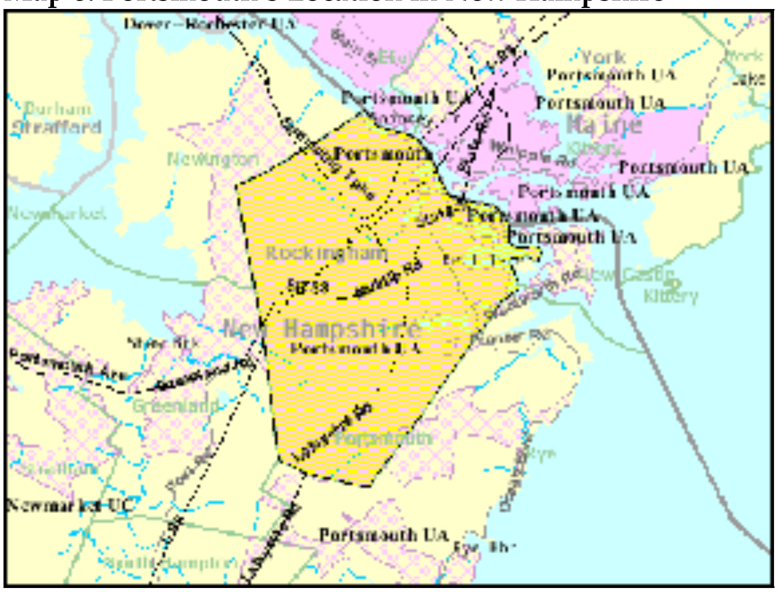
3.1 PORTSMOUTH, NH

3.1.1 People and Places

Regional Orientation

Portsmouth, New Hampshire (43.0717° N, 70.7631°W) is located by the mouth of the Piscataqua River which allows deep water access to Portsmouth Harbor.[159] Portsmouth is one of the cities that are located along the State's small seaboard of about eighteen miles.

Map 8. Portsmouth's Location in New Hampshire



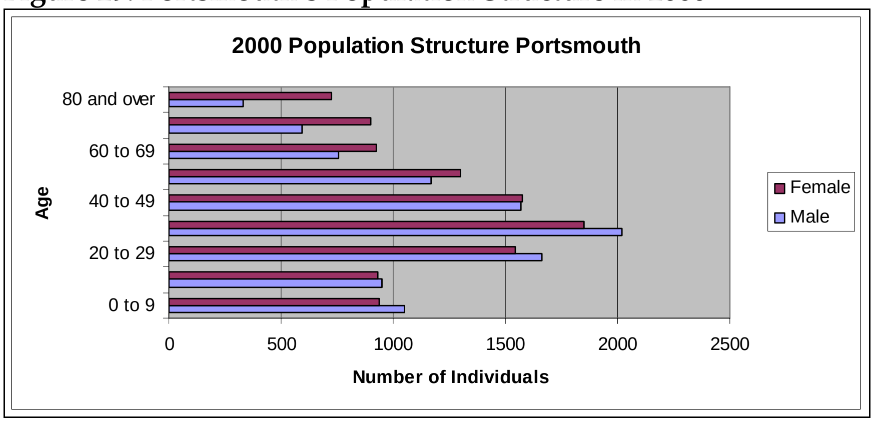
Historical/Background Information

The City of Portsmouth is the second oldest city in New Hampshire. It was originally settled in 1623 as Strawberry Banke and was incorporated as Portsmouth in 1631. Fishing, farming, shipbuilding, and coastal trade were the major industries throughout New Hampshire in the 1600s. By 1725, Portsmouth was a thriving commercial port, exporting timber products and importing a wide range of goods.[160] However, the 1800s brought change to Portsmouth as the seacoast declined as a commercial center. Many nearby towns, like Dover, Newmarket, and Somersworth turned instead to textile manufacturing.[161] The Portsmouth Naval Shipyard, established in June 1800, is the oldest naval shipyard continuously operated by the United States Government.[162] Today the urban sprawl of Boston has significant economic effects on Portsmouth and all of southern New Hampshire. A new interstate highway system as well as a favorable tax structure has encouraged many people to move to southern New Hampshire. Modern times have introduced high-tech industries and an increase in tourism that has transformed Portsmouth and all of southern New Hampshire, making New Hampshire into the fastest growing state in the Northeast.[163]

Demographic Profile

According to Census 2000 data, Portsmouth had a total population of 20,784, down from the reported population of 25,925 in 1990. Of this total in 2000, 51.4% were female and 48.6% were male. The median age for Portsmouth was 38.5 years and 80.7% of the population was 21 years or older while 18.7% of the population was 62 or older. Portsmouth's age structure shows its peak in the ages of 30-39. In general, the population is skewed slightly toward the younger age categories.

Figure 29. Portsmouth's Population Structure in 2000



The majority of the population of Portsmouth in 2000 was white (75.1%), with 12.3% Black or African American (much higher than other NH and ME communities), 0.9% Native American, 3.6% Asian, and 0.1% Pacific Islander or Hawaiian. Of the total population, 12.5% were Hispanic/Latino (also higher than most NH and ME communities). With regard to region of birth, 37.3% were born in New Hampshire, 56.5% were born in a different state and 4.9% were born outside the U.S (including 2.8% who were not United States citizens).

Figure 30. Portsmouth's Racial Structure in 2000

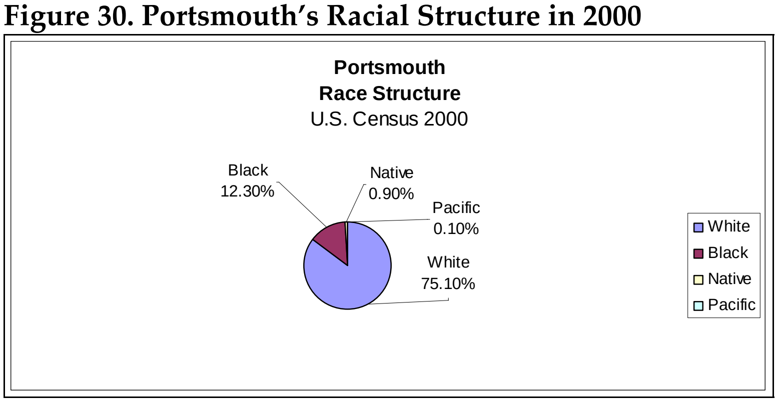
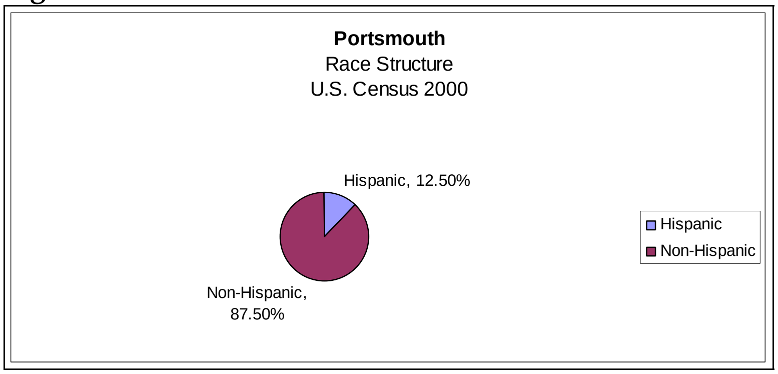


Figure 31. Portsmouth's Ethnic Structure in 2000



For 93.4% of the population 5 years old or higher in 2000, only English was spoken in the home, leaving 6.6% in homes where a language other than English was spoken, including 2.0% of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over in 2000, 91.4% were high school graduates or higher and 41.9% had a bachelor's degree or higher. Again of the population 25 years and over, 2.6% did not reach ninth grade, 6.1% attended some high school but did not graduate, 24.3% completed high school, 17.8% had some college with no degree, 7.3% received their associate degree, 28% earned their bachelor's degree, and 13.9% received either their graduate or professional degree.

Although the religion percentages are not available through U.S. Census data, according to Hall Arber et al. (2000) the number of Protestant churches in Portsmouth was 27 versus only one Synagogue and three Catholic Churches.[164] Further, the American Religion Data Archive indicates that in 2000, the religion with the highest number of congregations and adherents in Rockingham County was Catholic with 25 congregations and 117,542 adherents. Other prominent congregations in the county were United Church of Christ (23 with 6,352 adherents), American Baptist (21 with 4,449 adherents) and United Methodist (16 with 4,391 adherents). The total number of adherents to any religion was up 70.5% from 1990.

Issues/Processes

Not unlike most fishing communities, Portsmouth fishermen are concerned that their livelihood is dependent on regulations that they believe are overly stringent.[165] In 2002, the Portsmouth Fishing Co-op closed its doors due to changes in federal fishing restrictions. It has since reopened, but continues to struggle as it faces uncertain times.[166]

Cultural Attributes

Portsmouth boasts a number of museums, including the Albacore Park & Maritime Museum which offers year round submarine tours. Additionally, the Strawberry Banke Museum is a living museum that recreates life 300 years ago. Portsmouth also hosts an annual chowder fest which is the largest in New Hampshire. Beginning in 1980 Portsmouth once had a Blessing of the Fleet ceremony. However, due to an injury during the ceremony and a subsequent law suit the ceremony was forced to carry a large insurance policy that it could not afford. As a result, the ceremony no longer takes place.[167]

3.1.2 Infrastructure

Current Economy

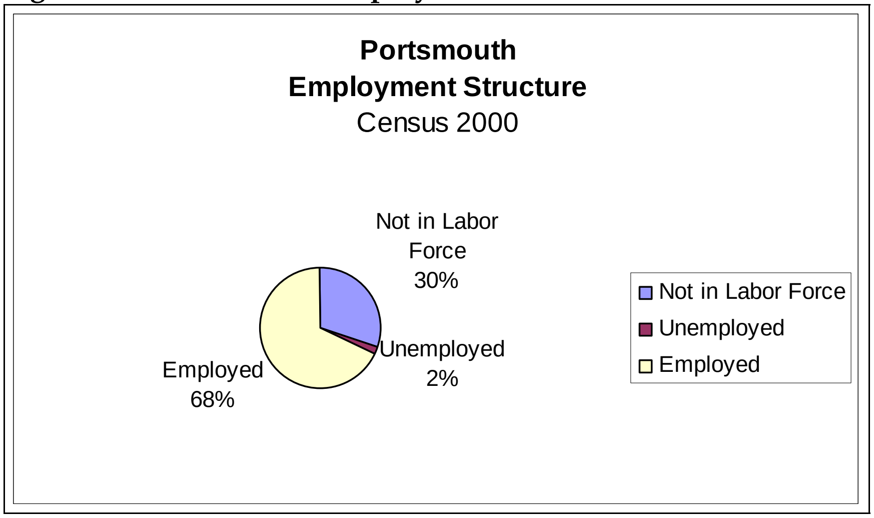
High-Liner Foods USA has a processing plant in Portsmouth that employs about 250 people.[168] It imports and processes frozen fish into breaded products for the wholesale and retail markets, and is one of the most modern and diversified fish processing plants in the world.
[169]

In 2004, the top employers in the city of Portsmouth were the following: Liberty Mutual (1800), Columbia HCA Hospital (1040), City of Portsmouth (881), Demoulas Market Basket (425), Lonza Biologies (390), Erie Scientific/Sybron Lab Products (310), Pam-Am Airlines/Boston-Maine Airways (300), US Department of State – National Passport Center (259), High-Liner Foods USA (241).[170]

According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 76 or 0.6% of all jobs. Self employed workers, a category where fishermen might be found, accounts for 1,084 or 9.1% of the labor force. Manufacturing (12.5%), retail trade (15.2%), professional, scientific, management, administrative, and waste management services (13.2%), educational, health and social services (18.8%) and entertainment, recreation, accommodation and food services (9.0%) were the primary industries.

According to the U.S. Census 2000, 69.9% (12,296 individuals) of the total population 16 years of age and over are in the labor force, of which 2.0% are unemployed and 0.3% are in the Armed Forces.

Figure 32. Portsmouth's Employment Structure in 2000



The median household income in 2000 was $45,195 (which increased since 1990 when the median household income was $30,591) and median per capita income was $27,540. For full-time year round workers, men made approximately $12,942 more per year than women.

The average family in Portsmouth in 2000 consisted of 2.75 persons. With respect to poverty, 6.4% of families (up from 5.1% in 1990) and 9.3% of individuals earned below the official US Government poverty line, and 24.7% of families in 2000 earned less than $35,000 per year.

In 2000, Portsmouth had a total of 10,183 housing units of which 97.1% are occupied and 40.2% are detached one unit homes. Less than half (39.9%) of these homes were built before 1940. Mobile homes account for 2.7% of the total housing units; 98.5% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area was $168,600. Of vacant housing units, 25.7% were used for seasonal, recreational, or occasional use. Of occupied units, 57.2% were renter occupied.

Governmental

Portsmouth's government is comprised of a mayor, 9 elected Council Members, and a city manager.[171] Portsmouth was settled in 1623 and incorporated in 1849.[172]

Fishery involvement in government

Information on fishery involvement in government is unavailable through secondary sources.

Institutional

Fishing Associations

The Portsmouth Fisherman's Cooperative was formed to provide fuel, ice and unloading services to the local, small-scale fishing community.[173] The Northeast Consortium, created with the support and leadership of U.S. Senator Judd Gregg (R-N.H.), has committed resources to fund the Portsmouth co-op staff to facilitate partnerships between the co-op and researchers in 2005.[174]

Fishing Assistance Centers

Seafarer's Friend is a non-denominational Christian organization found in Boston, Portsmouth, and Portland, that visits fishing vessels and other fishing related industries to provide assistance and religious counsel.

Other fishing related institutions

The Recreational Fishing Alliance is a national, grassroots political action organization representing individual sport fishermen and the sport fishing industry,[175] and the Coastal Conservation Association (CCA) is an organization composed of recreational fishermen and that addresses conservation issues nationally and at the state level. It was formed in 1998 in New Hampshire.[176]

Physical

Portsmouth has an extensive public transportation infrastructure including rail, ferry, and bus transportation. Portsmouth lies almost halfway between Portland, ME (52 miles), and Boston, MA (57 miles).

3.1.3 Involvement in Northeast Fisheries

Commercial

The primary fishing done by Portsmouth fishermen is large mesh groundfish and monkfish. Largemesh groundfish are the most valuable landings in Portsmouth during the 1997-2003 period. Additionally, monkfish, lobster, and sea scallops account for a large portion of the value of species landed in Portsmouth. In 2003, the value of largemesh groundfish and monkfish had declined from the 1997-2004 average values, while the value of lobster and scallops was higher than the average values for the same years.

The number of home ported vessels has varied between 1997-2003. In 1997 there were 54 vessels which increased to a high of 63 vessels in 2001, only to decrease back to 54 vessels in 2003. Thus, overall change has been minimal in this time period. As for the number of vessels where the owner's city is Portsmouth, it is marked by a more random accounting. The result has been a decrease of five vessels when comparing 1997 to 2003, again little overall change for the period. Landed value by vessels homeported in Portsmouth has steadily increased from $2.8 million in 1997 to $4.7 million in 2003. Landed value at the port of Portsmouth has fluctuated somewhat but has remained relatively stable between the years of 1997 and 2003.

Landings by Species

Table 19. Portsmouth, Value of Landings by Species

Species	Average from 1997-2004	2003 only
Largemesh Groundfish	1,797,339	1,690,891
Monkfish	1,187,553	997,357
Lobster	215,369	976,325
Scallop	166,205	339,362
Dogfish	109,825	18,070
Herring	36,831	184,903
Smallmesh Groundfish	16,253	2,264
Skate	4,685	2,742
Bluefish	3,095	2,714
Squid, Mackerel, Butterfish	2,814	368
Other	302,449	96,801

Vessels by Year

Table 20. Number of Homeported Vessels by Year

Year	# of vessels home ported	# vessels (owner's city)	Home port Value ($)	Landed port value ($)
1997	54	26	2,867,809	4,476,980
1998	44	20	2,875,939	3,421,488
1999	45	18	3,338,685	3,900,793
2000	62	21	5,156,955	5,456,999
2001	63	22	6,386,029	4,909,069
2002	59	25	4,340,580	4,146,607
2003	54	21	4,735,506	4,309,797

Recreational

Portsmouth supports a large recreational fishing industry. Numerous companies are available for deep sea fishing.[177] Many of these companies also offer whale watching and day cruises.

Subsistence

Information of subsistence fishing in Portsmouth is either unavailable through secondary data collection or the practice does not exist.

Future

When NMFS proposed Amendment 13 which closed vast areas to fishing, reduced the number of days fishermen can fish, and required new and expensive gear, New Hampshire Senator Judd Gregg (R) asked Senate Appropriations for more than $11 Million in economic assistance for New England fishing communities. If approved, each fishing community would receive $1 million to $2 million in assistance through its home state to create an "extremely low-interest" loan program, give grants, and possibly subsidize fishermen, according to Gregg.[178]
Portsmouth fishermen are concerned that NMFS regulations are overly stringent and will force them out of business. Specifically, they question the data gathering methods and ultimate validity of NMFS's stock assessments.[179]

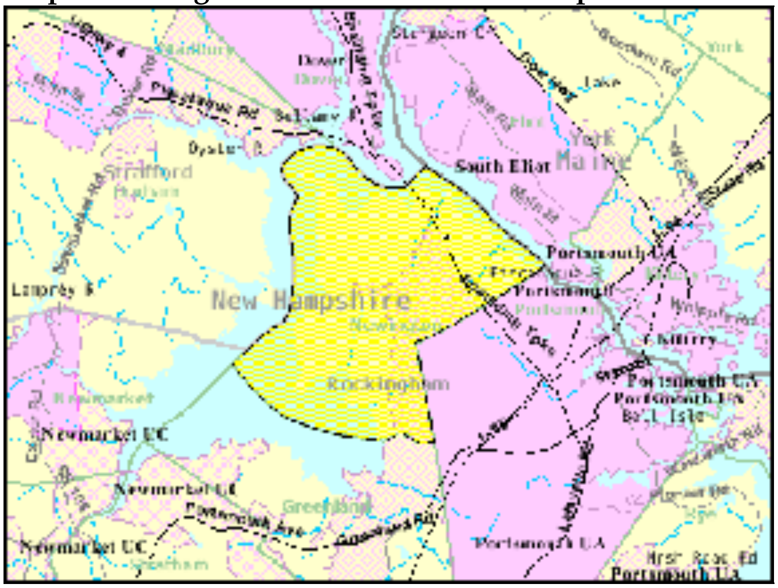
3.2 NEWINGTON, NH

3.2.1 People and Places

Regional orientation

The city of Newington (43.1°N, 70.8342°W) is located in New Hampshire's Seacoast Region in the county of Rockingham, 59 miles northeast of Boston, and 55 southwest of Portland. The town is bordered on three sides by the Piscataqua River and the Great Bay Estuary. Newington contains 8.2 square miles of land area and 4.1 square miles of inland water area.[180]

Map 9. Newington's Location in New Hampshire



Historical/Background information

This town was originally called Bloody Point, over early colonists' defeat of an attacking band of Native Americans in the late 1600s. Early in the 1700s, it was renamed Newington Parish. Newington is surrounded on three sides by the Piscataqua River and Great Bay.[181] The miles of navigable waterways of the extensive Great Bay estuary made transportation by vessel easier than by wagons over roads. Here early European settlers invented a sailing barge called the gundalow which sailed the waters from 1650s to the early 1900s, carrying bricks made of Great Bay blue clay, cord wood, fish, salt marsh hay, and other materials to Boston.

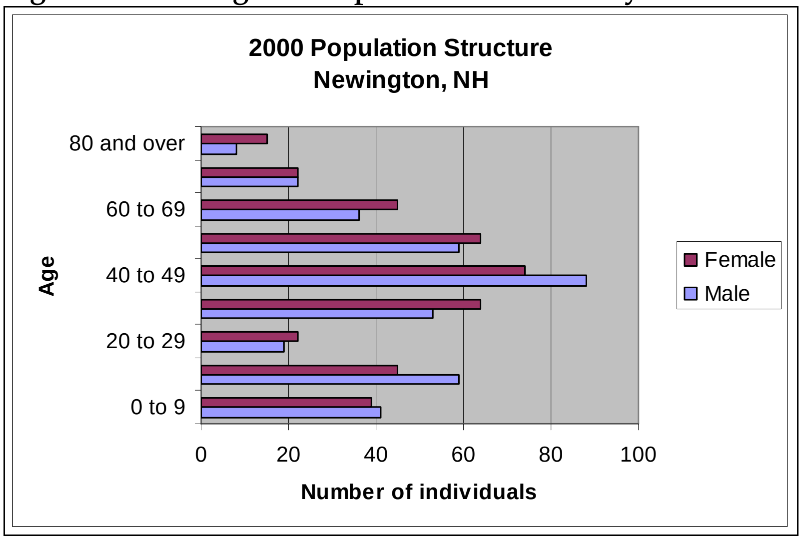
Today the shore of the lower estuary is heavily industrialized along the Piscataqua River. The presence of oil depots and power plants, as well as the development of a major port, have caused many to be concerned about the health of the estuary. This estuary is still an important site of recreational activity for residents and visitors alike. Both decision makers and the general public have begun to recognize the significance of the Great Bay Estuary to the shellfish and other marine fisheries.[182]

Demographic Profile

According to the Census 2000 data, the city had a population of 775, down from the reported population of 990 in 1990. Of this 2000 total, 49.7% were males and 50.3% were females. The median age was 42.6 years and 75.6% of the population was 21 years or older while 16.5% of the population was 62 or older.

Newington's population structure by age group shows that the highest percentage of the population in 2000 was between 40-49 years, and the percentages subtly decrease as age groups increase by decade. As is common in many smaller communities, there is a severe dip in the 20-29 age group, perhaps indicating out migration after high school for college or work. The fact that the population level at 40-49 is almost triple that of 20-29 may indicate people returning home in middle years.

Figure 33. Newington's Population Structure by Sex in 2000



The majority of the population of Newington in 2000 was white (96%), with 1.8% Black or African American, 1.0% Asian and 0.3% Native American. Of the total population, 1.8% identified themselves as Hispanic/Latino. Residents linked their heritage to a number of ancestries including: English (18.1%), Irish (9.7%), Scottish (7%), French (6.3%), and French Canadian (5.2%). With regard to region of birth, 47.6% were born in New Hampshire, 47.6% were born in a different state and 3.7% were born outside the U.S. (including1.4% who were not US citizens).

Figure 34. Newington's Racial Structure in 2000

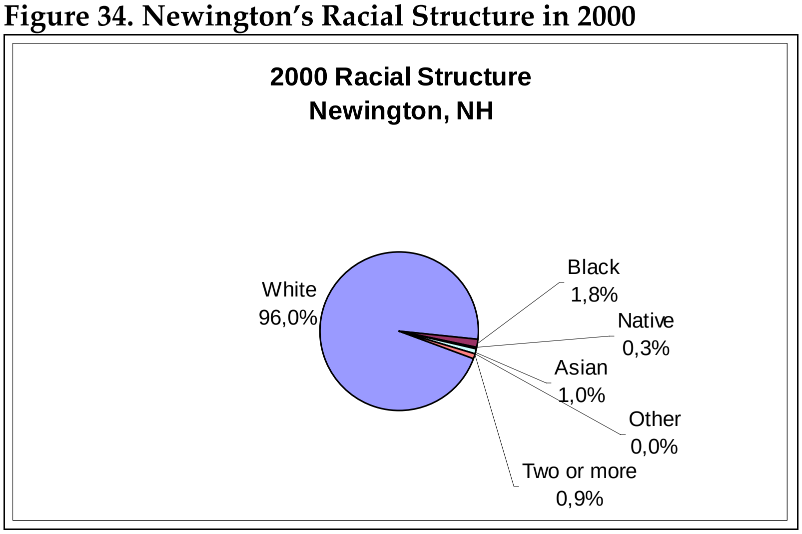
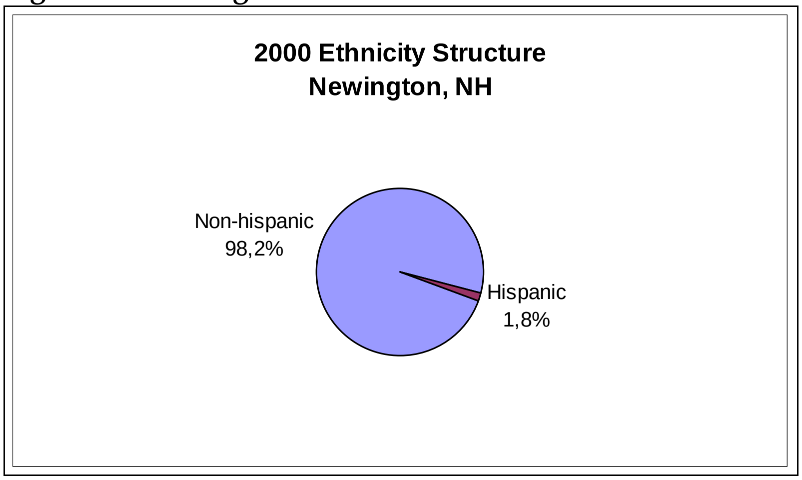


Figure 35. Newington's Ethnic Structure in 2000



For 92.3% of the population in 2000 only English was spoken in the home, leaving 7.7% in homes where a language other than English was spoken, including 3.4% of the population who spoke English less than 'very well' according to the 2000 Census.
Of the population 25 years and over in 2000, 86.4% were high school graduates or higher and 31.2% had a bachelor's degree or higher. Again of the population 25 years and over, 5.5% did not reach ninth grade, 8.1% attended some high school but did not graduate, 27.5% completed high school, 17.5% had some college with no degree, 10.2% received their associate degree, 23.1% earned their bachelor's degree, and 8.1% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religious Data Archive in 2000 the religions with the highest number of congregations in Rockingham County were Catholic (25 with 117,542 adherents), United Church of Christ (23 with 6,352 adherents), and American Baptist (21 with 4,449 adherents). The total number of adherents to any religion was up 70.5% from 1990.

Issues/Processes

New Hampshire in general, but towns closest to Portland such as Newington especially, are overrun by intense coastal development and tourism.[183] This is mainly because of Newington's picturesque coast and proximity to large cities such as Boston. The Newington fishing industry also competes with other water dependant industries. For example, Newington exports tallow (the by-product from animal fat renderings and deep-fryer grease) and steel scrap. One recent export is wood chips to Europe by ship for use as fuel for electrical power generating plants.[184]

Cultural Attributes

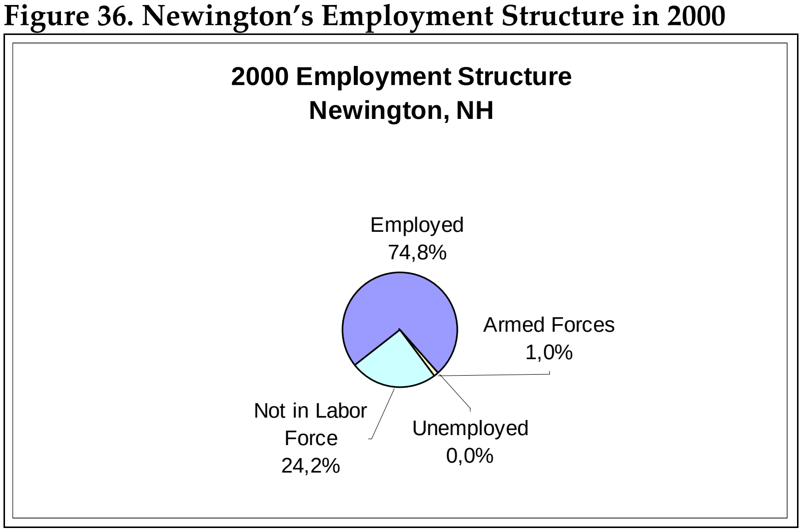
Information on cultural attributes in Newington is either unavailable through secondary data collection or the practice does not exist.

3.2.2 Infrastructure

Current Economy

In nearby Exeter, NH, the Sealure North American Company allows lobster fishermen to purchase sealure which is a natural hide bait specially treated with a highly potent, scientifically developed chemoreceptor scent.[185] In Newington, the Little Bay Lobster Company, formed in 1980, harvests lobsters and delivers them nationally and internationally.[186] Seven vessels of 75 feet each make week long trips to fish for lobster for the company. Besides the tanks for lobsters and crabs, their facility has freezer space and manufactures its own electricity.[187] The Shafmaster Fleet Services in Newington also harvests and deliver lobsters.[188] And in Portsmouth, the New England Marine and Industrial, Inc. formed in 1984 sells industrial supplies and commercial fishing gear.[189] Of the total population over 16 years of age and over, 60.6% (470 individuals) are in the labor force with 0% unemployed and 1.0% in the Armed Forces. According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for no local jobs. Self employed workers, a category where fishermen might be found, accounted for 58 jobs or 12.5% of the labor force. Educational health and social services (19.2%), manufacturing (15.3%), professional, scientific, management, administrative services (11.8%), and retail trade (9.9%) were major employment categories.
Newington has a large commercial area as well as a number of industries which attract employees and shoppers from around the region to Newington. The largest employers in Newington are the following: Fox Run Mall (600), Thermo Electron (lab equipment manufacturing – 600), Combustion Engineering (175), Xings at Fox Run (retail – 100), Georgia Pacific (gypsum board – 90), and Sprague Energy (fuel storage – 65).[190] Tyco and Westinghouse also have facilities in Newington.[191]

Figure 36. Newington's Employment Structure in 2000



Median household income in Newington in 2000 was $59,464 (an increase since 1990 when the median household income was $41,607) and median per capita income was

$31,172. For full-time year round workers, men made approximately $18,500 more per year than women.

The average family in Newington in 2000 consisted of 3.01 persons. With respect to poverty, 4.9% of families (down from 6.5% in 1990) and 4.6% of individuals earned below the official US Government poverty line, and 17.4% of families in 2000 earned less than $35,000 per year.

In 2000 Newington had a total of housing units, of which 96.4% were occupied and 85.9% were detached one unit homes. Approximately one-quarter (22.7%) of these homes were built before 1940. Mobile homes and boats accounted for 10% of the total housing units; 82.9% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $256,800. Of vacant housing units, 45.5% were used for seasonal, recreational, or occasional use. Of occupied units, 22.1% were renter occupied.

Governmental

Newington has a Board of Selectmen and a town manager.[192]

Institutional

Fishing associations

The New Hampshire Commercial Fishermen's Association monitors and participates in and contributes to fora related to concerns and issues regarding the commercial fishing industry of New Hampshire.[193]

Fishery assistance centers

Information on assistance centers in Newington is either unavailable through secondary data collection or it does not exist.

Other fishing related institutions

Information on other fishing related institutions in Newington is either unavailable through secondary data collection it does not exist.

Physical

Newington's commercial district is the epicenter of New Hampshire's third largest retail market, and there is a strategic proximity to the highway 4 that connects the cities of Rochester, Dover, Somersworth, and Portsmouth. An easy access to Maine and

Massachusetts is also assured by the proximity to Interstate 95. Newington is also served by the Boston & Maine Railroad, and a commercial airport at Pease.[194]

Newington also hosts the largest deep-water port in New Hampshire. The port is three miles along the Piscataqua riverfront. Newington's port has over 3 million barrels of bulk storage facilities for oil, gasoline, liquefied petroleum gas, and asphalt, and it handles large quantities of salt and gypsum rock. As much as 80% of New Hampshire's ocean-going shipping docks in Newington.[195]

3.2.3 Involvement in Northeast Fisheries

Commercial

Newington annual landed value for 2003 was of $8.1 million including an annual lobster landing value of $6.9 million, and an annual herring landing value of $983,827.[196]
The North of Cape Cod midwater trawl fleet (pair and single) consists of 15 vessels with principal ports of Gloucester MA, Newington NH, New Harbor ME, Portland ME, Rockland ME, and Vinalhaven ME. This sector made 720 trips and landed 62,145 metric tons of herring in 2003. Maine had the highest reported landings (46%) in 2003, followed by Massachusetts (38%), New Hampshire (8%), and Rhode Island (7%).[197]

A commercial fishery for American lobster is very active in Great Bay Estuary.[198] Other commercial fisheries in the Great Bay estuary include herring, baitfishing for alewives, mummichogs (*Fundulus sp.*) and tomcod using gillnets, seines and minnow traps; trapping for eels; and angling and dipnetting for smelt.[199]

In the early 1980's there were four commercial shellfish aquaculture operations in the Great Bay Estuary, engaged in the culture of indigenous (Eastern) oysters, European flat oysters, and hard clams (*Mercenaria mercenaria*). There has also been a great deal of activity in the past few years associated with finfish culture. In 1996 Great Bay Aquafarms commenced operation on a commercial summer flounder hatchery and nursery, the first commercial summer flounder facility in the United States. They currently produce fingerlings which are then transferred for growout to other locations, but plan to construct their own growout facility on site in the future. The company's operations are based in a warehouse on the Public Services of New Hampshire (PSNH) power generation site in Newington, and the facility is located entirely indoors. They use sophisticated recirculation and biofiltration technologies to grow the fish in land-based tanks. More than 250,000 fish were produced in 1996. Research on lumpfish, several flounder species, cod and haddock is being conducted at the University of New Hampshire (UNH) Coastal Marine Laboratory. Engineering research on offshore fish pens has been conducted in association with one of the finfish projects by the UNH Ocean Engineering Department.[200]

Landings by Species

Table 21. Dollar Value by Federally Managed Groups of Landings in Newington

	Average from 1997-2004	2003 only
Lobster	3,119,827	6,904,112
Herring	294,554	983,827
Scallop	75,694	0
Monkfish	11,989	0
Dogfish	2,415	0
Largemesh Groundfish	2,321	0
Squid, Mackerel, Butterfish	1,424	11,388
Skate	74	0
Smallmesh Groundfish	31	0
Other	175,668	230,512

Vessels by year

Table 22. All columns represent Federal Vessels Permits or Landings Value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Home port value ($)	Landed port value ($)
1997	6	8	29,602	0
1998	7	8	25,340	0
1999	7	10	8,132	0
2000	8	12	23,673	45,17,859
2001	9	11	39,708	8,671,224
2002	9	12	3,003	7,191,963
2003	9	14	0	8,129,839

Recreational

Large oyster beds occur within the Great Bay estuary, which are harvested recreationally.[201] The Great Bay Estuary also supports a diverse community of resident, migrant, and anadromous fishes, many of which are pursued by recreational fishermen. The mainly pursued species are striped bass, bluefish, salmon, eels, tomcod, shad, smelt, and flounder. Fishing is not limited to boats, as cast or bait fishing is done from the shore in many places (including the bridges crossing the estuary), and ice fishing is popular in the tidal rivers. Recreational fishing in salt water does not require a license except for smelt in Great Bay Estuary; trout, shad and salmon in all state waters; and to take any fish species through the ice. Another important recreational fishing activity is trap fishing for lobsters.[202] Further, Finish Line Charters in Newington provides open ocean sport fishing.[203]

Subsistence

Information on subsistence fishing in Newington is either available through primary data collection or the practice does not exist.

Future

Information on plans for the future of Newington has not been collected at this time. Information on people's perception of the future has not been collected at this time.

4.0 MASSACHUSETTS

4.1 BOSTON, MA

4.1.1 People and Places

Regional orientation

The City of Boston (42.35º N, 71.06º W) is the capital of Massachusetts, and is located in Suffolk County. Boston Harbor opens out onto Massachusetts Bay. The city covers a total of 89.6 square miles, of which only 48.4 square miles (54%) is land.

Map 10. Location of Boston in Massachusetts

Historical/Background information

The City of Boston has been an important port since its founding in 1630. Early on, it was the leading commercial center in the colonies.[204] During colonial times, the city's economy was based on fishing, shipbuilding, and trade in and out of Boston Harbor. "From its founding until the 1760s, Boston was America's largest, wealthiest, and most influential city."[205] It also played an important role in our nation's history, as the location of the Boston Tea Party, the Boston Massacre, and the beginning of the American Revolution. After the Revolutionary War, Boston became one of the wealthiest international ports in the world, exporting products such as rum, tobacco, fish, and salt.[206] Once an important manufacturing center, with many factories and mills based along Boston's numerous rivers and in the surrounding communities, many of the manufacturing jobs began to disappear around the early 1900s, as factories moved to the

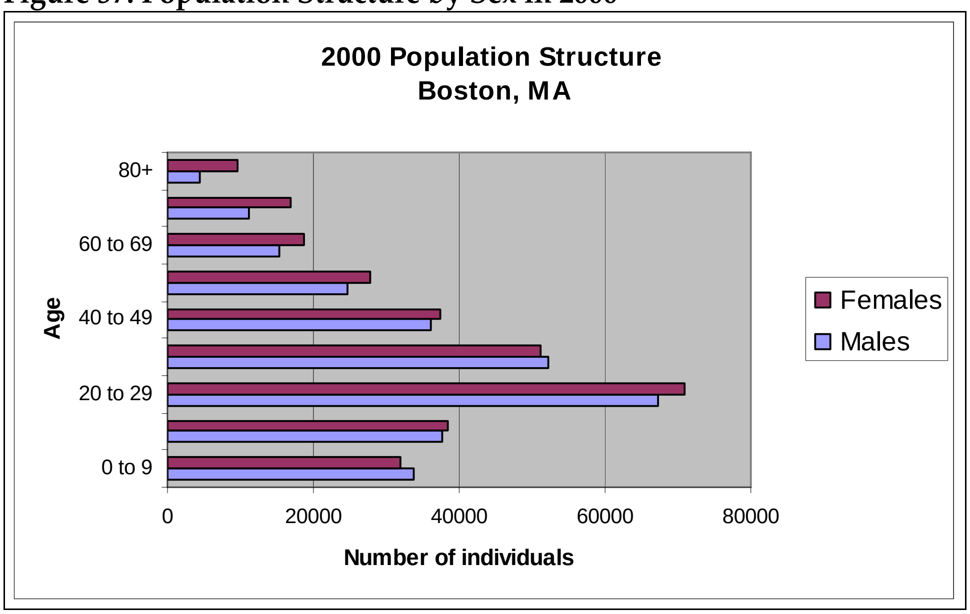
South. These industries were quickly replaced, however, by banking, financing, retail, and healthcare, and Boston later became a leader in high-tech industries.[207] The city remains the largest in New England and an important hub for shipping and commerce, as well as being an intellectual and educational hub. The Boston Fish Pier, located on the South Boston waterfront, has been housing fishermen for almost a century, and is the oldest continuously operating fish pier in the United States.[208] The Fish Pier is also home to the nation's oldest daily fish auction.[209]

Demographics

According to Census 2000 data, Boston has a total population of 589,141 -- up 2.6% from the reported population of 574,283 in 1990. Of this total in 2000, 51.9% were female and 48.9% were male. The median age was 31.2 years and 73.5% of the population was 21 years or older while 12.2% were 62 or older.

Unlike most other Northeast fishing communities, Boston's population structure shows a preponderance of 20-29 year-olds, representing the large influx of young people who move there in search of jobs, as well as a large population of students. There are also many residents in the 30-39 year old category.

Figure 37. Population Structure by Sex in 2000



The majority of the population of Boston in 2000 was white (54.3%), with 26.4% of residents Black or African American, 0.9% Native American, 7.7% Asian, and 0.3% Pacific Islander or Hawaiian. A total of 14.4% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (15.8%), Italian (8.3%), West Indian (6.4%), and English (4.5%). With regard to region of birth, 47.4% were born in Massachusetts, 23.5% were born in a different state and 25.8% were born outside of the U.S. (including 16.2% who were not United States citizens).

Figure 38. Boston's Racial Structure in 2000

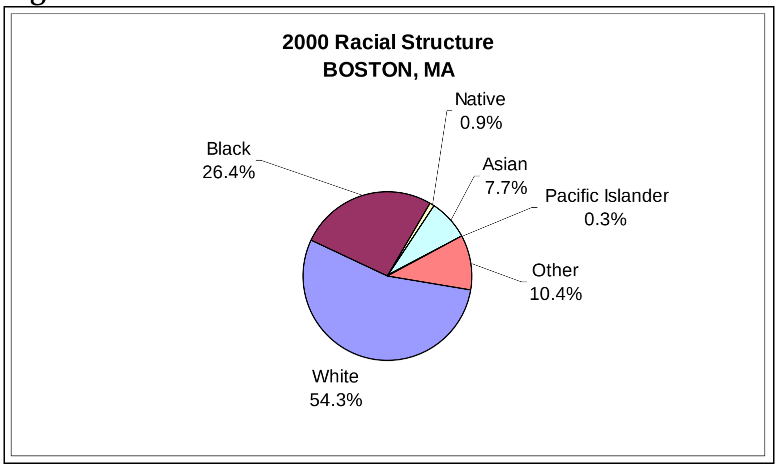
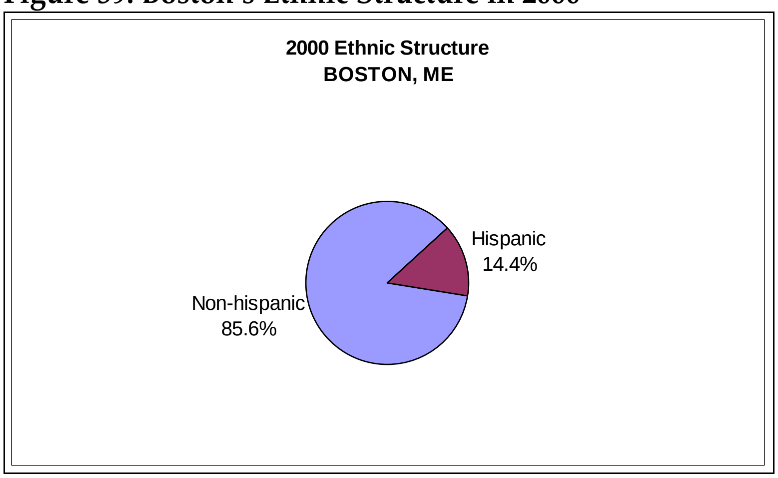


Figure 39. Boston's Ethnic Structure in 2000



For 66.6% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 33.4% in homes where a language other than English was spoken, including 16.3% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 78.9% were high school graduates or higher and 35.6% had a bachelor's degree or higher. Again of the population 25 years and over, 9.1% did not reach ninth grade, 12.0% attended some high school but did not graduate, 24.0% completed high school, 14.5% had some college with no degree, 4.9% received their associate degree, 20.2% earned their bachelor's degree, and 15.3% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Suffolk County was Catholic with 73 congregations and

205,060 adherents. Other prominent congregations in the county were Jewish (22 with 24,700 adherents), American Baptist Churches in the USA (35 with 9,115) and Episcopal (25 with 9,405 adherents). The total number of adherents to any religion was up 44.8% from 1990.

Issues/Processes

The high cost of real estate in Boston means that fishermen and other maritime users of waterfront areas are in danger of being displaced. Groups such as the Boston Harbor Association are working to prevent this from happening.[210] The Conservation Law Foundation filed suit against the Massachusetts Port Authority (Massport) in 2004, for failing to maintain the Boston Fish Pier (which they had recently purchased) as a working commercial pier. The Pier is in need of repair, has no ice house, and the businesses relying on the pier have not been issued long-term leases.[211]

The Massachusetts Division of Marine Fisheries proposed in 2004 to shut down a section of Massachusetts Bay extending from Boston north to Marblehead to cod fishing, in order to protect prime spawning ground. This proposal caused much concern for fishermen in the area, already severely limited by restrictions on cod fishing.[212] In 2005 the city was looking at plans to develop a liquid natural gas terminal on Outer Brewster Island, the outermost of the city's harbor islands, a plan that drew much criticism from environmentalists and others.[213] Lobster fishermen in particular worried that this would disrupt lobster habitat, and that the facility would prevent them from accessing important fishing areas.[214]

Cultural Attributes

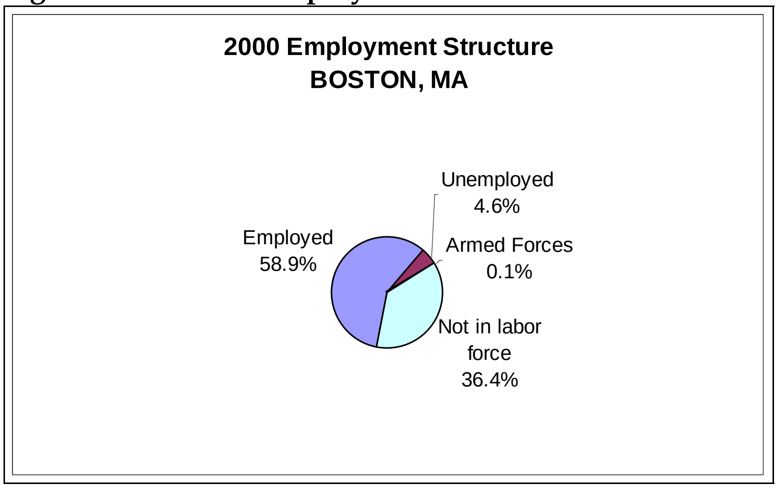
Boston hosts a number of events which celebrate the city's connections with the sea. The annual Blessing of the Fleet is held at the Boston Marina and Shipyard.[215] The city holds an annual Harborfest as part of the city's Fourth of July celebrations, which celebrates the city's role in American history as a maritime port, and includes the Boston Chowderfest.[216] The International Boston Seafood Show is primarily a culinary trade show.[217] The East Boston Seaport Festival celebrates the city's maritime heritage.[218]

4.1.2 Infrastructure

Current Economy

According to the U.S. Census 2000, 58.9% (308,395 individuals) of the total population 16 years of age and over were in the labor force, with 4.6% unemployed and 0.1% in the Armed Forces.

Figure 40. Boston's Employment Structure in 2000



"Boston's seafood processing industry includes 88 companies, employs nearly 2,000 people, and generates roughly $650 million in annual sales to regional, national, and international markets."[219] Stavis Seafoods, a fish processing and distribution facility on the Boston waterfront, employs over 100 people.[220] The new Harbor Seafood Center is expected to create 120 jobs.[221] Additionally, the development of Boston's Seaport District is likely to create thousands of jobs over the next decade.[222]

According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 296 positions or 0.1% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 12,988 positions or 4.5% of jobs. Education, health, and social services (26.8%) was the industry grouping that accounted for the most employment. Additionally, professional, scientific, management, administrative, and waste management services (14.9%); finance, insurance, real estate, and rental and leasing (10.4%); and arts, entertainment, recreation, accommodation and food services (9.2%) accounted for much of the city's employment.

Median household income in Boston was $39,629 (up 35.8% from $29,180 in 1990) and per capita income was $23,732. For full-time year round workers, men made approximately 15.5% more per year than women.

The average family in Boston in 2000 consisted of 3.17 persons. With respect to poverty, 15.3% of families (up from 15.0% in 1990) and 19.5% of individuals earned below the official US Government poverty line, while 39.9% of families in 2000 earned less than $35,000 per year.

In 2000, Boston had a total of 251,935 housing units, of which 95.1% were occupied and 11.7% were detached one unit homes. A total of 53.5% of these homes were built before 1940. There were a few mobile homes, boats, RVs and vans in this area, accounting for 0.1% of the total housing units; 88.1% of detached units had between 2 and 9 rooms. In

2000, the median cost for a home in this area was $190,600. Of vacant housing units, 12.6% were used for seasonal, recreational, or occasional use. Of occupied units 67.8% were renter occupied.

Governmental

Boston has a mayor and a thirteen member city council.

Fishery involvement in government

The Port of Boston has a Designated Port Area which is restricted to maritime industry to allow the continued existence of a working port.[223]

Institutions

Fishery associations

Boston lobstermen have formed the Boston Harbor Lobster Cooperative.[224] The General Category Tuna Association is also located in Boston.[225]

Fishery Assistance Centers

Boston has multiple organizations dedicated to aiding mariners passing through Boston, including commercial fishermen. The Seafarer's Friend Society is a non-denominational Christian ministry to the maritime service, which provides a number of services to mariners including providing food, support, and access to job services.[226] The Boston Port and Seaman's Aid Society runs the Mariners House, which offers a place for traveling mariners to stay, as well as services to assist mariners, and provides scholarships and grants to further its mission.[227]

Other fishing-related institutions

"The Boston Harbor Association is committed to preserving and promoting Boston Harbor as a Working Port". The association is working to create a development of maritime users, and is working to create a framework for discussions about current and future development along Boston's waterfront.[228] The organization Save the Harbor, Save the Bay is also working to protect Boston Harbor from environmental degradation, as well as developing an accessible waterfront and promoting a connection between the community and the sea.[229]

The New England Aquarium, located in Boston, is conducting research on lobster aquaculture, bluefin tuna, bycatch reduction, North Atlantic right whales, and other topics relevant to Boston area fishermen.[230] The Conservation Law Foundation, also headquartered in Boston, is working to promote sustainable fisheries in New England, including working to develop an area-based fisheries management system and ongoing efforts to end overfishing of groundfish stocks through legal action.[231]

Physical

"Boston is 106 miles south of Portland, Maine; 44 miles northeast of Providence, Rhode Island; 93 miles northeast of Hartford, Connecticut; and 218 miles northeast of New York City."[232] Logan International Airport is located in East Boston, and is New England's largest airport. The airport is also easily accessible from the piers, facilitating the shipping of seafood. Boston has a subway system, a commuter rail system, and Amtrak service to Portland, Providence, New York, and beyond. There is also a large bus station in the city, as well as extensive local bus service throughout the city and the metropolitan area. Interstates 90 and 93 run through the heart of Boston, while Interstate 95 runs outside of the city, making Boston a very accessible city by road.

The Boston Fish Pier, located on the South Boston waterfront, has been housing fishermen for almost a century, and is the oldest continuously working fish pier in the United States. This facility houses twenty fish-processing facilities, as well as the fish auction and provides dock space for many of the area's fishermen.[233] The Boston Fish Exchange found here is the nation's oldest daily fish auction, in operation for over 100 years.[234]

The Harbor Seafood Center houses several seafood processors in its 65,000 square feet of space, opened in 2001. Legal Seafoods also operates a 75,000 square foot processing facility in this same area.[235] Stavis Seafoods, located on the Boston waterfront since 1929, operates a groundfish processing facility here, as well as a distribution operation, shipping fresh and frozen seafood around the world.[236] Channel Fish Processing Co. is one of the many fish processing companies located in this area of Boston that buys catch directly from the docks of fishing communities around New England, and processes it here for distribution.[237]

4.1.3 <u>Involvement in Northeast Fisheries</u>

Commercial

"While fishing-related business is dwarfed by some of the others, it is significant not only for its role as a component of Boston's economy, but also for its importance in serving dispersed, smaller communities that are more obviously dependent upon fishing and fishing-related businesses… The importance of Boston to the New England region is very significant, in that it is a nexus for the international transshipment of fishery products throughout New England."[238] "The twenty or more brokers in Boston service hundreds of boats up and down the coast…. Vessels offload fish at the nearest convenient dock, it's trucked to Boston, and from there is absorbed by regional, national and international markets."[239]

Between twelve and fifteen fishing boats dock at the Boston Fish Pier each day. More than 23 million pounds of fish are processed at the Fish Pier each year, of which 8 million come from the fishing vessels which dock here.[240] Many fishermen also fish from the Cardinal Medeiros pier in South Boston.

The landings show that the largemesh groundfish are the most valuable fishery in Boston. Of these species, the most valuable in 2003 was witch flounder, worth $996,050. Monkfish and lobster are also significant fisheries, with monkfish worth $1.8 million in 2003 and lobster worth over $2 million. While the value of landings in the groundfishery was less in 2003 than the 1997-2004 average, the value of both lobster and monkfish to Boston fishermen increased.

There are far more vessels with their home port in Boston than there are vessel owners in Boston, indicating that most fishermen docked in Boston harbor live elsewhere. The landings values for both home port and landed port varied over the period from 1997-2003, with no significant pattern. The value of landed port exceeded the value of home port in every year, meaning some fishermen come from elsewhere to land their catch here.

Landings by Species

Table 23. Dollar value of Federally Managed Groups of landing in Boston, MA

	Average from 1997-2004	2003 only
Largemesh Groundfish	5,262,818	4,391,326
Monkfish	1,534,618	1,788,093
Lobster	1,200,312	2,124,795
Squid, Mackerel, Butterfish	76,273	418,216
Skate	53,865	92,259
Herring	39,761	0
Scallop	34,978	27,356
Summer Flounder, Scup, Black Sea Bass	11,097	26,924
Smallmesh Groundfish	5,892	17,852
Bluefish	1,322	119
Dogfish	358	0
Tilefish	64	510

	Average from 1997-2004	2003 only
Other	133,005	18,615

Vessels by Year

Table 24. All columns represent vessel federal permits or landings value combined for 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	66	16	8,003,112	10,166,277
1998	49	10	6,987,391	9,307,697
1999	45	8	7,232,619	9,404,756
2000	37	10	7,895,375	9,079,023
2001	42	9	6,352,896	8,256,072
2002	45	9	7,680,500	8,559,765
2003	42	9	8,078,632	8,906,065

Recreational

Fishing charters can be found at the Boston Harbor Shipyard and Marina.[241] Flying Fish Charters is one charter company that runs fishing trips in and around Boston.[242] Recreational fishermen can buy bait, tackle, and fuel at Eric's Bait and Tackle at the Boston Harbor Shipyard and Marina.[243] The Boston Harbor Islands are a popular fishing spot, and are one of the few places in Boston that offer sportfishing year round.[244]

Subsistence

No information has been found on the subsistence fishing in Boston.

Future

A team of business people is looking at the possibility of developing a 500,000 sq. ft. seafood market and processing complex in unused areas of the South Boston waterfront. The facility would house processing, packaging, cold storage, selling, and shipping, and could create hundreds of jobs. A spokesperson for the project called it "the last best chance to keep the fishing industry in Boston"; they intend to make Boston into the fresh seafood capital of the East Coast.[245] Massport has dedicated 10 acres of the Massport

Maritime Terminal for seafood processing facilities, to complement existing facilities at the Boston Fish Pier and the Boston Seafood Center.[246]

The Center for Community Economic Development has created the Seaport Community Access Project which is working to promote the participation of people of color in the Seaport development process and ensure they can have a share in long-term economic benefits from the project. This project is likely to create thousands of jobs in the next decade.[247]

Judging by the amount of development planned for the waterfront, and relating to the seafood industry, it is clear that at least many in the business community are optimistic about the future of Boston as the seafood capital of New England. However, as this development is going towards infrastructure such as processing and wholesale, and not towards maintaining a fishing fleet here, it also seems that Boston will continue to shift away from being a fishing community, and more towards becoming a hub of seafood distribution. The Conservation Law Foundation recently sued Massport over their failure to maintain the Boston Fish Pier; CLF claims "the ability of the fishing industry to land fish directly in Boston makes the survival of a working Fish Pier critically important to the future of this industry and the viability of Boston's small but important commercial fishing fleet."[248]

4.2 GLOUCESTER, MA

4.2.1 People and Places

Regional orientation

The city of Gloucester (42.62°N, 70.66°W) is located on Cape Ann, on the northern east coast of Massachusetts. It is 30 miles northeast of Boston and 16 miles northeast of Salem. The area encompasses 41.5 square miles of territory, of which 26 square miles is land.

Map 11. Location of Gloucester on Cape Ann, within Massachusetts

Historical/Background information

The history of Gloucester has revolved around the fishing and seafood industries since its settlement in 1623. Part of the town's claim to fame is being the oldest functioning fishing community in the United States. It was established as an official town in 1642 and later became a city in 1873. By the mid 1800s Gloucester was regarded by many to be the largest fishing port in the world. Unfortunately, with so many fishermen going to sea there were many deaths during the dangerous voyages. At least 70 fishermen died at sea in 1862 and the annual loss peaked at 249 in 1879. The construction of memorial statues and an annual memorial to fishermen demonstrates that the high death tolls are still in the memory of the town's residents.

In 1924 a town resident developed the first frozen packaging device, which allowed Gloucester to ship its fish around the world without salt. The town is still well-known as the home of Gorton's frozen fish packaging company, the nation's largest frozen seafood company.

As in many communities, after the U.S. passed and enforced the Magnuson Act and foreign vessels were prevented from fishing within the country's EEZ, Gloucester's fishing fleet soon increased -- only to decline with the onset of major declines in fish stocks and subsequent strict catch regulations.

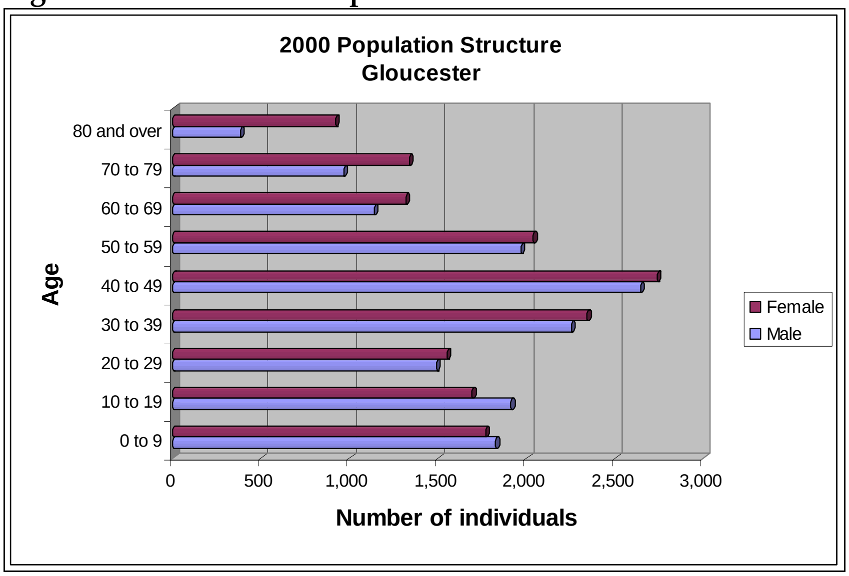
For more detailed information regarding Gloucester's history see Hall-Arber et al. (2001).[249]

Demographic Profile

According to Census 2000 data, Gloucester had a total population of 30,273, up from a reported population of 28,716 in 1990. Of this total in 2000, 52.1% were female and 47.9% were male, with the age structure between genders very similar to the U.S. average – with a peak between ages 40 to 49.

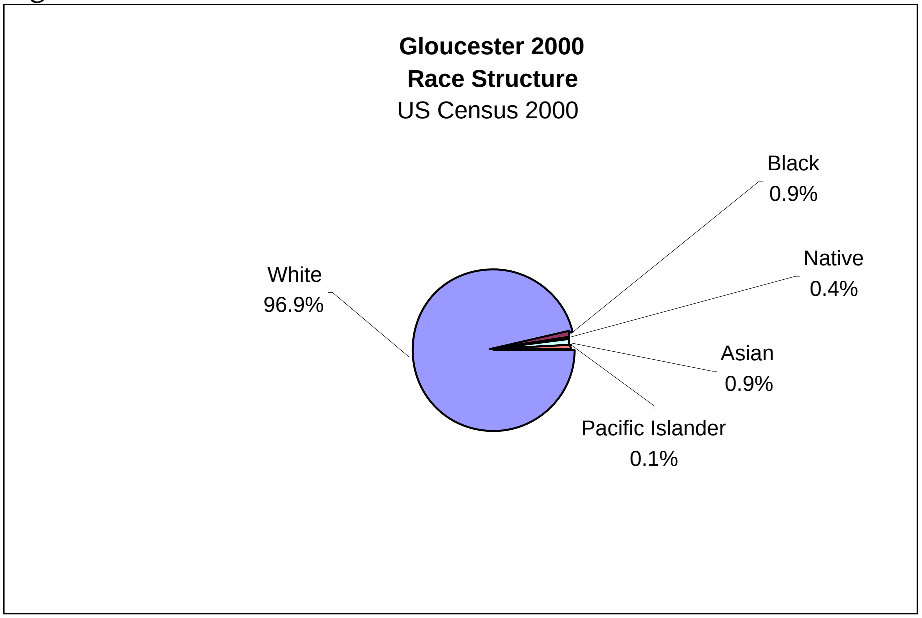
However, when compared to the age structure of Portland, ME, Gloucester has a much lower percentage between the ages of 20-29 and a higher percentage between 40-49 years. This may be an indication of out-migration after high school graduation for college or work since the fishing industry is not as strong as it was in the past. The median age for Gloucester in the year 2000 was 40.1 years and 75.2% of the population was 21 years or older while18.1% of the population was 62 or older.

Figure 41. Gloucester's Population Structure in 2000



The majority of the population of Gloucester in 2000 was white (97.0%) with only 0.6% Black or African American, 0.4% Native American, 0.9% Asian and 0.1% Pacific Islander or Hawaiian. Of the total population, 0.5% were Hispanic/Latino. Residents linked their heritage to a number of European ancestries including: English (15.1%), Irish (20.1%), Italian (21.9%) and Portuguese (9.8%). With regard to region of birth, 77.4% were born in Massachusetts, 16.2% were born in a different state and 5.3% were born outside the U.S (of whom 2.6% who were not U.S. citizens).

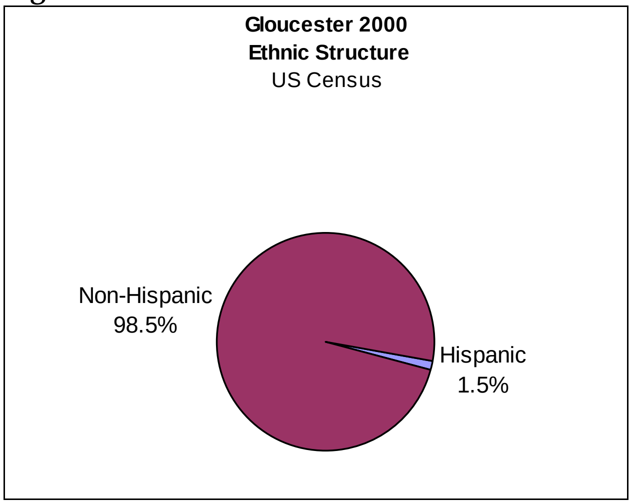
Figure 42. Gloucester's Racial Structure in 2000



According to Griffith and Dyer (1996)[250]: "Probably 80 percent of Gloucester's fishermen are Italian (mostly Sicilian). Although large immigration flows ended in the mid-1970's, there are at least 26 vessels (out of approximately 200) on which only Italian is spoken. Even among the fishermen who arrived at a very young age, Italian is often the first and virtually only language spoken. Some of these men depend on their wives to communicate with the English-speaking population when necessary."

According to the US Census 2000, for 89.7% of the population only English was spoken in the home, leaving 10.3% in homes where a language other than English was spoken (a much larger percentage than the US average), including 3.6% of the population who spoke English less than 'very well'. Further, Doeringer et al. (1986:6) noted with regard to both Gloucester and New Bedford: "[m]any workers are geographically immobile because of close ties to community and family -- ties that are reinforced in some ports by the presence of a large number of recent immigrants, many of whom lack facility in English."[251]

Figure 43. Gloucester's Ethnic Structure in 2000



Of the population 25 years and over in 2000, 85.7% were high school graduates or higher and 27.5% had a bachelor's degree or higher. Again of the population 25 years and over, 5.2% did not reach ninth grade, 9.2% attended some high school but did not graduate, 25.9% completed high school, 31.5% had some college with no degree, 8.7% received their associate degree, 17.2% earned their bachelor's degree, and 10.2% received either their graduate or professional degree.

Although the religion percentages are not available through U.S. Census data, according to the American Religion Data Archives in 2000, the religion with the highest number of congregations and adherents in Essex County was Catholic with 70 congregations and 362,900 adherents. Other prominent congregations in the county were United Church of Christ (49 with 15,358 adherents), United Methodist (31 with 8,713 adherents), Jewish (29 with 21,700), Episcopal (28 with 14,064) and American Baptist (24 with 5,291). The total number of adherents to any religion was up 4.1% from 1990.

Issues/Processes

Similar to other fishing communities in the Northeast, Multispecies Amendment 13 threatened Gloucester's fishing industry. This amendment attempts to rebuild groundfish stocks by decreasing the allowed fishing days at sea. Because so much of Gloucester's economy and history has been based on fishing, the regulations brought by the amendment have prominently been in the news, as have problems associated with fish catch depletion. Increasing drug-related arrests were also in the media at the time of Amendment 13, which may be partially attributed to the decrease in the fishing industry's strength.

Cultural Attributes

Gloucester demonstrates dedication to its fishing culture through numerous social events, cultural memorial structures, and organizations. St. Peter's Fiesta, celebrated since 1927, is in honor of the patron saint of fishermen. It is put on by the St. Peter's Club, an organization that facilitates social interactions for fisherman. The celebration lasts for five days at the end of June each year. Festivities for this celebration include a seine boat race and a greasy pole competition, but the parade carrying a statue of St. Peter around the town and a blessing of the Italian-American fishing fleet are the high points of the festival. [252]

The Seafood Festival in September was started in 1994 to promote seafood in Gloucester. As the fishing industry dropped due to catch declines, the town saw this celebration and educational forum as a way to show the world that fishing is still very important to them and that it is surviving the catch restrictions and stock depletions.[253]

The year 2004 marked the 20th anniversary of the Gloucester Schooner Festival, which is sponsored by Gorton's Seafood.[254] "The Gloucester Schooner Festival celebrates the major contribution of the classic fishing schooner to the history of Gloucester. The events feature the last remaining of these great old vessels and their replicas, as they compete in the Mayor's Race for the Esperanto Cup, a trophy from the first International Fishermen's Races sailed in 1920."[255] Two other festivals that celebrate area's fishing culture are the Gloucester Seaport Festival and the Essex Clamfest.

Other indications of the fishing culture in Gloucester include its annual Fishermen's Memorial Service, a tradition to honor fishermen lost at sea. The earliest recording of this ceremony was in the mid 1800s. In the 1960s this service stopped due to the closure of Fishermen's Union Hall (the organization previously in charge of it), but in 1996 the Gloucester Mayor asked residents to revive the tradition. Now there is a committee that documents the ceremony's speeches and ceremonial walk from the American Legion Square to the Fishermen's Monument each year, so that the tradition is not lost in the future.[256]

Interesting infrastructure that demonstrates the significance of fishing history in this city include "Our Lady of Good Voyage Church" built in 1893 and the recently opened Gloucester Maritime Heritage Center, which provides visitors and the city residents with information of the historic and current fishing industry. The statue named "The Man at the Wheel" was built in memory of the more than 5000 fishermen who have died at sea since 1623[257]. In 2001 a new statue dedicated to fishermen's wives was built by The Gloucester Fishermen's Wives Association.

4.2.2 <u>Infrastructure</u>

Current Economy

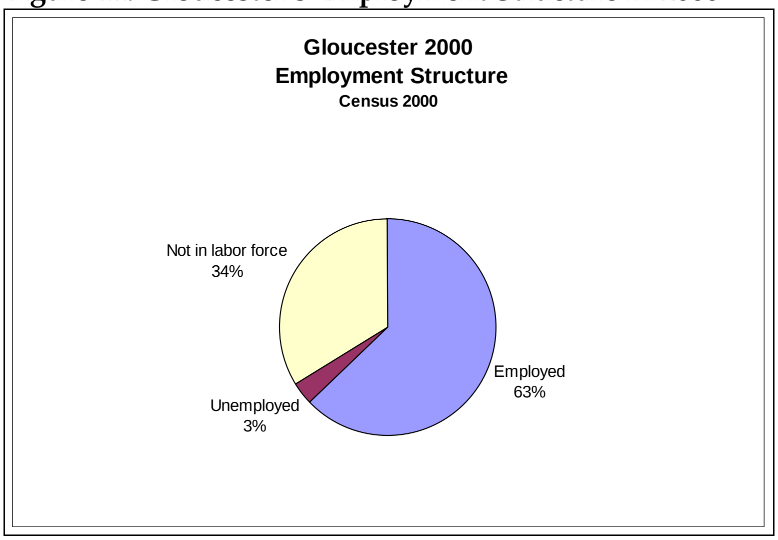
Gloucester Seafood Display Auction, opened in 1997 by the Cuilla family, quickly grew to become the largest open display auction of fresh seafood in North America as of 2000.

It allows buyers to purchase fish directly from the boats rather than having to rely on fish brokers, as they did in the past.

Cape Pond Ice, employing 30 people in the busy summer season of 2004, was started in 1848. It is the only ice business remaining in Gloucester, and provides other ice services, such as vegetable transport and ice sculptures to offset the declining business from the fishing industry.[258] B&N Gear is the only bottom trawl gear seller in town (Finch 2004). Gorton's employs approximately 500 people, but it is important to note that at least as of 2000, the company had been processing and packaging only imported fish since the mid 1990s.

According to the US Census 2000 website, 66.1% (24,397 individuals) of the population 16 years or older was in the labor force, with 3.2% unemployed and 0.2% in the Armed Forces.

Figure 44. Gloucester's Employment Structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 382 or 2.5% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 8.6% of the labor force. Manufacturing (16.7%), retail trade (10.8%), educational, health and social services (20.2%) and entertainment, recreation, accommodation and food services (9.2%) were the primary industries.

Major employers that provide over 100 jobs in Gloucester include the following businesses with the number of employees in parentheses: Varian Semi Conductor Equipment Associates (950), Gorton's (500), Battenfeld Gloucester Engineering (400), Shaw's Supermarkets (350), Addison Gilbert Hospital (325), NutraMax Products (220), and Seacoast Nursing and Retirement (160).

The median household income in 2000 was $47,772 (a considerable increase from 1990 when the median household income was $32,690) and median per capita income in 2000 was $25,595. For full-time year round workers, men made approximately $10,899 more per year than women.

The average family in Gloucester in 2000 consisted of 3.0 persons. With respect to poverty, 7.1% of families (up from 6.7% in 1990) and 8.8% of individuals earned below the official US Government poverty line, and 26% of families in 2000 earned less than $35,000 per year.

In 2000, Gloucester had a total of 13,958 housing units, of which 90.2% were occupied and 54.3% were detached one unit homes. Just over half (53.9%) of these homes were built before 1940. Mobile homes accounted for only 0.1% of the total housing units; 88.7% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $204,600. Of vacant housing units, 70.4% were used for seasonal, recreational, or occasional use. Of occupied units, 40.3% were renter occupied.

Governmental

Gloucester's city government is run by an elected mayor and city council.

Fishery involvement in government

The Gloucester Fisheries Commission is the only municipal-level government sector focused on fisheries, but in 2004 it was inactive.

Institutional

<u>Fishing Associations</u>
Both the Gloucester Fishermen's Association and Gloucester Lobstermen's Association are located in Gloucester. The Massachusetts Fishermen's Partnership, established in Gloucester in 1995, is an organization for fishermen of any sector within the Massachusetts fishing industry.[259]

<u>Fishery assistance centers</u>

The Gloucester Fishermen and Family Assistance Center was established in 1994. Currently it is run and funded by grants from the Department of Labor. "In an effort to help fishermen, their families, and other fishing workers to transition to new work, Massachusetts applied for and received grants from the U. S. Department of Labor to set up career centers. National Emergency Grants (NEG) fund centers in Gloucester, New Bedford and Cape Cod and the Islands to provide re-employment and re-training services to those individuals who can no longer make an income from fishing and fishing related businesses."[260]

The Gloucester Fishermen's Wives Association (GFWA) was founded in 1969 by the wives of Gloucester fishermen. In 2001 they constructed a memorial statue to the fishermen's wives of Gloucester.[261]

Other fishing related institutions
Northeast Seafood Coalition is located in Gloucester.

Physical

There are several ways to access Gloucester and to travel within the city. Cape Ann Transportation Authority (CATA) is the bus system that runs from Gloucester to Rockport. State Routes 128, 127, and 133 are highway system providing access within and to the city. The neighboring town of Beverly has a small municipal airport with three asphalt runways. Amtrak and MBTA trains provide public transportation from Gloucester to the Boston area.[262]

Gloucester has been a full service port for the commercial fishing industry in the region; however, this status would be jeopardized if one or more of the facilities went out of business. Thus far it has provided all the necessary facilities for fishermen in the town, and even facilities needed for neighboring fishing communities. Offloading facilities are located within the city at Capt. Vince and the Gloucester Seafood Display Auction. There are nine lobster buyers that are either based in or come to Gloucester for purchasing. Fishermen can purchase necessary equipment and have it repaired in town by either Gloucester Marine Railways or Rose Marine, both of which can provide haul out service for large vessels. There are three other facilities that provide services for vessels under 40ft. Gloucester has a choice of nine gear and supply shops in town.[263] Harbor plans in 2006 have been formulated to maintain the necessary fishing infrastructure.[264] There are at least 11 locations that provide long-term mooring space and seven for temporary mooring space. At least four facilities provide a place for fishermen to purchase fuel.[265] Some of the 10 fishing charter and party boats may be captained by part-time fishermen that needed a new seasonal income.[266]

4.2.3 Involvement in Northeast Fisheries

Commercial

Although there are threats to the future of Gloucester's fishery (see "History" above and "Future" below), the fishing industry remains strong in terms of recently reported landings. Gloucester's commercial fishing industry had the 13th highest landings in pounds (78.5 million) and the nation's ninth highest landings value in 2002 ($41.2 million). In 2003 recorded state landings totaled 11.6 million pounds, with catches of lobster, cod, and haddock at 2.0 million, 4.7 million, and 2.6 million pounds landed.[267] In 2002 Gloucester had the highest landings value of lobster in Massachusetts with the state-only landings worth $2 million and the combined state and federal landings recorded from federally permitted vessels was just over $10 million.

Gloucester's federally managed group with the highest landed value was largemesh groundfish with nearly $18 million in 2003. The number of vessels home-ported (federal) increased slightly from 1997 to 2003, but there was a slight reduction for the years 1998, 1999, and 2000.

Landings by Species

Table 25. Landings in Pounds for state-only permits

Catch	Pounds landed in 2003
Cod**	4,727,220
Haddock**	2,576,252
Lobster***	2,035,442
Monkfish	587,186
Pollock	503,396
Crab***	178,842
White Hake	171,061
Skate	155,138
Winter Flounder	151,782
Atlantic Mackerel	136,441
Yellowtail Flounder	125,855
Soft Shell Clam*	89,558
Bluefish**	63,446
Red Hake	37,016
Striped Bass**	35,475
Gray Sole (Witch)	25,639
Sea Herring	23,800
Dab (Plaice)	15,754
Cusk	8,672

Catch	Pounds landed in 2003
Wolffish	5,964
Razor Clam*	3,148
Conch*	1,430

Asterisks indicate data sources:

None: MA DMF has 2 gear-specific catch reports: Gillnet & Fish Weirs. All state-permitted fish-weir and gillnet fishermen report landings of all species via annual catch reports. NOTE: Data for these species do not include landings from other gear types (trawls, hook & line, etc.) and therefore should be considered as a subset of the total landings. (Massachusetts Division Marine Fisheries).

One (*): All state-permitted fishermen catching shellfish in state waters report landings of all shellfish species to us via annual catch reports. NOTE: These data do not include landings from non-state-permitted fishermen (federal permit holders fishing outside of state waters), nor do they include landings of ocean quahogs or sea scallops.)

Two (**): These species are quota-managed and all landings are therefore reported by dealers via a weekly reporting phone system (IVR).

Three (***): All lobstermen landing crab or lobster in MA report their landings to us via annual catch reports.

Table 26. Dollar value of landings by species in Gloucester

	Average from 1997-2003	2003 only
Largemesh Groundfish	15,161,180	17,998,475
Lobster	5,184,888	8,985,389
Monkfish	2,887,704	3,554,682
Herring	1,931,691	2,906,675
Smallmesh Groundfish	774,099	386,194
Squid, Mackerel, Butterfish	685,701	938,745
Scallop	586,629	574,314
Dogfish	399,375	24,824
Redcrab	159,996	0
Skate	73,011	103,222
Surf Clams, Ocean Quahogs	24,565	3,821
Bluefish	19,722	11,326
Tilefish	6,071	0

	Average from 1997-2003	2003 only
Summer Flounder, Scup, Black Sea Bass	1,435	251
Other	3,340,668	2,307,546

Vessels by Year

Table 27. All columns represent vessel permits or landings value combined between 1997 and 2003

Year	# vessels home ported	# vessels (owner's city)	Home port value (in millions of $)	Landed port value (in millions of $)
1997	277	216	15	23
1998	250	196	18	28
1999	261	199	18	26
2000	261	202	20	42
2001	295	230	19	38
2002	319	247	21	41
2003	301	225	22	28

Recreational

Gloucester is home to roughly a dozen fishing charter companies and party boats fishing for bluefin tuna, sharks, striped bass, bluefish, cod, and haddock. Between 2001- 2005, there were 50 charter and party vessels making 4,537 total trips registered in logbook data by charter and party vessels in Gloucester carrying a total of 114,050 anglers (NMFS VTR data).

Subsistence

Information on subsistence fishing in Gloucester is either unavailable through secondary data collection or the practice does not exist.

Future

The Massachusetts Department of Housing and Community Development recognizes that the fishing industry is changing. The city must adapt to these major economic changes. Although the city is preparing for other industries, such as tourism, they are also trying to preserve both the culture of fishing and the current infrastructure necessary to allow the fishing industry to continue functioning. The city is also currently working with the National Park Service to plan an industrial historic fishing port, which would include a working fishing fleet.[268] This would preserve necessary infrastructure for the fishing industry and preserve the culture to further develop tourism around fishing.

According to newspaper articles[269] and city planning documents, residents have conflicting visions for the future of Gloucester. Many argue that the fishing industry is in danger of losing its strength. For example an anthropological investigation of the fishing infrastructure in Gloucester[270] found that the port is in danger of losing its full-service status if some of the businesses close down. With stricter governmental regulations on catches and declining fish stocks, many residents are choosing to find other livelihood strategies, such as tourism or other businesses. In 1996 the NMFS piloted a vessel buyback program to decrease the commercial fishing pressure in the northeast. Of the 100 bids applying to be bought by the government, 65 were from Gloucester fishermen.[271] This could be taken as an indication that these fishermen do not see any future in fishing for themselves in the Northeast. NMFS adjusted this program to just buy back permits rather than vessels. Massachusetts had the highest sale of permits, though the number of Gloucester permits could not be obtained at this time.[272]

On the other hand, there are fishermen who claim the fishing and seafood industries will remain strong in the future, despite the pessimistic forecasts. The Gloucester Seafood Festival and Forum is one example of celebrating and promoting Gloucester seafood industry.[40]

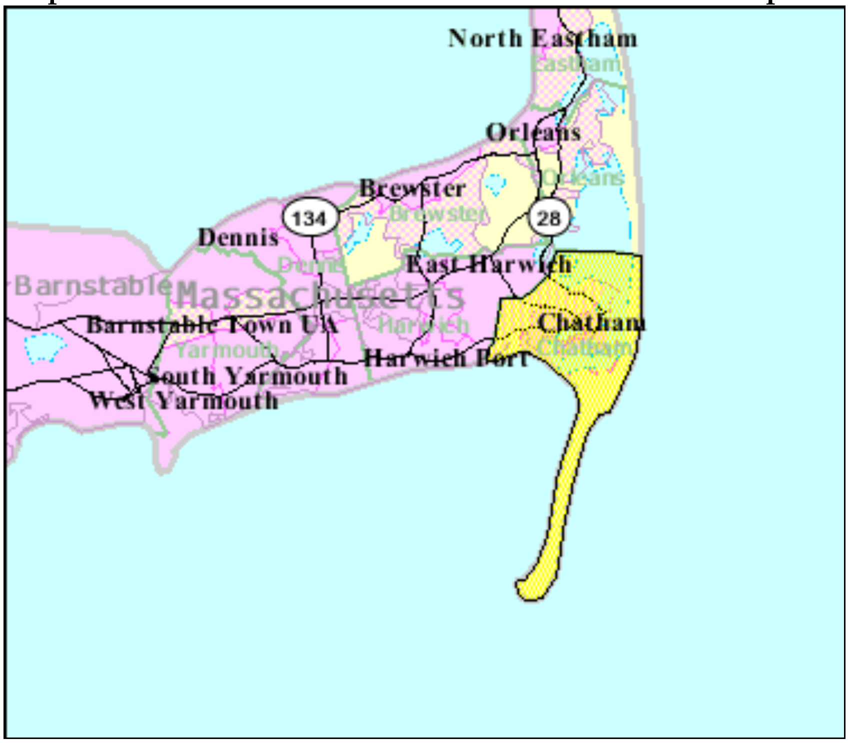
4.3 Chatham, MA

4.3.1 People and Places

Regional Orientation

Chatham, Massachusetts is located at the southeastern tip of Cape Cod. To the east is the Atlantic Ocean, to the South is Nantucket Sound, to the north is Pleasant Bay. The only adjacent town (located at both the north and west town line boundaries) is Harwich. Major geographical features of the town are hills, wooded uplands, extensive barrier beaches and spits, harbors, numerous small estuaries, and salt and freshwater ponds.[273] Chatham is 17 miles east of Hyannis, 89 miles southeast of Boston, and 223 miles away from New York City.[274]

Map 12. Chatham's Location within Massachusetts on Cape Cod



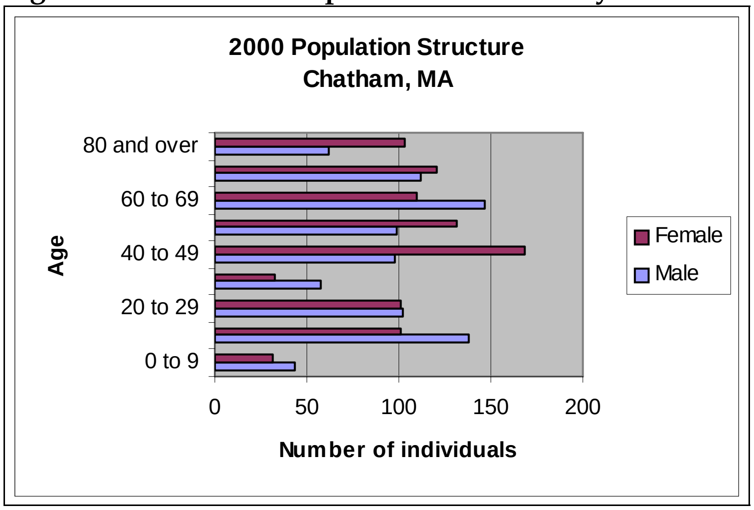
Historical/Background

The English settled in the Chatham area in the mid 1600s. William Nickerson, a name that is still prominent in Chatham, acquired nearly the entire town's area. Because of Chatham's geography and lack of developed transportation, the town's economy and living conditions were vulnerable to warships. The population began to stabilize with fishing trade, ship building, fishing, and salt making in the mid 18th century. With the building of the railroad in 1887, Chatham quickly became a summer resort destination for wealthy people. By 1950, the summer season population was more than double the year round population. According to the Town of Chatham website, Chatham now receives from 20-25,000 visitors each summer.[275] Although the cost of living is increasing in Chatham from the dominant tourism industry, there is still a fishing community that is determined to get through the difficult period of stock depletion and strict fishery regulations.

Demographics

According to Census 2000 data, Chatham has a total population of 1,667, down from the reported population of 1,916 in 1990. Of this total in 2000, 52.3% were female and 47.7% were male. The median age was 53.3 years and 86.4% of the population was 18 years or older while 32.5% were 65 or older. Chatham's age group distribution is unusual compared to other small fishing towns in the Northeast, given its very small percentage of the total population between 30 and 39 years and between 0 and 9 years.

Figure 45. Chatham's Population Structure by Sex in 2000



The majority of the population of Chatham in 2000 was white (94.2%), with 2.2% black, 2.1% other, and 1.0% citing two or more races. Only 1.9% of the total population was Hispanic/Latino.[276] Residents linked their heritage to a number of ancestries: Irish (27.5%), English (26%), German (6.5%), and Italian (6.8%).[277] With regard to region of birth, 54.3% were born in Massachusetts, 36.4% were born in a different state and 8.8% were born outside of the United States (including 4.1% who were not United States citizens).

Figure 46. Chatham's Racial Structure in 2000

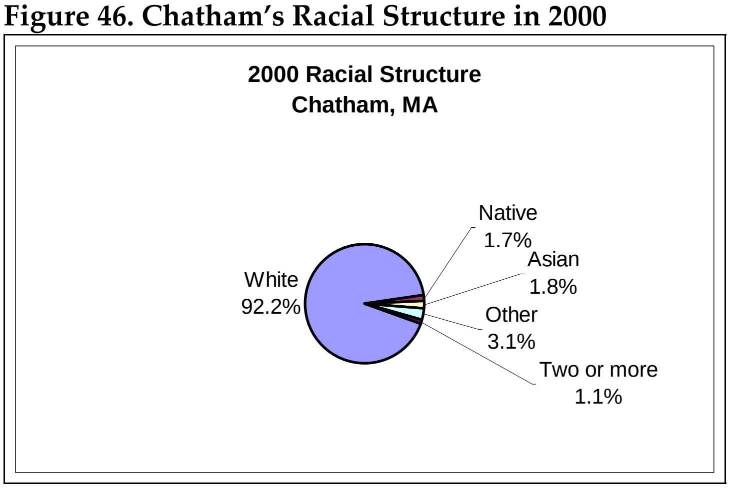
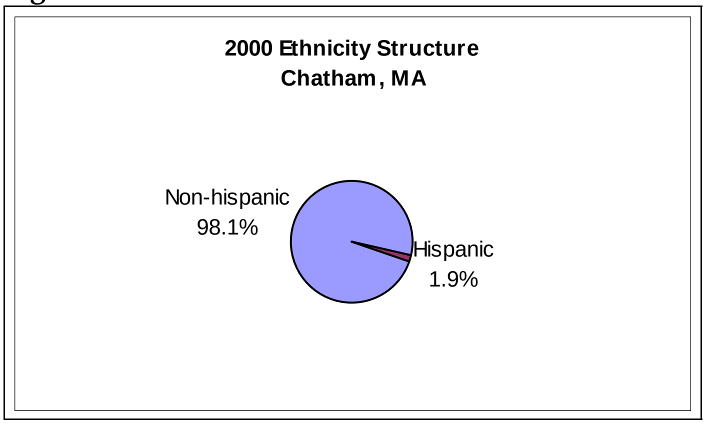


Figure 47. Chatham's Ethnic Structure in 2000



For 95.1% of the population 5 years old and higher in 2000 only English was spoken in the home, leaving 4.9% in homes where a language other than English was spoken. Of those who spoke other languages, 2.9% of them spoke English less than "very well".

Of the population 25 years and over, 89.9% were high school graduates or higher and 45.1% had a bachelor's degree or higher. Again of the population 25 years and over, 5.0% had not reached ninth grade, 5.1% attended some high school but did not graduate, 22.2% completed high school, 14.1% had some college with no degree, 8.4% received their associate degree, 32.8% earned their bachelor's degree, and 12.3% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religious Data Archive in 2000, 57.1% of Barnstable County did not claim membership to any religious affiliation. The religions with the highest number of congregations in Barnstable County included Catholic (29 with 89,000 adherents), Episcopal (11 with 8,028 adherents), and Baptist (7 with 1,387 adherents). The total numbers of adherents to any religion was down 20.7% from 1990.

Issues/Processes

Information gathered during a visit to the Cape Cod Commercial Hook Fishermen's Association (CCCHFA) in 2004 revealed that the fishing industry in Chatham faces similar challenges to other fishing port communities in the Northeast. With tourism and the increase of gentrification, the fishing industry is threatened by a lack of mooring space, and the threat of land-based fishing infrastructure closing down (e.g., Town Pier was for sale). At the same time many believed that the history of fishing has been a large part of the allure that draws tourists to Chatham, so it could lose its cultural appeal if the fisheries really did fade away. With a group such as the CCCHFA, the fishermen appear to be fighting the challenges of stricter catch regulations and decreased catches by finding alternative ways to keep their fishing industry alive. (Also refer to section

"Fisheries involvement in the government" for more information on CCHFA sector allocation.)

There is controversy over the harvesting of shellfish in the National Seashore Wilderness Sanctuary (Monomoy). Some people have been trying to organize against the extraction of shellfish in this area. This is the most important shellfishery in New England. A few years ago Chatham had $4.5 million industry from shellfish, while the entire state of Maine had only $9 million. The process of turning the clam beds (a result of extraction) actually releases sulfates from the soil producing a more conducive environment for other creatures, including more shellfish.[278]

The Cape Cod Regional Economic Development Council (CCREDC) has not seemed to recognize the importance of commercial fishing on Cape Cod, however; they rely on census data which often hides fishermen's incomes in the self employment and agricultural categories. Melissa Weidman of CCCHFA estimated that there are 10,000 fishermen on Cape Cod, while the CCREDC reported only 50 fishermen. One example of an important business to fishing in Chatham is Cape Fish Supply. It is the biggest supplier for the entire Cape. People come here from Provincetown. The next biggest supplier is New Bedford.[279]

Cultural Attributes

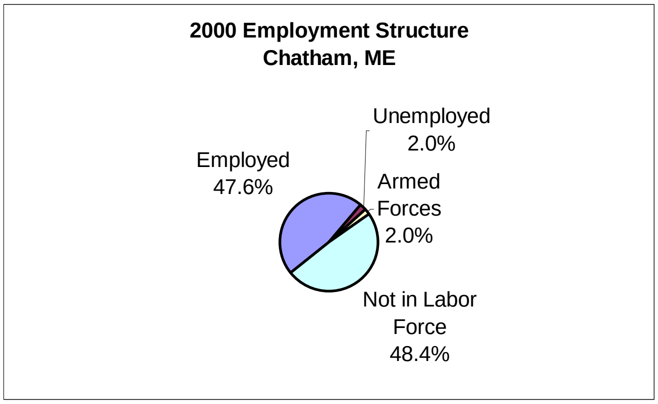
The Cape Cod Commercial Hook Fishermen's Association plays a major role in the Chatham community. In 2005 they hosted their 5th annual Hookers Ball. The event's proceeds help support the work of the grassroots sustainable fishery organization. Approximately 500 tickets are sold to both local fishermen, summer residents and visitors.[280] Another way that the community remembers its maritime history is during the Chatham Maritime Festival, which celebrates Chatham's maritime heritage with an exciting day of contests, races and a fishing parade.[281]

4.3.2 Infrastructure

Current Economy

The economy of Chatham drives a population fluctuation as tourists and seasonal residents come in and out for the summer. Representative of this is the fact that the two businesses in Chatham that employ the most people are summer resorts (Chatham Bars Inn and Chatham Wayside Inn). Chatham Bars Inn, established in 1914,[282] is the largest employer in Chatham with approximately 200 year-round employees and 550-600 summer employees. The resort provides housing for some of its seasonal employees, the majority of which are from other countries or are college students.[283]
According to the U.S. Census 2000, 51.6% of the total population 16 years of age and over were in the labor force, with 2.0% unemployed and 2.0% in the Armed Forces.

Figure 48. Chatham's Employment structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 3.6% of available jobs. Self employed workers, a category where fishermen might be found, accounted for 16.8% of the labor force. Educational, health and social services (19.1%), arts, entertainment, recreation, accommodation and food services (17.9%), retail trade (17.3%), construction (10.7%), and finance, insurance, real estate, and rental and leasing (10.2%) were the primary industries.

The median household income in Chatham in 2000 was $47,037 (up from $26,716 in 1990) and median per capita income was $28,542. For full-time year round workers, men made approximately $988 more per year than women.

The average family in Chatham in 2000 consisted of 2.52 persons. With respect to poverty, 0.9% of families and 7.8% of individuals earned below the official U.S. Government poverty line, while 23.9% of families earned less than $35,000 per year.

According to the Census 2000, Chatham had a total of 1,891 housing units of which 810 were occupied and 85.4% were detached one unit homes. Over one third (36%) of these homes were built before 1940. There were no mobile homes/vans/boats in this area that served as housing units; 98.9% of detached units had between 2 and 9 rooms. The median cost for a home in this area was $372,900. Of vacant housing units, 89.5% were used for seasonal, recreational, or occasional use. Of occupied units 27.2% were renter occupied.

Government

The town of Chatham was incorporated as a town in 1730. The town is operated by a Town Manager, a Board of Selectmen, an Executive Secretary, and an Open Town Meeting.

Institutional

Fishing associations

Organizations in Chatham associated with fishing include the Cape Cod Commercial Hook Fishermen's Association and the Friends of the Chatham Waterways (see more information below).

Fisheries involvement in government

The Chatham maritime community is supported by the Cape Cod Commercial Hook Fishermen's Association (CCCHFA). The association began in 1993 with a small group of commercial hook and line fishermen who got together to discuss problems in the industry. Their purpose is to address problems by building sustainable fisheries for the future, and representing the traditional fishing communities. One of the programs that the CCCHFA created is the S.S. Shanty Community Fisheries Action Center.[284] They also spearheaded the creation of and received the first sector allocation for the groundfish fishery.[285] This may encourage other sectors to form and to request other sector allocations.

The purpose of the center is to empower fishermen, educate concerned residents, and facilitate collaboration between conservation, fishing and community organizations to generate a more active and effective marine community on Cape Cod.[286]

Fishing assistance centers

No fishing assistance centers that provide monetary support were identified in Chatham during this research, however, the CCCHFA could be classified as an assistance center.

Other fishing-related organizations

Hook and line fishermen of Cape Cod established the CCCHFA in 1993. This grassroots organization now has 2500 members and several programs to support Cape Cod traditional maritime communities and increase awareness about the fishing culture in the area.[287] Another organization that is vital to the Chatham community is the Friends of Chatham Waterways. The association has an interest in the broader municipal issues that may have an impact on Chatham's maritime heritage or upon the natural environment of the community.[288]

Physical

Chatham is supported by the State Routes 28 and 137. There is no freight rail service, but the network of intermodal facilities serving eastern Massachusetts and Rhode Island is easily accessible. Chatham is a member of the Cape Cod Regional Transit Authority (CCRTA), which operates a b-bus demand response service. The b-bus is convenient, low-cost public transportation from your home on Cape Cod and back. The Cape Cod Regional Transit Authority provides this door-to-door, ride-by-appointment service for people of all ages for trips for any purpose, including school, work, shopping, college, doctor's appointments, visiting friends and even Boston medical trips. B-buses carry up to 19 passengers and are all lift-equipped.[289] The Chatham Municipal Airport is a General Aviation (GA) facility located 2 miles NW of town, and scheduled airline flights are available at the Hyannis Municipal Airport in the neighboring town of Barnstable.[290]

4.3.3 <u>Involvement in Northeast Fisheries</u>

Commercial

Cod had the highest landings in pounds within state waters for 2003. However, Chatham's main fishery currently appears to be shellfish (quahogs and soft shell clams). Federal landed value data reveals that largemesh net-caught groundfish were the highest value catch between the years 1997 and 2004, with the landed value of this federally managed group at $4.5 million in 2003. It is apparent from Table 1 (below) that there are a variety of landed groups in Chatham.

The town owns and runs the steamer seeding plant, which is located on the town pier. Approximately 150 people depend on the shell fishing in Chatham.[291]

Landings by Species

Table 28. Dollar value of landed species in Chatham

	Average from 1997-2004	2003 only
Largemesh Groundfish	4,498,910	4,551,982
Other	1,397,394	1,035,280
Dogfish	684,887	180,829
Lobster	663,905	1,468,812
Monkfish	559,484	1,195,468
Squid, Mackerel, Butterfish	260,050	126,293
Summer Flounder, Scup, Black Sea Bass	255,126	284,478
Scallop	159,807	415,840
Skate	153,959	649,442
Smallmesh Groundfish	50,341	65,788
Surf Clams, Ocean Quahogs	40,534	1,856
Bluefish	33,987	80,557
Herring	109	237

	Average from 1997-2004	2003 only
Tilefish	15	0

Table 29. All columns represent vessel permits or landings value between 1997 and 2003

Year	# Vessels home ported	# vessels (owner's city)	Home port value ($)	Landed port value
1997	146	65	6,050,939	6,995,815
1998	131	55	6,260,042	7,095,848
1999	130	54	8,634,155	9,366,834
2000	131	55	6,676,939	11,900,694
2001	135	53	7,266,848	12,446,346
2002	162	58	7,402,449	11,290,377
2003	161	54	6,619,728	7,501,941

Recreational

There are at least four fishing charter businesses located in Chatham which cater to the summer visitors and residents.[292] Due to restricted DAS, especially for groundfish, and to limits on striped bass some commercial fishermen have begun to use their fishing boats as day charters. This allows fishermen to still make money at sea even when they cannot catch and sell fish commercially. Thursday through Saturday fishermen cannot sell their catches, so catch and release fishing is practiced by the few that are combination commercial/recreational charter fishermen.[293]

Subsistence

No information has been obtained at this time on subsistence fishing.

Future

During a field visit to Chatham by the NEFSC Social Science Branch community profilers, the CCCHFA mentioned that intense pressure exists on the coastal fishing infrastructure due to gentrification and increasing costs. For example, half of Stage Harbor is for sale. So far, there have not been any buyers from the industry and the asking price is too high for the town to buy (they did try to raise money with the Landtrust, but couldn't afford it). Now the fishing community is concerned that a non-fishing family will buy the pier and turn it into their own personal dock for yachts. The impacts of this would be serious as fishermen who use this docking facility would have to look elsewhere and space is already at a premium.

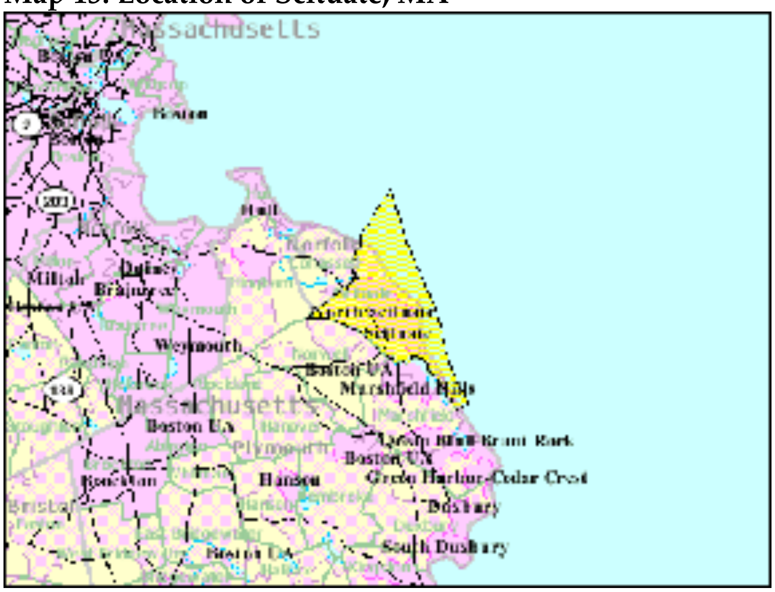
4.4 SCITUATE, MA

4.4.1 People and Places

Regional orientation

The Town of Scituate (42.20º N, 70.73º W) is located in the South Shore region of Massachusetts, in Plymouth County, 30 miles south of Boston. Scituate faces Cape Cod Bay and is bordered by Marshfield and Norwell to the south and Cohasset to the north. It encompasses 31.79 square miles, of which 17.18 square miles is land, and 14.61 square miles is water.[294]

Map 13. Location of Scituate, MA



Historical/Background information

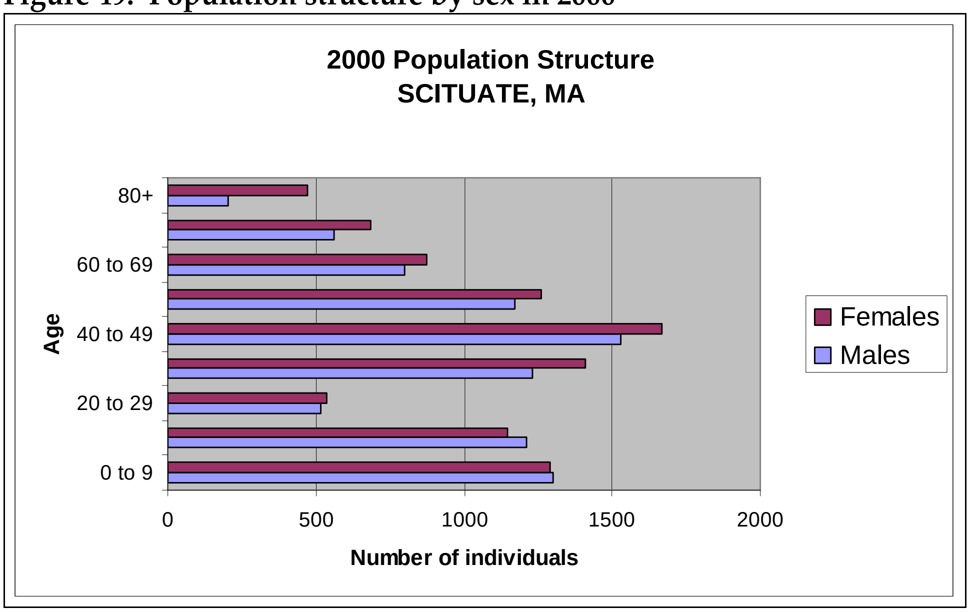
The name Scituate comes from a Wampanoag Indian word meaning "cold brook"[295]. The first permanent European settlement in Scituate was in 1627 or 1628, when a group from Plymouth headed north looking for fertile lands to cultivate. The town was incorporated in 1636.[296] Portions of the area that originally made up Scituate later became the towns of Norwell and Hanover, and a portion of Scituate was ceded to Marshfield.[297] Scituate was an important fishing port by the end of the eighteenth century because of its protected harbor, but mud flats and shallow water made the harbor difficult to enter, so the town built Scituate Light here, completing construction in 1811.[298] Shipbuilding was also an important industry to residents of Scituate; between 1645-1871, there were over 1,000 ships built in the North River, which separates Scituate from Marshfield.[299] At the start of the 20th century, Scituate was still a small town with around 2,000 residents. Scituate has since transitioned from a summer colony to a residential community, rapidly expanding in recent years because of its proximity to Boston, its miles of beaches, and its excellent school system, all of which draw residents to this town. [300] It also has one of the lowest crime rates in the state.[301] Scituate has 21 miles of waterways, including five beaches, four rivers, and a large, sheltered harbor.[302] Scituate's commercial fishing fleet adds to the town's appeal and historical ties. "The Town of Scituate is a delightful mix of rural, suburban and seaside lifestyles within a 25 mile ride to the City of Boston."[303]

Demographics

According to Census 2000 data, Scituate had a total population of 17,863, up 6.4% from[304] the reported population of 16,786 in 1990. Of this total in 2000, 52.3% were female and 47.7% were male. The median age was 40.7 years and 71.8% of the population was 21 years or older while 18.1% were 62 or older.

Scituate's population structure is typical of a relatively young, family-oriented community. The most populous age bracket is 40-49, followed by 30-39, and there are also lots of children and teenagers. The population takes a dip for the 20-29 age bracket, as is common in many fishing communities when young people leave to go to college or to seek jobs. There are also more women than men in all age brackets past the age of 20, indicating that either men are leaving the town to go elsewhere or that women are migrating to Scituate for jobs or for some other reason.

Figure 49: Population structure by sex in 2000



The majority of the population of Scituate in 2000 was white (96.5%), with 0.8% of residents Black or African American, 0.3% Native American, 0.7% Asian, and 0.0% Pacific Islander or Hawaiian. Only 0.8% of the total population was Hispanic/Latino.

Residents linked their heritage to a number of ancestries including: Irish (44.2%), English (17.9%), Italian (14.4%), and German (8.6%). With regard to region of birth, 74.3% were born in Massachusetts, 21.7% were born in a different state and 3.8% were born outside of the U.S. (including 1.6% who were not United States citizens).

Figure 50: Racial Structure in 2000

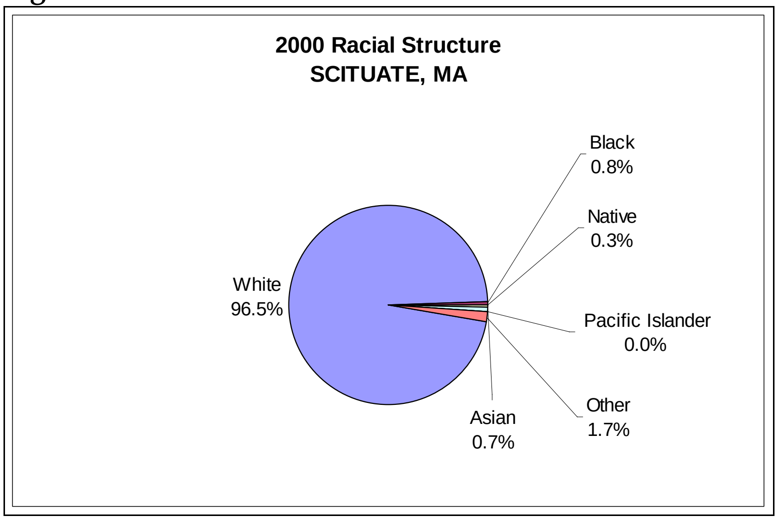
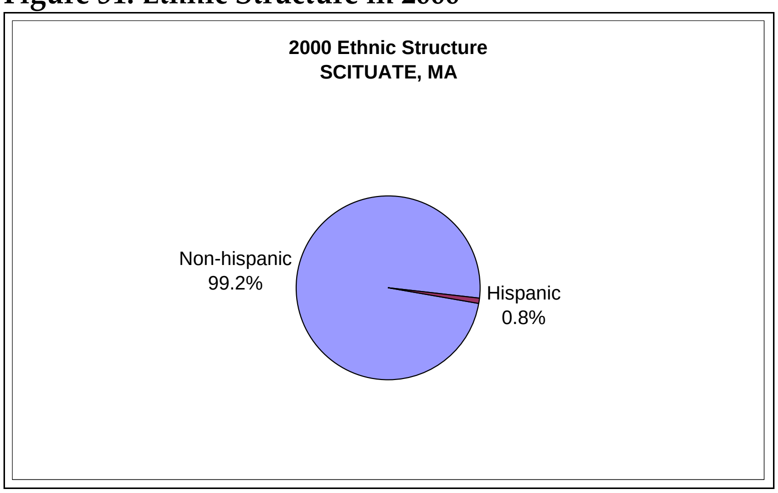


Figure 51: Ethnic Structure in 2000



For 94.5% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 5.5% in homes where a language other than English was spoken, and including 2.0% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 95.8% were high school graduates or higher and 47.6% had a bachelor's degree or higher. Again of the population 25 years and over, 0.9% did not reach ninth grade, 3.3% attended some high school but did not graduate, 20.4% completed high school, 18.9% had some college with no degree, 8.9% received their associate degree, 32.1% earned their bachelor's degree, and 15.4% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Plymouth County was Catholic with 40 congregations and 205,060 adherents. Other prominent congregations in the county were Jewish (8 with 23,600 adherents), United Church of Christ (25 with 9,491) and Episcopal (15 with 6,894 adherents). The total number of adherents to any religion was down 36.1% from 1990.

Issues/Processes

The Town Pier, which is the only deep-water facility in Scituate, is run-down, and the groundfishing fleet and lobstermen are competing for the same limited space.[305]

Cape Cod Bay, where many Scituate fishermen work, is critical Northern right whale habitat, and parts of the bay are frequently closed to fixed fishing gear or require gear modifications at times when the whale are present, impacting Scituate lobstermen.[306] Discussions on closing all or part of the Stellwagen Bank National Marine Sanctuary off the coast of Scituate to fishing also has many fishermen worried.[307]

Cultural attributes

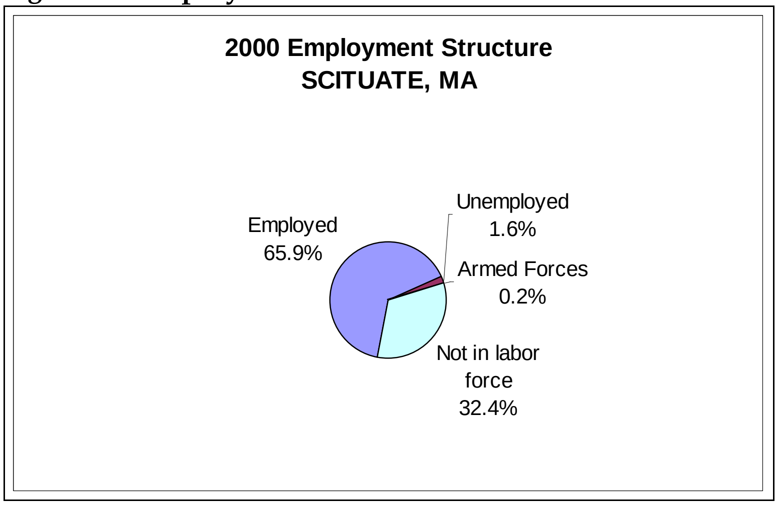
Each August, Scituate celebrates its heritage with the Heritage Days festival, featuring a fishing tournament for striped bass and bluefish, and a lobster bake.[308] In the fall, the town holds a ChowderFest as part of its Fall for Scituate festival.[309] Scituate's Maritime and Irish Mossing Museum is dedicated to the town's maritime heritage, including the shipbuilding industry that once thrived here, and the historically important trade of harvesting Irish Moss algae in Scituate.[310]

4.4.2 Infrastructure

Current Economy

According to the U.S. Census 2000, 65.9% (9,243 individuals) of the total population 16 years of age and over were in the labor force, of which 1.6% were unemployed and 0.2% were in the Armed Forces.

Figure 52: Employment Structure in 2000



The largest employer in the town of Scituate is by far the town itself, which, including town government, services, and the school district, employs 600-700 people. Other sizable employers are Jamie's Grille and Pub and the Village Market.[311] According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 77 positions or 0.9% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 837 positions or 9.3% of jobs. Education, health, and social services (22.1%) was the industry grouping that accounts for the most employment. Additionally, finance, insurance, real estate, and rental and leasing (12.9%), professional, scientific, management, administrative, and waste management services (10.9%), and retail trade (10.3%) accounted for much of the city's employment.

Median household income in Scituate in 2000 was $70,868 (up 36.2% from $52,044 in 1990) and per capita income was $33,940. For full-time year round workers, men made approximately 50.0% more per year than women.

The average family in Scituate in 2000 consisted of 3.13 persons. With respect to poverty, 1.4% of families (down from 1.8% in 1990) and 2.6% of individuals earned below the official US Government poverty line, while 11.1% of families in 2000 earned less than $35,000 per year.

In 2000, Scituate had a total of 7,685 housing units of which 87.1% were occupied and 86.2% were detached one unit homes. Nearly 30% of these homes were built before 1940. There were a few mobile homes in this area, accounting for 0.2% of the total housing units; 84.3% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $276,000. Of vacant housing units, 82.3% were used for seasonal, recreational, or occasional use. Of occupied units 17.0% were renter occupied.

Governmental

The Town of Scituate is governed by a Board of Selectmen, with five members elected to three year terms, and has a Town Meeting form of government.[312]

Fishery involvement in government

Scituate has a Shellfish Officer who is given authority to enforce shellfishing regulations within the town. The Board of Selectmen is responsible for issuing shellfish permits.[313]

Institutional

Fishery associations

The Massachusetts Lobstermen's Association is located in Scituate; this organization represents the interests of commercial lobstermen throughout Massachusetts.[314] The South Shore Lobstermen's Association is also located in Scituate.[315]

Fishery Assistance Centers

No information has been found on fishery assistance centers in Scituate.

Other fishing-related institutions

The headquarters of the Stellwagen Bank National Marine Sanctuary is located in Scituate; the Sanctuary Advisory Council includes fishermen, and the activities of the Sanctuary can affect fishing in Scituate and other communities.[316]

Physical

Scituate is 20 miles from Plymouth and 30 miles from Boston. State Routes 3A and 123 connect Scituate with Route 3, which travels between Cape Cod and Boston. Neighboring Marshfield has its own municipal airport; the closest large airport is Logan International Airport in Boston, 19 miles away. The Massachusetts Bay Transportation Authority provides public transportation via commuter rail to Boston from some nearby communities along the South Shore. Construction is underway for the Greenbush commuter rail line that will pass directly through Scituate with a planned start date of January 2007.[317] The Plymouth and Brockton Street Railway Company provides bus service between Scituate and Boston.[318]

There are three harbors in Scituate: Scituate Harbor, and the North and South Rivers.[319] Scituate Harbor is on the landward side of two protected coves. Scituate has a Town Pier with space for about 15 vessels, located in the harbor. One section of the harbor's moorings is also designated solely for commercial vessels.[320] The groundfish vessels tie up at the Town Pier, while the lobster boats use the moorings. The Town Pier is used exclusively by the commercial fishing fleet; catches are unloaded here onto trucks where they are shipped to dealers and processors. Ice is also shipped here from New Bedford or Gloucester; access to ice is a big problem here. The lobstermen have created their own landing, with marina floats donated by the harbormaster. There are also eleven marinas in Scituate. The town has a total of 673 moorings and 650 slips for use by both commercial and recreational vessels.[321] Diesel fuel is available from the pier.[322] There are two boat ramps in town.[323] Belsan Bait and Tackle in Scituate serves primarily recreational fishermen.[324]

4.4.3 Involvement in Northeast Fisheries

Commercial

The majority of commercial vessels in Scituate are lobster vessels; there are about 15 groundfish vessels found at the town pier. Three retail markets, Nautical Mile Seafood, Mulaney's Harborside, and Fourth Cliff buy lobsters from the local lobstermen.[325] Scituate has a very diverse fishery, with a number of different species and gear types. Lobster was the most valuable species landed here in 2003, bringing in nearly $1.8 million. The second most valuable species in 2003 was cod ($765,137), followed by monkfish ($472,681). The landings values for most species in 2003 were higher than the 1997-2004 averages; the notable exception was dogfish, with zero landings due to closures. Overall, the number of vessels home ported in Scituate remained relatively constant from 1997-2003, as did the value of fishing to home ported vessels. The value of landings in Scituate, on the other hand, generally increased over the same period. Also of interest to note is that the number of vessels owned by Scituate residents declined over the same period, indicating that perhaps the vessel owners are moving out of Scituate, or that the vessels are changing hands.

Landings by Species

Table 30: Dollar value of Federally Managed Groups of landing in Scituate, MA

	Average from 1997-2004	2003 only
Largemesh Groundfish	1,357,372	1,733,522
Lobster	970,575	1,778,092
Monkfish	429,429	472,681
Dogfish	89,907	0
Skate	15,804	31,763
Squid, Mackerel, Butterfish	15,350	100,072
Redcrab	11,986	0
Scallop	7,368	45,014

	Average from 1997-2004	2003 only
Bluefish	5,430	3,402
Summer Flounder, Scup, Black Sea Bass	4,202	15,393
Surf Clam, Ocean Quahog	2,411	5,485
Smallmesh Groundfish	2,388	10,013
Tilefish	146	1,168
Other	29,904	23,268

Vessels by Year

Table 31: All columns represent vessel permits or landings value combined between 1997-2003 for Scituate

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	79	55	2,574,242	1,371,648
1998	70	50	2,727,569	2,855,762
1999	78	59	2,015,519	2,092,982
2000	75	53	2,934,249	4,770,224
2001	79	50	2,093,487	3,484,206
2002	81	50	2,257,045	3,837,513
2003	74	49	2,597,671	4,219,873

Recreational

Scituate has a few fishing charter companies that fish for striped bass, bluefish, bluefin tuna, cod, and other species,[326] including one boat that specializes in shark fishing.[327] Fishing off bridges, docks, and beaches is popular in Scituate as well. Scituate also has shellfishing in many of its beaches and estuaries.

Subsistence

No information has been found on subsistence fishing in Scituate.

Future

The town is working on plans to improve Scituate Harbor village; design improvements were conceived with the goal of increasing the town's physical connection to its maritime heritage by making the waterfront more attractive and accessible. This plan is, however, focused on improving the village's commercial district, and makes little mention of the commercial fishing fleet or existing infrastructure.[328] T.K.O. Malley's, a harborfront restaurant, has requested permission to add dock slips to its facility, including two that will be designated for use by commercial vessels. The Scituate town marina also has plans to expand their facilities; this will allow for more recreational vessels in Scituate Harbor, where recreational boating is constantly expanding, but represents a further transition from a commercial harbor to one catering to recreational vessels.[329]

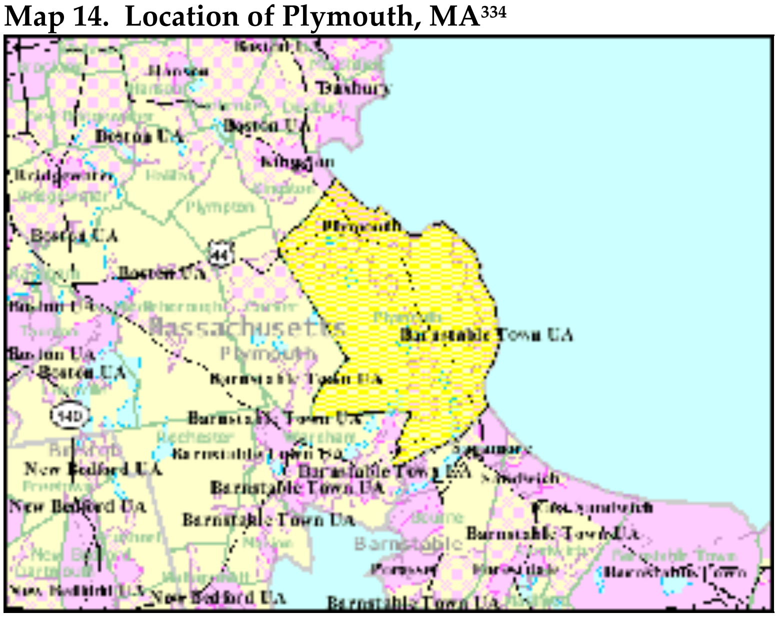
The town pier in Scituate reports a steady demand for dockage among commercial fishing boats, indicating that the industry here is also relatively steady.[330]

4.5 PLYMOUTH, MA

4.5.1 <u>People and Places</u>

The Town of Plymouth (41.96º N, 70.67º W) is located in Southeastern Massachusetts, and is the seat of Plymouth County. Plymouth faces Cape Cod Bay, and just borders Cape Cod. This enormous town covers 97.57 square miles of area[331] and is both the largest and the oldest municipality in Massachusetts.[332] Because of its large extent, there are many unofficial villages within the town boundaries: North Plymouth, Plymouth Center, West Plymouth, Chiltonville, Manomet, The Pinehills, Ellisville, Cedarville, South Plymouth, Bournedale (mainly part of neighboring Town of Bourne), and Buttermilk Bay (a neighborhood of Plymouth accessible by road only through neighboring Towns of Bourne and Wareham).[333]

Map 14. Location of Plymouth, MA[334]



Historical/Background information

Plymouth played a very important role in American history as one of the first colonies, a fact not soon forgotten by the town or any of the one million tourists who visit here annually.[335] The pilgrims were English separatists, leaving the Church of England and their homeland in search of religious freedom, believing the Church of England had not fulfilled the Reformation. They initially traveled to Holland, but then decided to journey to America. Originally headed for Northern Virginia, the Pilgrims were blown off course and found themselves off Provincetown. They eventually settled at Plymouth, creating the first European settlement in New England, there drawing up the Mayflower Compact which established a new government. Plymouth was founded on December 21, 1620, later to become Plymouth Colony and eventually a part of the Massachusetts Bay Colony.[336]

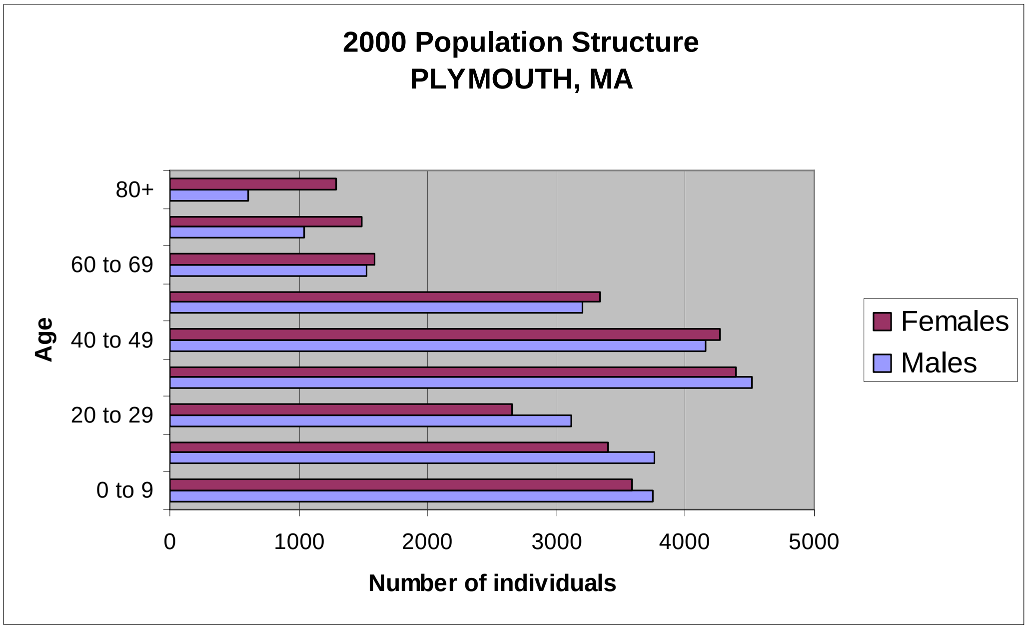
Long before the Pilgrims ever arrived, the Wampanoag living in the Plymouth area were highly dependent on fishing.[337] Today Plymouth is a fishing and tourist center, with marine-related industries and cranberry-packing houses.[338] Plymouth's beautiful scenery and its proximity to Boston have encouraged many people to move here and the town has seen a rapid increase in growth, with the population increasing by 145% in the last two decades.[339]

Demographics

According to Census 2000 data, Plymouth had a total population of 51,701, up 13.4% from the reported population of 45,608 in 1990. Of this total in 2000, 50.3% were female and 49.7% were male. The median age was 36.5 years and 71.0% of the population was 21 years or older while 13.2% were 62 or older.

Plymouth's population structure was typical of a relatively young, family-oriented community. The largest age bracket was between 30-39, followed by 40-49, and there were also lots of children and teenagers. The population takes a dip for the 20-29 age bracket, as is common in many fishing communities when young people leave to go to college or to seek jobs; here it seems that either more women leave than men, or that some men move to Plymouth from elsewhere.

Figure 53: Population structure by sex in 2000



The majority of the population of Plymouth in 2000 was white (94.4%), with 2.5% of residents Black or African American, 0.7% Native American, 0.8% Asian, and 0.1% Pacific Islander or Hawaiian. Only 1.7% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries: Irish (34.2%), Italian (18.1%), English (16.7%), German (7.3%), and Portuguese (6.3%). With regard to region of birth, 79.7% were born in Massachusetts, 16.0% were born in a different state and 3.5% were born outside of the U.S. (including 1.5% who were not United States citizens).

Figure 54: Racial Structure in 2000

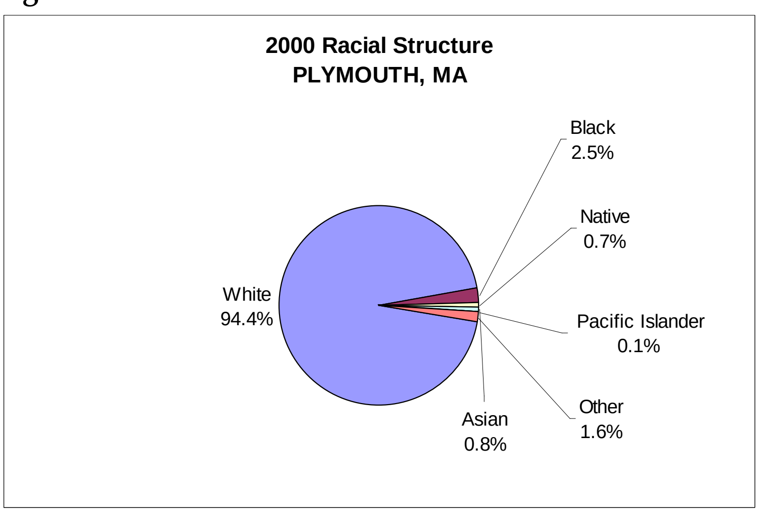
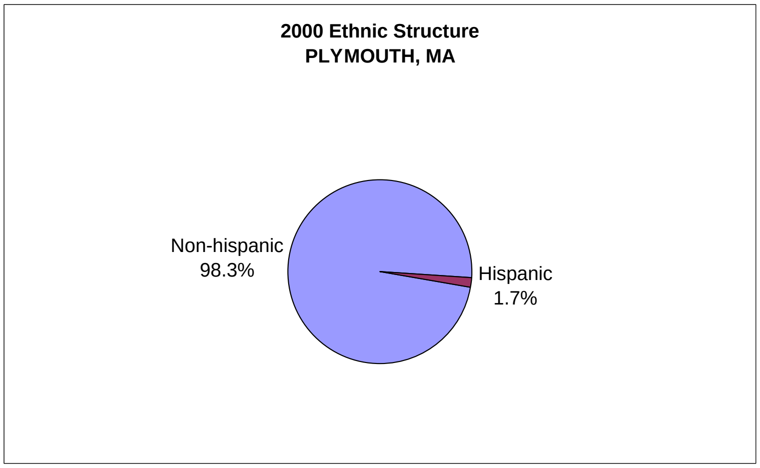


Figure 55: Ethnic Structure in 2000



For 93.4% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 6.6% in homes where a language other than English was spoken, including 1.6% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 89.4% were high school graduates or higher and 26.4% had a bachelor's degree or higher. Again of the population 25 years and over, 2.8% did not reach ninth grade, 7.8% attended some high school but did not graduate, 32.0% completed high school, 22.5% had some college with no degree, 8.5% received their associate degree, 17.9% earned their bachelor's degree, and 8.5% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Plymouth County was Catholic with 40 congregations and 205,060 adherents. Other prominent congregations in the county were Jewish (8 with 23,600 adherents), United Church of Christ (25 with 9,491) and Episcopal (15 with 6,894 adherents). The total number of adherents to any religion was down 36.1% from 1990.

Issues/Processes

As noted above, the population of the town of Plymouth has grown by 145% over the last two decades, encouraged by its proximity to Boston.[340] This puts numerous demands on the municipality to meet this growth with schools and other infrastructure.

The Town Wharf, where the commercial fishing fleet is stationed, was described in 2002 as in very poor condition and badly in need of repair.[341] It was temporarily closed in the winter of 2004, after having been found to be structurally unsound; plans for a new wharf were in the works.[342] The new plans involved implementing a user fee for commercial fishermen and anyone else using the wharf to pay for the proposed improvements; currently fishermen tying up to the dock to unload or get fuel and ice pay no fee. Fishermen argue that the proposed fee structure could drive some of them out of business.[343] The plans will also reduce the amount of space used for unloading by Reliable Fish Co., to make room for other businesses, which the owner of Reliable Fish says will have a dramatic effect on his business.[344]

Cape Cod Bay, where many Plymouth fishermen work, is critical Northern right whale habitat, and parts of the bay are frequently closed to fixed fishing gear or require gear modifications at times when the whale are present, which impacts lobstermen from Plymouth.[345]

Cultural attributes

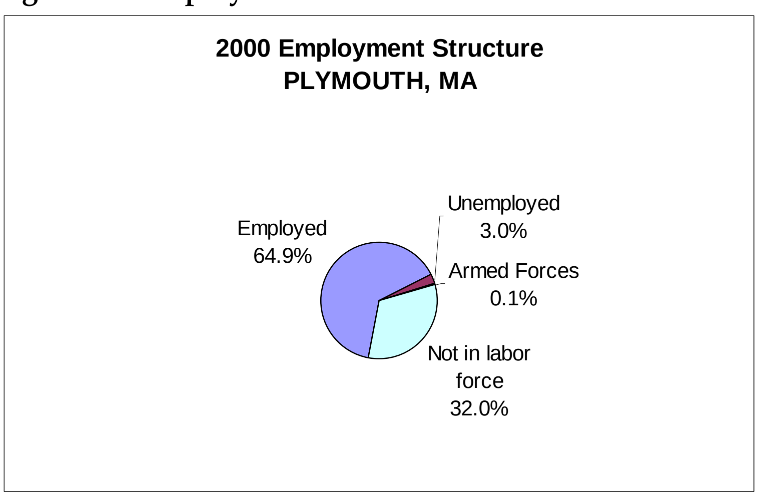
In July Plymouth holds the annual Blessing of the Fleet. Commercial fishing vessels are decorated and parade around the harbor.[346] The celebration honors Plymouth's maritime traditions with food, education, and celebration, and honors those who have chosen to make their living from the sea with a memorial service.[347] The town also has a Fishermen's Memorial Park.[348]

4.5.2 <u>Infrastructure</u>

Current Economy

According to the U.S. Census 2000, 64.9% (27,104 individuals) of the total population 16 years of age and over were in the labor force, with 3.0% unemployed and 0.1% in the Armed Forces.

Figure 56: Employment Structure in 2000



The largest employer in Plymouth is Jordan Hospital (1,100 employees), followed by Entergy (630), Party Lite (400), and Tech Etch (400).[349] The Lobster Pound has roughly 20 employees.[350]

According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting accounted for 0.7% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 6.2% of jobs. Education, health, and social services (21.2%) was the industry grouping that accounted for the most employment. Additional important categories were retail trade (14.7%), professional, scientific, management, administrative, and waste management services (9.5%), and finance, insurance, real estate, and rental and leasing (9.4%).

Median household income in Plymouth was $54,677 (up 37.1% from $39,886 in 1990) and per capita income was $23,732. For full-time year round workers, men made approximately 42.5% more per year than women.

The average family in Plymouth in 2000 consisted of 3.16 persons. With respect to poverty, 4.4% of families (down from 4.8% in 1990) and 5.4% of individuals earned below the official US Government poverty line, while 29.2% of families in 2000 earned less than $35,000 per year.

In 2000, Plymouth had a total of 21,250 housing units of which 86.7% were occupied[351] and 75.4% were detached one unit homes. Almost 20% of these homes were built before 1940. There are a few mobile homes, boats, RVs and vans in this area, accounting for 3.5% of the total housing units; 93.3% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area was $166,300. Of vacant housing units, 79.3% were used for seasonal, recreational, or occasional use. Of occupied units 22.4% were renter occupied.

Governmental

The Town of Plymouth is governed by a Board of Selectmen with five members elected in overlapping three year terms.[352]

<u>Fishery involvement in government</u>

The town has an eleven member Harbor Committee, appointed by the Board of Selectmen, which oversees various activities in and around the harbor.[353] The Downtown/Harbor Task Force focuses on issues affecting the waterfront area of downtown Plymouth and created a Master Plan to encourage mixed use development of this area. One of the goals of their Master Plan is to maintain and expand marine businesses in this area, including those related to commercial and recreational fishing. Another goal involves improving existing infrastructure, including docks.[354]

There is also a Harbormaster's Office with a Harbormaster, several Assistant Harbormasters and staff. In addition, there is an Inland Fisheries Committee whose purpose is "to promote, enhance and restore the passage of anadromous fish such as River Herring and catadromous fish to their current and historic waterways." [355]

Fishery associations

The Plymouth Lobstermen's Association maintains a winch for unloading on the Town Pier as well as floats on the pier with dues collected from members.[356]

Fishery Assistance Centers

No secondary or archival information on fishery assistance centers in Plymouth has been found.

Other fishing-related institutions

The Manomet Center for Conservation Sciences, located in Plymouth, conducts research on fish behavior and fishing practices to develop sustainable and selective fishing practices. The Center works with commercial fishermen, local communities, and with state and federal agencies.[357]

Physical

Plymouth is 5 miles from the Cape Cod Canal, 32 miles from New Bedford, and 40 miles from Boston. Plymouth is accessed by road via Route 3, which travels between Cape Cod and Boston, and Route 44, which travels west to Providence. Plymouth has its own municipal airport; the closest large airport is Logan International Airport in Boston. The Massachusetts Bay Transportation Authority provides public transportation via commuter rail to Boston and other areas of the South Shore.[358]

Plymouth Harbor is protected by Plymouth Beach, a long barrier beach separating the harbor from Plymouth Bay and Cape Cod Bay. The fishing fleet is based at the Town Wharf, located next to the harbor's 4,000 foot breakwater. The Town Pier, which is part of the town-owned Town Wharf section of town, is primarily used by commercial passenger vessels, including the whale watch and fishing charter vessels, but also has the unloading facilities for the fishing fleet, and a privately-owned fueling station. The lobster and commercial fishing vessels do not pay for their space along these two docks.

To the north of the Town Wharf are the town boat ramp and the large state boat ramp, which is restricted to recreational use only. Two fish markets and a bait shop are also located adjacent to the wharf.[359] Plymouth Boat Yard and Jesse's Marine are two facilities with a common owner, providing service and hauling for both commercial and recreational vessels in Plymouth. The supply shop at Jesse's Marine supplies commercial gear, including lobster traps and blocks as well as bait bags and clam rakes.[360] Brewer Marine in the harbor has 100 slips, diesel, and haul out services.[361] Fishermen's Outfitter, located in the marina, sells gear and tackle for sport fishing.[362] Electra-dyne is a local company manufacturing electrical equipment for both commercial and recreational fishermen.[363]

4.5.3 Involvement in Northeast Fisheries

Commercial

There are at least 40 commercial lobster vessels and 30 commercial fishing vessels in Plymouth Harbor. Commercial fishing vessels are generally docked at the Town Wharf, but both these and the lobster boats unload along the Town Dock. The unloading facilities are operated by Reliable Seafood Co. on the Town Wharf, a wholesale seafood distributor which has been distributing most of the fish and lobsters caught by the fleet for the last 75 years.[364] The Lobster Pound in Manomet, a seafood retailer and wholesaler, also purchases lobsters from about 35-40 vessels from Plymouth and other areas, buying directly from the vessels at the Town Dock. The fish they sell is mostly fresh fish shipped from New Bedford or Boston.[365] Ice is trucked to port from New Bedford, and the same trucks take the catch away with them.[366]

In 2003, Plymouth lobstermen complained about low catches of lobster, likely resulting from a combination of increased size limits, overfishing, and lower water temperatures due to a harsh winter. Some lobstermen said it was the worst year they'd seen.[367] Despite this, the value of lobster landings in Plymouth in 2003, at $2.8 million, was more than double the average yearly landings for the years 1997-2004. Likewise, the value of largemesh groundfish was more than double the average yearly landings for the same years. Cod was the second most valuable species in 2003, worth $447,230, and yellowtail flounder was third, with landings worth $370,233. Overall, the value of landings in Plymouth varied considerably, with a spike in 2000, a sharp decline in 2001, and then another large jump in 2002. The number of vessels both home ported in Plymouth and with owners living in Plymouth was somewhat more consistent.

Landings by Species

Table 32: Dollar value of Federally Managed Groups of landing in Plymouth, MA

	Average from 1997-2004	2003 only
Lobster	1,254,957	2,844,760
Largemesh groundfish	613,668	1,473,131
Monkfish	247,765	247,500
Dogfish	226,491	23,077
Surf Clams, Ocean Quahogs	37,281	0

Scallop	22,489	98,337
Skate	13,156	15,196
Summer flounder, Scup, Black Sea Bass	8,298	217
Squid, Mackerel, Butterfish	6,918	96
Smallmesh groundfish	1,943	817
Bluefish	1,447	817
Other	65,059	60,143

Vessels by Year

Table 33: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	58	46	1,437,210	1,009,851
1998	53	42	693,202	1,212,163
1999	54	40	870,648	1,025,862
2000	50	39	1,175,634	5,449,592
2001	56	48	1,718,939	1,284,575
2002	56	44	2,507,990	5,052,361
2003	59	45	2,680,580	4,764,091

Recreational

Recreational fishing is a popular activity among Plymouth's numerous tourists. Captain John Boats, a whalewatching company, also offers deep sea fishing aboard a party boat in Cape Cod Bay and on Stellwagen Bank, including overnight fishing trips.[368] The Captain Tim Brady and Sons company also offers whalewatching tours and open and charter boat fishing in both deep sea and in-shore waters.[369] There are a total of 12 charter fishing boats based in Plymouth to accommodate an apparently large demand for recreational fishing.[370] Lobster Tails cruises takes passengers out to haul lobster traps from Plymouth Harbor and to learn about the history of lobster fishing and the biology of lobsters.[371] Shellfishing in area shellfish beds is also a popular activity. Between 2001-2005, there were 18 charter and party vessels making 2,093 total trips registered in logbook data by charter and party vessels in Plymouth carrying a total of 70,199 anglers (NMFS VTR data). Fishing is also done from the town's docks, jetties, and beaches.[372]

Subsistence

No information has been found on the subsistence fishing in Plymouth.

Future

Specific goals of the Downtown Village Center/Waterfront Master Plan include: establishing new piers along the waterfront between the State and Town Piers, providing a central fish cold storage facility, and possibly adding additional docking facilities on the north side of the breakwaters. The town is also aiming to improve the water quality of the harbor to re-open shellfishing beds.[373] However, the Fort Point Associates report on waterfront development notes, "While retaining Plymouth's fishing boats is important to its diversity and character, the Town is unlikely to capture expanded fishing uses given industry conditions and competing facilities" in Marshfield, Scituate, and Provincetown. The town is considering reconstructing the derelict Town Wharf; because excursion vessels are more profitable, they would be moved here and the commercial fishing vessels would be moved to the Town Pier. The Fort Point Associates report also recommends implementing usage fees for commercial fishermen to use the Town Pier. [374]

Reliable Fish Co., which does a majority of packing and wholesale distribution of fish in Plymouth, has plans to demolish its current facility and construct a new building to include a restaurant. Reliable Fish would continue to distribute fish in the wholesale market.[375]

Fishermen are concerned that the proposed plan for usage fees for the new Town Wharf will put them out of business, or at least make it more difficult for them to make a living, given the difficult situation they are in already with increasingly stringent regulations. [376]

4.6 NEW BEDFORD, MA

4.6.1 People and Places

Regional Orientation

New Bedford is the fourth largest city in the commonwealth of Massachusetts. It is situated on Buzzard Bay, located in the southeastern section of the state. New Bedford is bordered by Dartmouth on the west, Freetown on the north, Acushnet on the east, and Buzzards Bay on the south. It is 54 miles south of Boston, 33 miles southeast of Providence, Rhode Island, and approximately 208 miles from New York City.[377]

Map 15. New Bedford's location in Massachusetts

Historical/Background information

New Bedford, originally part of Dartmouth, was settled by Plymouth colonists in 1652. Fishermen established a community in 1760 and developed it into a small whaling port and shipbuilding center within the next five years. By the early 1800s New Bedford had become one of the world's leading whaling ports. Over one half of the U.S. whaling fleet, which totaled more than 700 vessels, was registered in New Bedford by the mid 1800s.

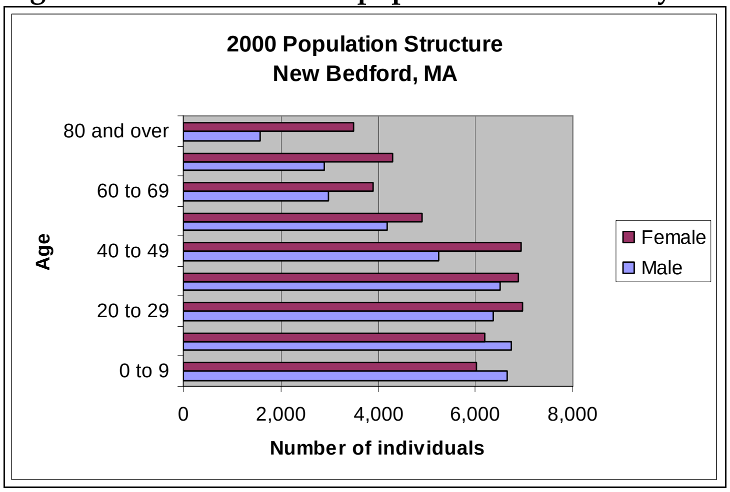
The discovery of petroleum greatly decreased the demand for sperm oil, bringing economic devastation to New Bedford and all other whaling ports in New England. The last whale ship sailed out of New Bedford in 1925.[378] In attempts to diversify the economy, the town manufactured textiles until the southeast cotton boom in the 1920s. Since then, New Bedford has continued to diversify its economy, but the city is still a major commercial fishing port.[379] It consistently ranks in the top two ports in the US for landed value.

Demographics

According to Census 2000 data, New Bedford had a total population of 93,768, down from the reported population of 99,922 in 1990. Of this population 47.1% were males and 52.9% were females. The median age was 35.9 years and 71.2 % of the population was 21 years or older while 18.9% was 62 or older.

New Bedford's age structure by sex shows a higher number of females in each age group between 20 and over 80 years. There is no drop in the 20-29 age group (as occurs in many smaller fishing communities), which could be due to New Bedford's proximity to Boston (several universities) and the local sailing school, and the Northeast Maritime Institute.

Figure 57: New Bedford's population structure by sex in 2000



New Bedford's racial composition in 2000 was 79% white, 9.1% other, 6.1% claiming two or more races, and 4.5% Black or African American. In addition, Hispanic/Latinos made up 10.2% of the population. In terms of ancestry, the residents of New Bedford trace their backgrounds to several countries, but most of all to Portugal. In 2000 the most common ancestries were Portuguese (41.2%), Sub-Saharan African (9.1%) and Cape Verdean (8.9%). Cape Verdeans are Portuguese speakers.

Figure 58: New Bedford's Racial Structure in 2000

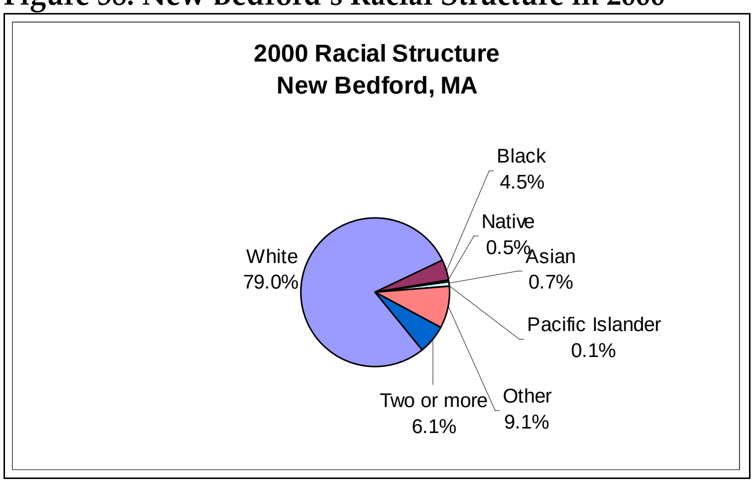
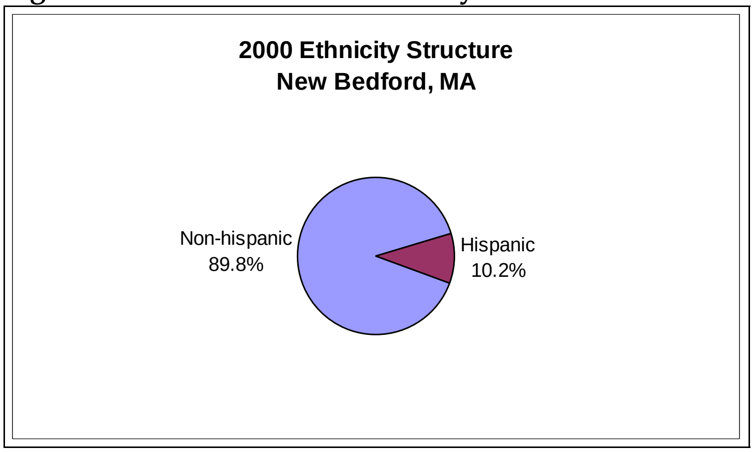


Figure 59: New Bedford's ethnicity structure in 2000



For 62.2% of the population in 2000, only English was spoken in the home, leaving 37.8% in homes where a language other than English was spoken, including 17.3% of the population who spoke English less than 'very well' according to the 2000 Census. Of the population 25 years and over, 57.6% were high school graduates or higher and 10.7% had a bachelor's degree or higher. Again of the population 25 years and over, 24.3% did not reach ninth grade, 18.1% attended some high school but did not graduate, 27.7% completed high school, 13.9% had some college with no degree, 5.3% received their associate degree, 7.5% earned their bachelor's degree, and 3.2% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religious Data Archive, in 2000 the religion with the highest number of congregations and adherents in the Bristol County was Catholic with 85 congregations and 268,434 adherents. Other prominent congregations in the county were United Methodist (17 with 3,583 adherents), United Church of Christ (19 with 5,728) and Episcopal (18 with 5,100). The total number of adherents to any religion was up 9.4% from 1990.

Issues/Processes

New Bedford struggles with a highly contaminated harbor and harbor sediment. New Bedford Harbor is contaminated with metals and organic compounds, including polychlorinated biphenyls (PCBs).[380] Because of the high concentrations of PCBs in the sediment, New Bedford Harbor was listed by the U.S. Environmental Protection Agency (EPA) as a Superfund site in 1982 and cleanup is underway. Significant levels of these pollutants have accumulated in sediments, water, fish, lobsters, and shellfish in the Harbor and adjacent areas. New Bedford is also the only major municipality in the Buzzards Bay area to discharge significant amounts of untreated combined sewage, industrial waste, and storm water from combined sewer overflows.[381]

The pollution problem not only affects health and the ecosystem but has a large impact on New Bedford's economy. For example, closures of fishing areas in the harbor have caused economic losses in the millions for the quahog landings alone. Closure of the lobster fishery has resulted in an estimated loss of $250,000 per year and the finfish industry and recreational fishing have been negatively affected as well.[382] In addition to contaminated harbor sediments, numerous brownfield properties are located in proximity to the port, especially on the New Bedford side.[383]

Another issue is crews. According to a 2002 newspaper article, fishing vessel owners complain of a shortage of crewmen. They attribute this scarcity to low unemployment rates that have kept laborers from the docks. Many choose to bypass work that government statistics place among the most dangerous jobs in the country. Many crewmembers are either inexperienced or come from foreign countries. Both present safety issues, according to one fisherman, because inexperienced crew get hurt more often and foreign crew have significant language barriers that impede communication. Additionally, those willing to work sometimes struggle with alcohol and drug dependency. Ship captains routinely have applicants roll up their shirt sleeves to check for traces of heroin use.[384]

Cultural attributes

In September 2007, New Bedford will host the fourth annual Working Waterfront Festival, dedicated to the commercial fishing industry in New Bedford. This festival is a chance for the commercial fishing industry to educate the public about its role in the community and in providing seafood to consumers, through boat tours, demonstrations, and contests. The annual Blessing of the Fleet is held as part of the Working Waterfront Festival.[385]

The New Bedford community celebrates its maritime history with a culmination of activities in the New Bedford Summerfest. The Summerfest is held annually in July in conjunction with the New Bedford State Pier and the New Bedford National Whaling Historical Park. Summerfest also includes the Cape Verdean Recognition Day Parade and the Cape Verdean American Family Festival.[386]

The community has taken an active role in the remembrance of its maritime heritage. The Azorean Maritime Heritage Society, the New Bedford Whaling Museum and the New Bedford Whaling National Historical Park have cooperated to raise awareness of the maritime history of the Azorean community on both sides of the Atlantic.[387]

The New Bedford Whaling museum was established by the Old Dartmouth Historical Society in 1907 to tell the story of American whaling and to describe the role that New Bedford played as the whaling capital of the world in the nineteenth century. Today the whaling Museum is the largest museum in America devoted to the history of the American whaling industry and its greatest port.[388]

The New Bedford Whaling National Historical Park, created in 1996, commemorates the heritage of city as a whaling port. The park is spread over 13 city blocks and includes a visitor center, the New Bedford Whaling Museum, and the Rotch-Jones-Duff House and Garden Museum.[389]

4.6.2 Infrastructure

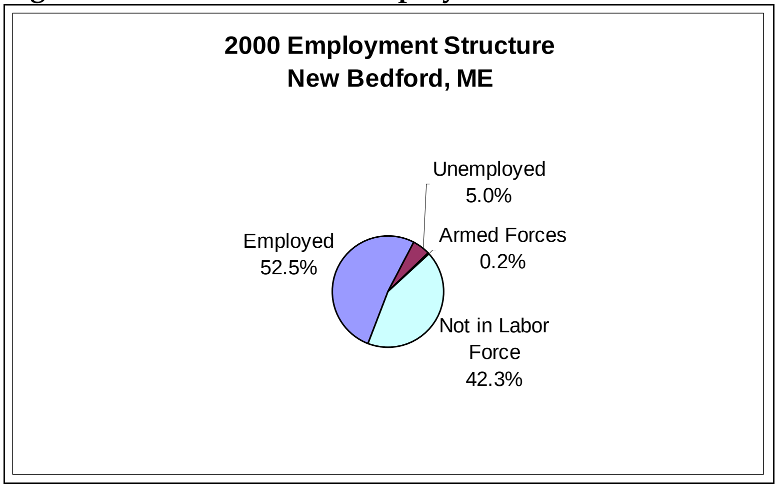
Current Economy

The New Bedford Economic Development Council (NBEDC), Inc was established in 1998 to improve the city's economic development by helping to attract business and job opportunities to the city. The NBEDC also provides small business funds and offers financial support (in loans) for new businesses or those who want to expand. One of their loan funds is specifically targeted at fishermen.[390]

With a federal grant and local funds, the city and the Harbor Development Council (HDC) in 2005 began construction on a $1 million, 8,500-square foot passenger terminal at State Pier to support passenger ferry service. The HDC received a federal grant for more than $700,000 to construct the passenger terminal and to improve berthing at the New Bedford Ferry Terminal[391].

The Community Economic Development Center is a non-profit organization vested in the economic development of the local community. The organization is unique in that it is involved with fisheries management. The center is currently engaged in a research project to better understand the employment status in the fishing industry. The center is a liaison for migrant workers and other newcomers to the community to have access to the benefits provided by the city. In the past the center at one time had a re-training program for displaced fishermen to move into aquaculture.
According to the U.S. Census 2000, 57.7% (42,308 individuals) of the total population 16 years of age and over were in the labor force, of which 5.0% were unemployed and 0.2% were in the Armed Forces.

Figure 60: New Bedford's employment structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 407 or 1.1% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 1,485 or 3.9% of the labor force. Educational, health and social services (20.9%), manufacturing (20.7%), retail trade (12.1%), entertainment, recreation, accommodation and food services (7.4%), and construction (7.1%) were the primary industries. According to a 1993 survey, major employers that provide over 100 jobs in New Bedford include the following businesses with the number of employees in parentheses: Acushnet Company (1,600), Cliftex (1,400), Aerovox (800), Calish Clothing (750), and Polaroid (465).[392]

Median household income in New Bedford in 2000 was $27,569 (an increase from $22,647 in 1990) and median per capita income was $15,602. For full-time year round workers, men made approximately $9,110 more per year than women.

The average family in New Bedford in 2000 consisted of 3.01 persons. With respect to poverty, 17.3% of families (up slightly from 16.8% in 1990) and 20.2% of individuals earned below the official US Government poverty line, and 48.8% of families in 2000 earned less than $35,000 per year.

In 2000, New Bedford had a total of 41,511 housing units of which 92.0% were occupied and 30.2% were detached one unit homes. Approximately half (49.9%) of these homes were built before 1940. Mobile homes in this area accounted for 0.3% of the total housing units; 95.0% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $113,500. Of vacant housing units, 0.3% were used for seasonal, recreational, or occasional use. Of occupied units 56.2% were renter occupied.[393]

Governmental

New Bedford was incorporated as a town in 1787 and as a city in 1847. The city of New Bedford features a Mayor and a City Council.[394]

Fishery involvement in government

The Harbor Planning Commission includes representatives from the fish-processing and harvest sectors of the industry.

Institutional

Fishing associations

There are a variety of fishing associations which aid the fishing industry in New Bedford, including the American Dogfish Association, the American Scallop Association and the Commercial Anglers Association. New Bedford also is home to a Fishermen's Wives Association which began in the early 1960s. Additionally, New Bedford has the Offshore Mariner's Wives Association which includes a handful of participants that organize the "Blessing of the Fleet."

Fishing Assistance Centers

Shore Support has been the primary fishing assistance center in New Bedford since 2000,[395] though the New Bedford Fishermen and Families Assistance Centers are also available as is the Trawlers Survival Fund.

Other fishing -related organizations

There are several other fishing related organizations and associations that are vital to the fishing industry such as the Fisheries' Survival Fund (Fairhaven), the New Bedford Fishermen's Union, the New Bedford Seafood Coalition, the New Bedford Seafood Council and the Offshore Mariner's Association.

Physical

The New Bedford Municipal Airport is located 2 miles NW of the city. Interstate 195 and State routes 24 and 140 provide access to the airports, ports, and facilities of Providence and Boston. The Consolidated Rail Corporation (Conrail) provides services into New Bedford.[396]

4.6.3 Involvement in Northeast Fisheries

Commercial

In the 1980s fishermen reaped high landings and bought new boats. Then in the 1990s they experienced a dramatic decrease in groundfish catches, a vessel buyback program, and strict federal regulations in attempts to rebuild the depleted fish stocks. A new decade brought more changes for the fishing industry.[397] By 2000 and 2001 New Bedford was the highest value port in the U.S. (generating $150.5 million in dockside revenue).[398] According to the federal commercial landings data, New Bedford's most successful fishery in the past seven years has been scallops, followed by groundfish. Both were worth significantly more in 2003 than the 1997-2004 average values, and the total value of landings for New Bedford generally increased over the same time period.
New Bedford contains approximately 44 fish wholesale companies,[399] 75 seafood processors and some 200 shore side industries.[400] Maritime International has one of the largest U.S. Department of Agriculture-approved cold treatment centers on the East Coast. Its terminal receives approximately 25 vessels a year, most carrying about 1,000 tons of fish each.[401]

Landings by species – State Only Permits

Table 34: Landings in pounds for state-only permits

Species	Pounds landed
Cod**	6,311,413
Haddock**	5,949,880
Lobster***	1,168,884
Scup**	593,394
Fluke**	480,165
Crab***	315,395
Loligo Squid**	207,769
Striped Bass**	189,055
Quahog (littleneck)*	147,249
Monkfish	137,300
Conch*	136,276
Skate	121,522
Quahog (cherrystone)	113,341
Black Sea Bass**	113,071
Pollock	65,500
Quahog (Chowder)*	64,999
Bluefish**	44,045

Species	Pounds landed
Quahog (mixed)*	11,513
Red Hake	10,100
Cusk	1,880
Illex Squid**	1,305
Soft Shell Clam*	985
Dab (Plaice)	870
Dogfish**	537
Winter Flounder	500
Yellowtail Flounder	383
Gray Sole (Witch)	200

Asterisks indicate data sources: Zero: MA DMF has 2 gear-specific catch reports: Gillnet & Fish Weirs. All state-permitted fish-weir and gillnet fishermen report landings of all species via annual catch reports. NOTE: Data for these species do not include landings from other gear types (trawls, hook & line, etc.) and therefore should be considered as a subset of the total landings. (Massachusetts Division Marine Fisheries).

Landings by species – Federal Permits

Table 35: Dollar value by species landed in New Bedford

Catch	1997-2004 Average	2003
Scallops	68,458,919	102,785,405
Largemesh Groundfish	29,234,009	38,101,563
Monkfish	9,860,316	7,461,998
Surf Clams, Ocean Quahogs	6,292,742	7,584,792
Other	4,469,666	3,946,386
Lobster	4,145,961	5,545,729
Skates	1,554,432	1,775,930
Squid, Mackerel, Butterfish	1,337,329	1,606,276
Summer Flounder, Scup, Black Sea Bass	1,124,292	1,124,486
Red Crab	925,401	1,563,422
Smallmesh Groundfish	617,155	2,135,623
Herring	398,074	2,553,863
Dogfish	108,169	171
Bluefish	9,211	13,439

Catch	1997-2004 Average	2003
Tilefish	2,310	1,483

Vessels by Year

Table 36: Vessel permits and landed value between 1997 and 2003

Year	# Vessels home ported	# vessels (owner's city)	Home port value ($)	Landed port value($)
1997	244	162	80,472,279	103,723,261
1998	213	137	74,686,581	94,880,103
1999	204	140	89,092,544	129,880,525
2000	211	148	101,633,975	148,806,074
2001	226	153	111,508,249	151,382,187
2002	237	164	120,426,514	168,612,006
2003	245	181	125,788,011	166,680,126

Recreational

While fishing in New Bedford Harbor is discouraged[402], a number of companies in New Bedford offer the public recreational fishing excursions including boat charters.[403]

Subsistence

Information on subsistence fishing in New Bedford is either unavailable through secondary data collection or the practice does not exist.

Future

For several years work was underway to construct the New Bedford Oceanarium that would include exhibits on New Bedford's history as a whaling and fishing port, and was expected to revitalize the city's tourist industry and create jobs for the area. The Oceanarium project failed to receive its necessary funding in 2003 and 2004, and while the project has not been abandoned, it seems unlikely the Oceanarium will be built anytime in the near future.

According to a 2002 newspaper article, many fishermen believe that based on the quantity and ages of the specimens they catch – the fish are coming back faster than studies indicate. While most admit that regulations have worked, they believe further restrictions are unnecessary and could effectively wipe out the industry. "If they push these regs too hard, the whole infrastructure of fishing here could collapse," according to a New Bedford fishermen.[404]

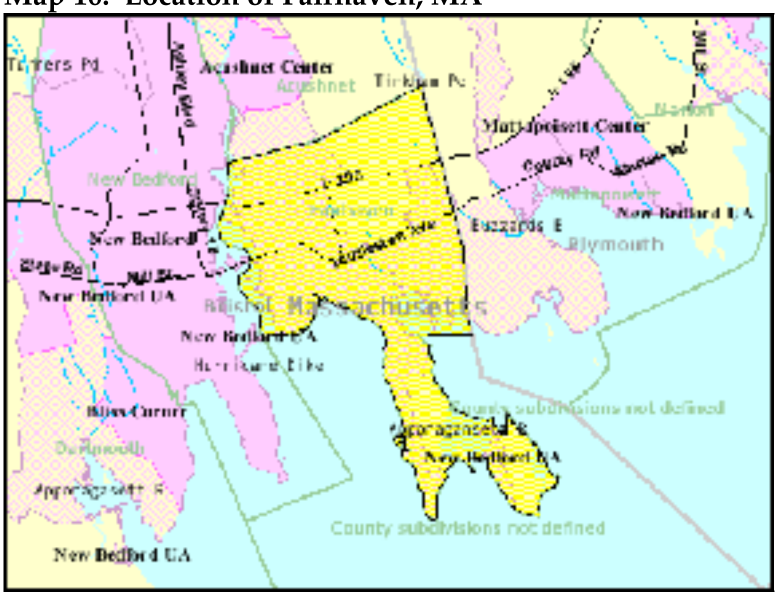
4.7 FAIRHAVEN, MA

4.7.1 People and Places

Regional orientation

The town of Fairhaven (41.66º N, 70.90º W) is located in southeastern Massachusetts, separated from the city of New Bedford by New Bedford/Fairhaven Harbor, and along Buzzard's Bay. The town has 12.41 square miles of land area and 14.10 square miles of total area. "Fairhaven is about 15 miles southeast of Fall River; 55 miles south of Boston; 35 miles southeast of Providence, Rhode Island; and 208 miles from New York City."[405]

Map 16. Location of Fairhaven, MA



Historical/Background information

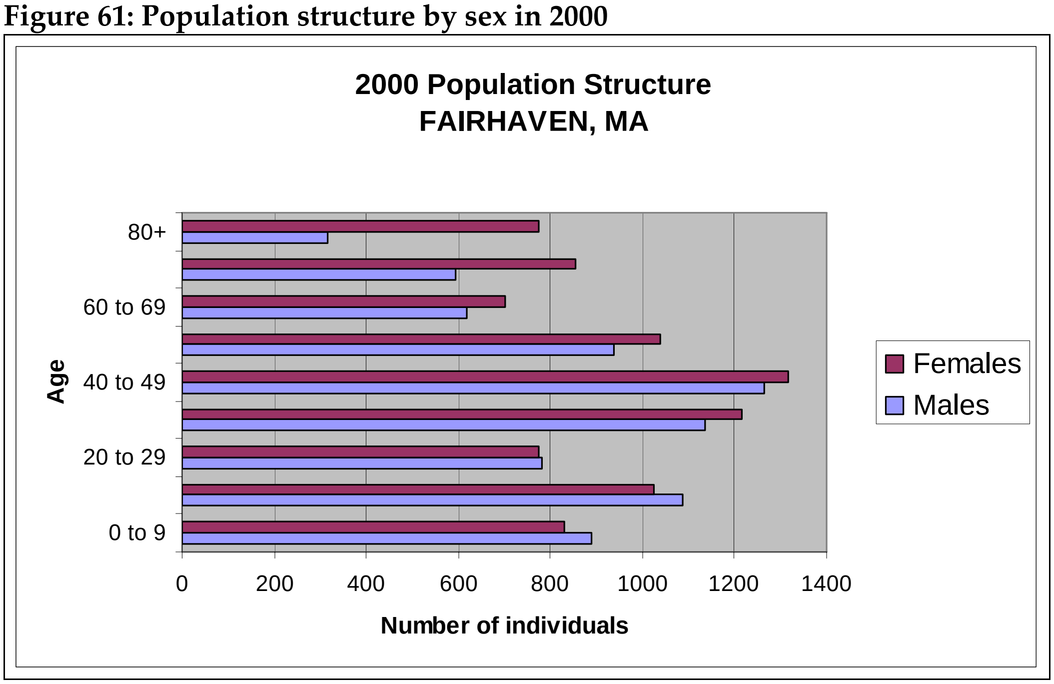
"The Town of Fairhaven is a suburban/fishing/resort community on Buzzard's Bay. The town suffered both material damage and loss of life during the raids and battles of King Philip's war and significant settlement took place only after the war. Until the middle of the 18th century, the town's economy was agricultural. Beyond that point there is a shift toward maritime activities such as shipbuilding, whaling and foreign trade focusing on the town's wharves. By 1838, Fairhaven was the second busiest whaling port in the country and at its peak the town boasted 46 ships and 1,324 men engaged in bringing back over $600,000 worth of whale products annually. Discovery of oil in Pennsylvania coming on the heels of a national depression ended whaling and the town turned to such industries as tack making. In 1903, the American Tack Company's new plant was said to be the largest and best tack mill in the world. Prominent Fairhaven resident Henry Huttleston Rogers went to Pennsylvania to learn about the oil industry and after making himself an oil millionaire, Rogers re-made his home town. He donated the town hall, library, church, schools, streets and water system. The buildings make up the state's finest collection of public buildings, almost all designed by Boston architect Charles Brigham. The community began taking on the character of a suburban town in the late 1870's when the street railway connected Fairhaven to New Bedford. At the same time Fairhaven began to develop as a summer resort area with significant rural areas still the site of working farms."[406]

Demographics

According to Census 2000 data, Fairhaven had a total population of 16,159, up 0.2% from the reported population of 16,132 in 1990. Of this total in 2000, 52.8% were female and 47.2% were male. The median age was 41.2 years and 75.3% of the population was 21 years or older while 22.2% were 62 or older.

The most populous age group for both men and women in the 2000 Census was the 40-49 year old grouping. The age structure shows a dip in population for both men and women in the 20-29 age bracket, perhaps indicating an out-migration of young people moving elsewhere to seek jobs. This dip is common in many fishing communities.

Figure 61: Population structure by sex in 2000



The majority of the population of Fairhaven in 2000 was white (96.1%), with 0.9% of residents Black or African American, 0.6% Native American, 0.6% Asian, and 0.1%

Pacific Islander or Hawaiian. Only 0.8% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including the following: Portuguese (33.3%), English (17.1%), French (15.6%), and Irish (14.7%). With regard to region of birth, 83.8% were born in Massachusetts, 10.0% were born in a different state and 5.7% were born outside of the U.S. (including 1.9% who were not United States citizens).

Figure 62: Racial Structure in 2000

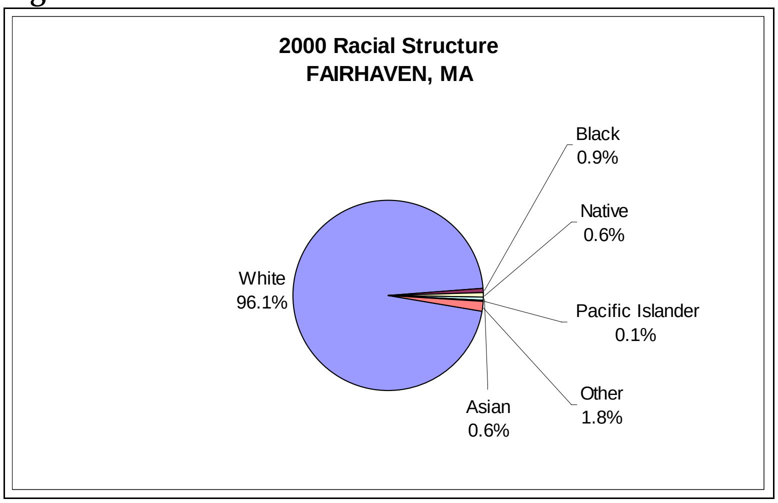
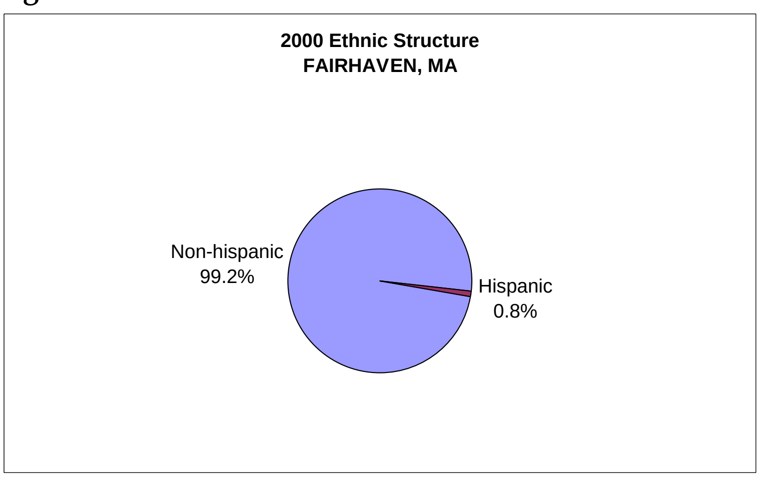


Figure 63: Ethnic Structure in 2000



For 89.4% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 10.6% in homes where a language other than English was spoken, and including 3.2% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 76.8% were high school graduates or higher and 16.9% had a bachelor's degree or higher. Again of the population 25 years and over, 9.4% did not reach ninth grade, 13.8% attended some high school but did not graduate, 35.6% completed high school, 17.9% had some college with no degree, 6.4% received

their associate degree, 11.4% earned their bachelor's degree, and 5.5% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Bristol County was Catholic with 85 congregations and 268,434 adherents. Other prominent congregations in the county were Jewish (5 with 11,600 adherents), United Church of Christ (19 with 5,728) and Episcopal (18 with 5,100 adherents). The total number of adherents to any religion was up 9.4% from 1990.

Issues/Processes

Fairhaven struggles with a highly contaminated harbor and harbor sediment that it shares with New Bedford. New Bedford Harbor is contaminated with metals and organic compounds, including polychlorinated biphenyls (PCBs).[407] Because of the high concentrations of PCBs in the sediment, New Bedford Harbor was listed by the U.S. Environmental Protection Agency (EPA) as a Superfund site in 1982 and cleanup is underway. Significant levels of these pollutants have accumulated in sediments, water, fish, lobsters, and shellfish in the Harbor and adjacent areas.[408]

When Atlas Tack, once the town's largest employer, closed in 1985, the facility was designated a Superfund site, contaminated with heavy metals and PCBs. This contributes to the pollution in New Bedford Harbor and in salt marsh estuaries around the town, and poses a public health risk to residents.[409]

In 2004, two fishing boats sank, one from Fairhaven and one owned by a Fairhaven man, killing seven men in total. The loss of the second of these, a scallop vessel, caused many to criticize scallop regulations for forcing fishermen to fish in rough weather.[410]

Cultural attributes

In September 2007, New Bedford will host the fourth annual Working Waterfront Festival, dedicated to the commercial fishing industry in New Bedford. This festival is a chance for the commercial fishing industry to educate the public about its role in the community and in providing seafood to consumers, through boat tours, demonstrations, and contests. The annual Blessing of the Fleet is held as part of the Working Waterfront Festival.[411]

The New Bedford community celebrates its maritime history with a culmination of activities in the New Bedford Summerfest. The Summerfest is held annually in July in conjunction with the New Bedford State Pier and the New Bedford National Whaling Historical Park. Summerfest also includes the Cape Verdean Recognition Day Parade and the Cape Verdean American Family Festival.[412]

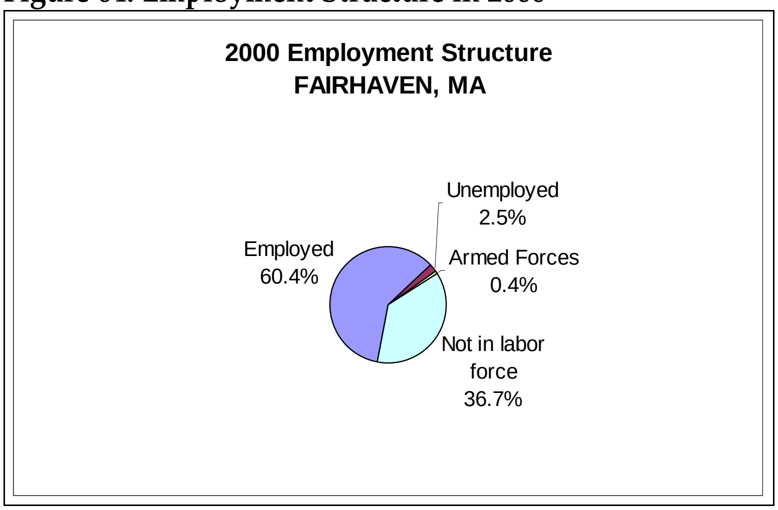
The community has taken an active role in the remembrance of its maritime heritage. The Azorean Maritime Heritage Society, the New Bedford Whaling Museum and the New Bedford Whaling National Historical Park have cooperated to raise awareness of the maritime history of the Azorean community on both sides of the Atlantic.[413]

4.7.2 Infrastructure

Current Economy

According to the U.S. Census in 2000, 63.3% (8,278 individuals) of the total population 16 years of age and over were in the labor force, of which 2.5% were unemployed and 0.4% were in the Armed Forces.

Figure 64: Employment Structure in 2000



The largest employer in Fairhaven is Acushnet Co., which manufactures golf equipment and supplies, including Titleist brand golf balls and Footjoy shoes and gloves, with 500 employees;[414] other important employers within the town include South Coast Hospital (200 employees), Walmart (150 employees), Stop and Shop (145 employees), and Nye Lubricants (102 employees).[415] AT&T, one of the town's largest employers, in 2004 laid off 140 employees from its Fairhaven-based call center, maintaining 200 employees on staff there.[416] Large employers in neighboring New Bedford include Southcoast Health System (hospital – 2000 employees), New Bedford City Hall (1500 employees), and Acushnet Rubber Co. (Rubber manufacturers – 700 employees). About 33% of Fairhaven commuters are employed in New Bedford.[417]

According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 153 positions or 1.9% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 499 positions or 6.3% of jobs. Education, health, and social services (24.4%) was the industry grouping that accounted for the most employment. Additionally, manufacturing (15.0%), and retail trade (13.4%) accounted for much of the city's employment.

Median household income in Fairhaven was $41,696 (up 38.5% from $30,097 in 1990) and per capita income was $20,986. For full-time year round workers, men made approximately 28.5% more per year than women.

The average family in Fairhaven in 2000 consisted of 2.98 persons. With respect to poverty, 6.5% of families (up from 4.5% in 1990) and 19.0% of individuals earned below the official US Government poverty line, while 29.7% of families in 2000 earned less than $35,000 per year.

In 2000, Fairhaven had a total of 7,266 housing units of which 91.1% were occupied and 72.6% were detached one unit homes. Nearly 40% (38.8%) of these homes were built before 1940. There were a few mobile homes, boats, RVs, and vans in this area, accounting for 0.5% of the total housing units; 93.6% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $132,400. Of vacant housing units, 64.1% were used for seasonal, recreational, or occasional use. Of occupied units, 27.5% were renter occupied.

Governmental

Fairhaven has a Town Meeting form of government with a Board of Selectmen. The town was incorporated in 1812.

Fishery involvement in government

Fairhaven has a Shellfish Department which issues commercial and recreational licenses for shellfishing. The department also has a program transplanting or purchasing seed to develop shellfish beds within certain areas of the community.[418]

Institutional

Fishery associations

The Fairhaven Shellfishermen's Association is working to replenish stocks of shellfish and to improve water quality.[419] There are also several fishing associations which aid the fishing industry in New Bedford, such as the American Dogfish Association, the American Scallop Association and the Commercial Anglers Association. New Bedford also is home to a Fishermen's Wives Association which began in the early 1960s. Additionally, New Bedford has the Offshore Mariner's Wives Association which includes a handful of participants that organize the "Blessing of the Fleet."

Fishery Assistance Centers

Shore Support has been the primary fishing assistance center in New Bedford since 2000,[420] though the New Bedford Fishermen and Families Assistance Centers are also available, as is the Trawlers Survival Fund.

Other fishing-related institutions

There are several other fishing related organizations and associations vital to the fishing industry such as the Fisheries' Survival Fund in Fairhaven, the New Bedford Fishermen's Union, the New Bedford Seafood Coalition, the New Bedford Seafood Council and the Offshore Mariner's Association.

Physical

"Fairhaven is about 15 miles southeast of Fall River; 55 miles south of Boston; 35 miles southeast of Providence, Rhode Island; and 208 miles from New York City."[421] Interstate 195 and Route 6 run through the town, connecting it to Cape Cod, Providence, and beyond. The Southeastern Regional Transit Authority operates in Fairhaven, providing buses to New Bedford. The closest airport is the New Bedford Municipal Airport; additionally, T.F. Green Airport in Warwick, RI is roughly 40 miles away.

Fairhaven has two large shipyards which service not only its own fishing fleet but also much of New Bedford's fleet. The D.N. Kelley and Son Shipyard is the oldest operating shipyard in the United States, in operation since 1864, and for many years has specialized in repairing and refitting commercial fishing vessels from New Bedford, expanding in the 1980s to service large yachts and commercial vessels of all kinds.[422] Other boats are serviced at the Fairhaven Shipyard, in business since 1879, which also specializes in commercial fishing vessels and other large boats. Fairhaven Shipyard also has a marina which services primarily recreational vessels.[423] Union Wharf is the town-owned dock where many of the commercial vessels tie up. Many of the commercial fishing vessels are also based out of the shipyards. There are two facilities in town where fish are unloaded, including MacLean's Seafood, a wholesaler, on Union Wharf, and another new landing facility that was recently built, but neither of these is involved with processing.[424] Earl's Marina, located on West Island at the southern tip of Fairhaven, primarily houses recreational vessels, providing easy access to Buzzard's Bay;[425] Fairhaven has a total of six marinas,[426] and a public boat ramp.[427] Athearn Marine Agency is a fishing vessel brokerage agency located in Fairhaven.[428]

4.7.3 Involvement in Northeast Fisheries

Commercial

Fairhaven's fishing industry is so closely linked to that of New Bedford as to often be considered one and the same. Most of Fairhaven's vessels unload and sell their fish in New Bedford, while vessels from both communities haul out in Fairhaven.[429] The Whaling City Seafood Display Auction in New Bedford, opened in 1994, services New Bedford, Fairhaven, and Southern New England, and allows fishermen to get fair market price for their catch.[430] The majority of Fairhaven's fleet is made up of scallop vessels, many of which are operated by Norwegians.[431] The town Shellfish Department has issued 30 commercial shellfishing licenses within the town, indicating that shellfishing is also important to Fairhaven's fishing industry.[432]

The highest landings in Fairhaven in 2003 were for lobster, valued at $2.8 million, followed by red crab ($304,906) and other crab ($297,009). Landings for all three of these were significantly higher in 2003 than the 1997-2004 average. Judging by the fact that the level of home port fishing in Fairhaven is much higher than the level of landings in the town, and by the fact that Fairhaven had zero landings in 1997-1999, it is clear that most landings are done in New Bedford. Overall, the number of vessels, both those with their home port in Fairhaven and those whose owners live in Fairhaven, did not change considerably over the period from 1997-2003. The level of home port fishing reached its peak at more than $13.6 million in 2000, and then declined slightly in subsequent years.

Landings by Species

Table 37: Dollar value of Federally Managed Groups of landing in Fairhaven, MA

	Average from 1997-2004	2003 only
Lobster	1,490,125	2,827,138
Other	155,553	511,752
Red crab	49,529	304,906
Surf Clams, Ocean Quahogs	14,390	24,557
Monkfish	1,392	0
Largemesh Groundfish	82	0
Summer Flounder, Scup, Black Sea Bass	27	0
Scallop	10	0

Vessels by Year

Table 38: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)

1997	47	66	7,276,335	0
1998	49	70	7,377,555	0
1999	42	65	9,171,719	0
2000	47	64	13,628,961	3,908,566
2001	46	62	10,244,277	3,648,901
2002	46	63	11,669,633	2,260,013
2003	44	60	10,023,955	3,668,353

Recreational

Fairhaven has a few charter fishing companies specializing in striped bass such as Fanta Sea Fishing Charters[433] and MacAtac Sportfishing.[434] Shellfishing is a popular recreational activity here; the town's Shellfish Department has 700 recreational shellfishing licenses issued.[435]

Subsistence

No information has been found on the subsistence fishing in Fairhaven.

Future

In 2004 the Commonwealth of Massachusetts Seaport Council granted $5 million to dredge New Bedford Harbor, in an attempt to improve the infrastructure for New Bedford and Fairhaven and to support the commercial fishing industry.[436] While New Bedford has an area on the harbor zoned specifically for marine industrial use, Fairhaven does not have this sort of zoning and is at risk for loss of waterfront access from development.[437]

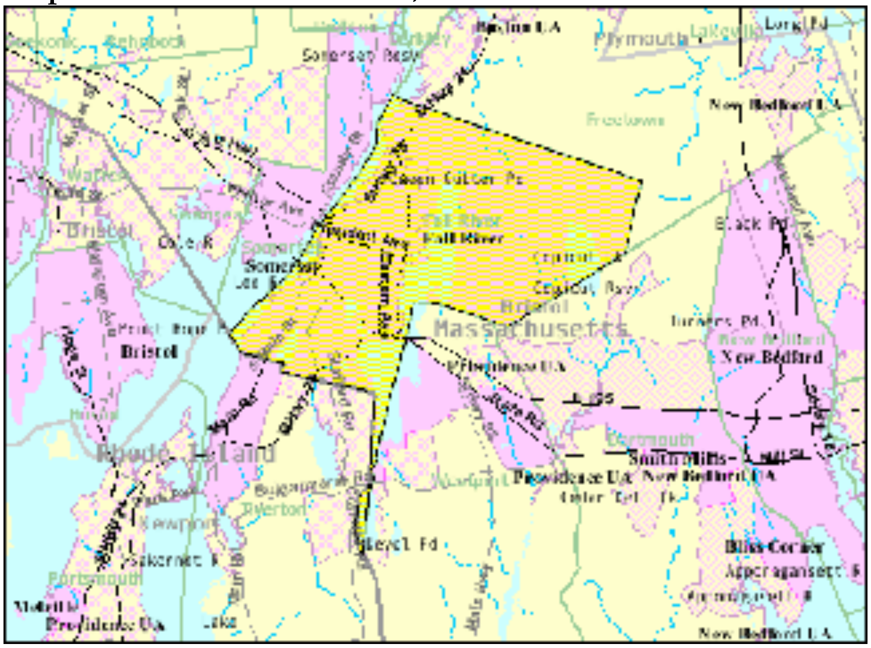
4.8 Fall River

4.8.1 People and Places

Regional orientation

The city of Fall River (41.70º N, 71.56º W) is located in Southeastern Massachusetts in Bristol County, along the Rhode Island border. It borders Westport, RI and is about 15 miles from New Bedford, MA. Fall River is 34 square miles in area[438] and sits on Mount Hope Bay at the mouth of the Taunton River.[439] Mount Hope Bay is a component of the larger Narragansett Bay.[440]

Map 17. Location of Fall River, MA



Historical/Background information

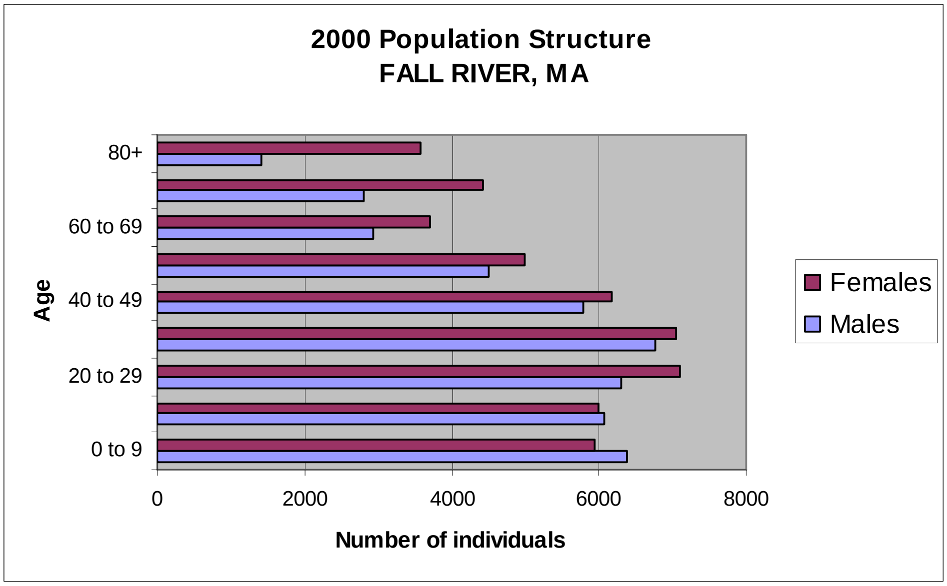
Fall River was home to the Wampanoag tribe until they were pushed out during King Phillip's War in 1675. The name comes from a translation of Quequechan, meaning falling waters, the Wampanoag name for the area. The original settlers to the area were farmers and ships' carpenters from Rhode Island. It was founded in 1803, and incorporated as a city in 1854.[441] Fall River has a long industrial history; the first cotton mill was built here in 1811. This started a trend in textiles manufacturing that would eventually make Fall River one of the textile capitals of the nation. By the early 20th century it was known as Spindle City and had over 100 mills employing over 30,000 people. The abundance of mills drew English, Irish, Russian, Lebanese, French, Polish, Eastern European, and Jewish immigrants to Fall River, giving it the highest percentage of foreign-born residents in the U.S. by 1900. The largest percentage of migrants came from Portugal and the Azores. Fall River is also well known for being the home of Lizzie Borden, who according to lore killed her parents with an axe in the late 1800s, a story which captivated the nation. During the Depression, there was a significant economic downturn as jobs moved to the south and many mills closed; this economic decline continued through much of the 20th century and is only recently reversing itself. Today Fall River continues to have a highly ethnically diverse population.[442]

Demographics

According to Census 2000 data, Fall River had a total population of 91,938, down 0.08% from the reported population of 92,703 in 1990. Of this total in 2000, 53.3% were female and 46.7% were male. The median age was 35.7 years and 72.2% of the population was 21 years or older while 19.1% were 62 or older.

The most populous age group in Fall River was 30-39, followed by closely 20-29 and 40-49. Women outnumbered men in all age groups beginning with age 20. Fall River does not experience the decline in population for the age group 20-29 experienced by many fishing communities, presumably because there are many employment opportunities for young people in this urban area.

Figure 65. Population structure by sex in 2000



The majority of the population of Westport in 2000 was white (90.9%), with 3.1% of residents Black or African American, 0.6% Native American, 2.4% Asian, and 0.3% Pacific Islander or Hawaiian. Only 3.3% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Portuguese (47.0%), French (13.4%), Irish (9.8%), English (6.6%), French Canadian (5.9%), and "other ancestries" (9.0%). Fall River is, in fact, home to one of the largest populations of Azorean Portuguese in the United States.[443] With regard to region of birth, according to the 2000 Census, 69.7% were born in Massachusetts, 9.2% were born in a different state and 19.8% were born outside of the U.S. (including 9.2% who were not United States citizens).

Figure 66. Racial Structure in 2000

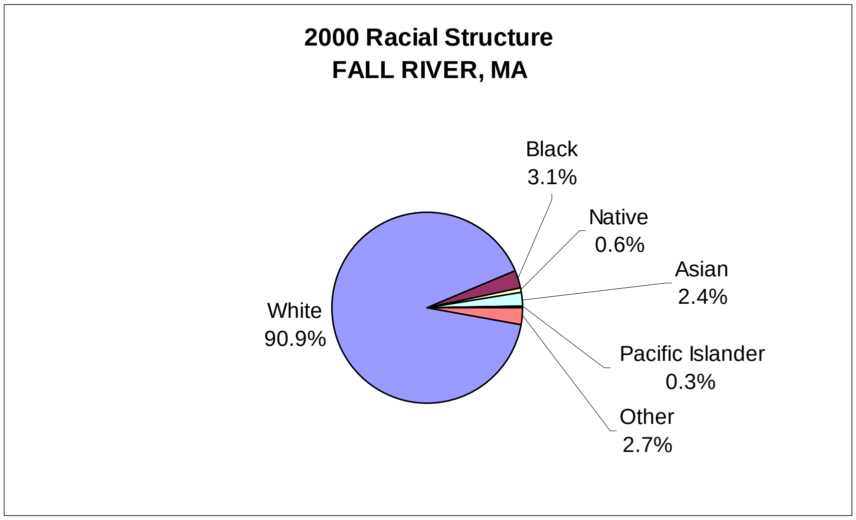
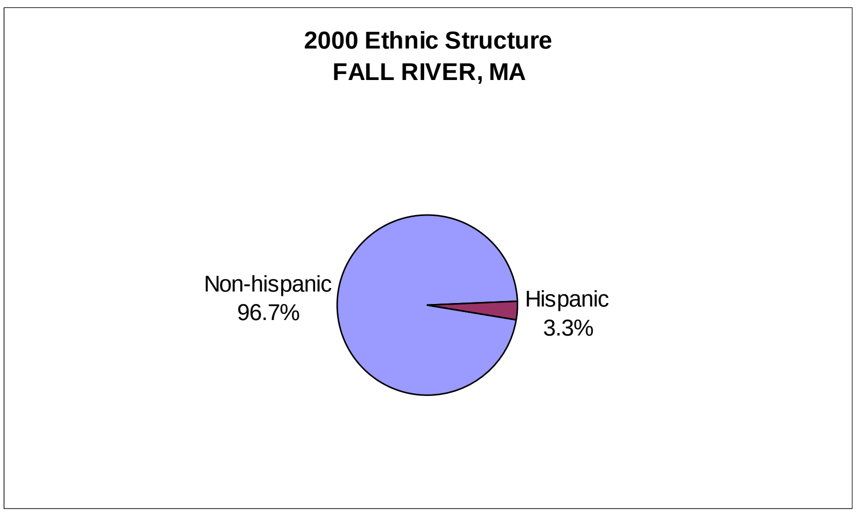


Figure 67. Ethnic Structure in 2000



For 65.4% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 34.6% in homes where a language other than English was spoken, and including 15.0% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 56.6% were high school graduates or higher and 10.7% had a bachelor's degree or higher. Again of the population 25 years and over, 23.9% did not reach ninth grade, 19.5% attended some high school but did not graduate, 26.1% completed high school, 13.5% had some college with no degree, 6.2% received their associate degree, 7.5% earned their bachelor's degree, and 3.2% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Bristol County was Catholic with 85 congregations and 268,434 adherents. Other prominent congregations in the county were Jewish (5 with 11,600 adherents), United Church of Christ (19 with 5,728) and Episcopal (18 with 5,100 adherents). The total number of adherents to any religion was up 9.4% from 1990.

Issues/Processes

Weaver's Cove Energy has gained approval, though subsequently legal challenges have been raised, to build a liquefied natural gas (LNG) facility in Fall River.[444] The LNG would be transported up the Taunton River, passing under four bridges along the way. There are concerns about the safety of people who live around the proposed facility, which could serve as a target for terrorists, and about the necessity of shutting down portions of Narragansett Bay and Mount Hope Bay to boat traffic when the tankers are moving through. Proponents argue the facility will bring tax revenue to the city.[445]

Cultural attributes

The Fall River Maritime Heritage trail guides visitors around historical sites displaying the city's nautical past, including Battleship Cove, a museum containing the nation's largest collection of 20th century U.S. Naval vessels. The Fall River Marine Museum, also along the heritage trail, features a large collection of model ships and other nautical memorabilia, along with the largest exhibit of artifacts from the Titanic in the United States. The city also has a variety of different ethnic festivals throughout the year, such as a Cambodian New Year festival, the Greek Festival, and several Azorean festivals, including the Great Feast of the Holy Ghost of New England, touted as the largest Azorean festival in the world.[446] "Fall River Celebrates America" is the name of an annual waterfront festival featuring live music, a parade, a Portuguese night, a talent search, and an international food fair.[447]

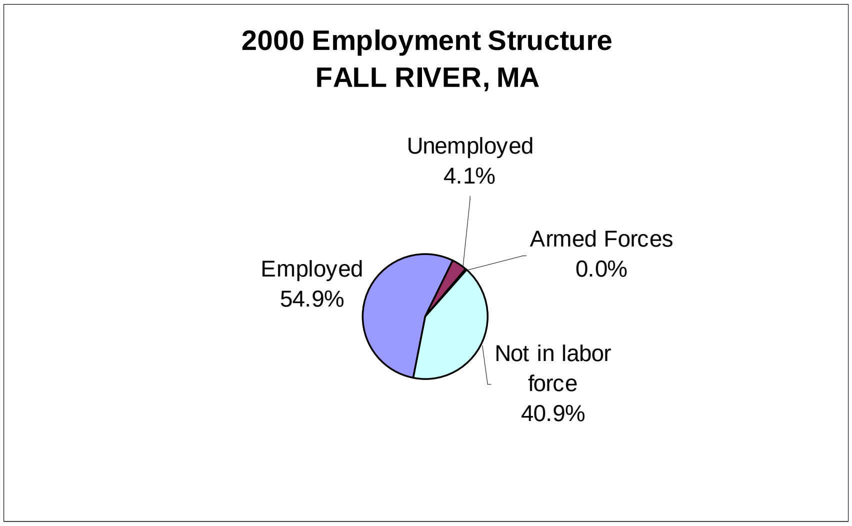
The city recently received a replica of the gates to the city of Ponta Delgada, Fall River's Azorean sister city. These will be placed along the waterfront at the entrance to an area known as Crab Cove, at the eventual location of a commuter rail to Boston.[448]

4.8.2 <u>Infrastructure</u>

Current Economy

According to the U.S. Census 2000, 59.1% (42,682 individuals) of the total population 16 years of age and over are in the labor force, of which 4.1% are unemployed and 0.0% are in the Armed Forces.

Figure 68. Employment Structure in 2000



The largest employers in Fall River as of 2002 included St. Anne's Hospital (1,079 employees), Labor Express (Temporary staffing – 1,000 employees), Bristol Community College (760 employees), Lightolier, Inc. (lighting fixtures – 650 employees), and Joan Fabrics (600 employees).[449] The old mills today host a mix of commercial, office, and industrial uses, which have helped to revitalize Fall River's economy. Fall River's industrial park hosts close to 50 businesses with 3,500 employees. The health care industry is one of the city's largest employment sectors.[450] In 2004 Blount Seafood relocated its headquarters and many of its processing operations to Fall River. The new facility produces soups and value-added seafood products here, while most of the traditional shellfish processing continues to take place at the company's Warren, RI facility. The new operations in Fall River were expected to create 100 new jobs.[451]

According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 100 positions or 0.3% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 1,312 positions or 3.3% of jobs. Manufacturing (24.3%) is the industry grouping that accounts for the most employment. Additionally, education, health, and social services (20.8%), retail trade (12.5%), and arts, entertainment, recreation, accommodation and food services (7.1%) accounted for much of the city's employment. Median household income in Fall River in 2000 was $29,014 (up 29.2% from $22,452 in 1990) and per capita income was $16,118. For full-time year round workers, men made approximately 36.9% more per year than women.

The average family in Fall River in 2000 consisted of 3.0 persons. With respect to poverty, 14.0% of families (up from 12.3% in 1990) and 17.1% of individuals earned below the official US Government poverty line, while 46.2% of families in 2000 earned less than $35,000 per year.

In 2000, Fall River had a total of 41,857 housing units, of which 92.6% were occupied and 19.8% were detached one unit homes. More than one half (53.0%) of these homes were built before 1940. There are a few mobile homes in this area, accounting for 0.1% of the total housing units; 94.7% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area was $132,900. Of vacant housing units, 3.2% were used for seasonal, recreational, or occasional use. Of occupied units 65.1% were renter occupied.

Governmental

Fall River has a mayor – city council form of government.[452]

Fishery involvement in government

Information on fishery involvement in government in Fall River is not available through secondary sources.

Institutional

Fishery associations

The New England Red Crab Harvesters Association was created in 1999 by Fall River-based red crab fishers to assist with the implementation of a federal Fisheries Management Plan for red crab. The harvesters in the association, made up of just four crab boats in Fall River, cooperate to some degree on their harvesting strategy by staggering landings so as to maintain a steady rate of processing. The Association has begun the process of having the fishery certified by the Marine Stewardship Council as sustainable, and is in the process of forming a harvest cooperative.[453]

Fishery Assistance Centers

Shore Support has been the primary fishing assistance center in New Bedford since 2000,[454] though the nearby New Bedford Fishermen and Families Assistance Centers are also available as is the New Bedford-based Trawlers Survival Fund.

Other fishing-related institutions

There are several other fishing related organizations and associations that are vital to the area's fishing industry such as the Fisheries' Survival Fund in Fairhaven, the New Bedford Fishermen's Union, the New Bedford Seafood Coalition, the New Bedford Seafood Council and the Offshore Mariner's Association. Save the Bay is a non-profit organization dedicated to restoring and protecting the environmental quality of Narragansett Bay. The organization works towards this goal by monitoring the health of the Bay, initiating action to clean up the Bay, and through advocacy and education programs.[455]

Physical

Fall River lies where the Taunton River meets Mount Hope Bay. Interstate 195 and Routes 24 pass through Fall River, connecting the city with Providence, Cape Cod, Newport, and Boston. The Southeastern Regional Transit Authority operates several city buses, as well as buses to New Bedford.[456] The Massachusetts Bay Transportation Authority has been considering extending the commuter rail service to Fall River from Boston.[457] Bay Colony Railroad and Conrail operate freight rail service from Fall River.[458] Peter Pan Buses also runs buses regularly from Fall River to Providence, Boston, Newport, and other area destinations.[459] Fall River is 15 miles from New Bedford, 18 miles from Providence, and 55 miles from Boston. The nearest commercial airports are T.F. Greene Airport in Warwick, RI, 26 miles away, and Logan International Airport, 55 miles from Fall River.[460] Fall River itself has a municipal airport.[461]

Fall River Line Pier operates the city's port, with two deep water berths and a large storage facility, which receives a wide variety of cargo, including frozen fish.[462] There is a state pier located in the area known as Crab Cove.[463] Bucko's Parts and Tackle Service in Fall River sells fishing gear.[464]

4.8.3 <u>Involvement in Northeast Fisheries</u>

Commercial

Atlantic Frost Seafoods is a shoreside processing facility based on a vessel docked in Fall River. They process mackerel and herring, and have a capacity of 150 tons per day. Atlantic Frost is owned by Global Fish, a Norwegian corporation which is one of the world's largest suppliers of pelagic fish.[465] In 2004, Blount Seafood, established in 1880, relocated its headquarters and much of its value-added seafood processing operations to Fall River. Its shellfish processing operation continues to take place in Warren, RI.[466]

There are presently four red crab vessels based in Fall River which are members of the New England Red Crab Harvesters Association.[467] Crabs landed here are shipped to a facility in Nova Scotia for processing.[468]

The landings data for Fall River show that red crab is by far the most valuable species landed here, with an average value of $1,649,802 for the years 1997-2006. Other important fisheries over the same time period are lobster, monkfish, and the butterfish, mackerel, and squid category. In 2003 landings of red crab were below the average value, and lobster landings were at just $1,800 compared to an average landings value of over $750,000. Butterfish, mackerel, and squid, an important category on the average, had almost no landings in 2003. The value of the monkfish and summer flounder, scup, and black sea bass categories were higher in 2003 than the ten-year average value. This information paints a picture of a highly variable fishery. Landings did fluctuate considerably between 1997-2005, from a low of just over $500,000 in 1998 to a high of over $7 million the following year. Landings then declined again for the next few years, but were up over $6 million in 2005. Level of home port fishing shows a similar variability, with a low of less than $6,000 in 1998, and a high of over $3 million in 2005. The trend in home port fishing seems to follow the landings somewhat, with landings being more than two orders of magnitude higher than home port fishing in some years, but in later years the level of home port fishing increases and is closer to, but still lower than, the level of landings. It seems many of the boats landing their catch here are ported elsewhere. Interestingly, the number of home port vessels is relatively consistent in all years, as is the number of city owner vessels.

Landings by Species

Table 39. Dollar value of Federally Managed Groups of landing in Fall River, MA

	Average from 1997-2006	2003 only
Redcrab	1,649,802	1,389,739
Lobster	755,086	1,801
Monkfish	207,700	302,615
Butterfish, mackerel, squid	201,154	73
Summer Flounder, Scup, Black Sea Bass	81,667	259,962
Herring	40,735	0
Other	35,178	0
Skate	6,455	29,824
Largemesh Groundfish	3,050	1,330
Dogfish	1,250	0
Smallmesh Groundfish	158	50
Tilefish	87	50
Bluefish	76	8
Surf Clam, Ocean Quahog	14	0

Vessels by Year

Table 40. All columns represent vessel permits or landings value combined between 1997-2005

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	7	7	13,944	1,472,363
1998	5	6	5,954	562,709
1999	7	7	323,872	7,013,229
2000	6	8	44,915	2,053,753
2001	6	7	45,658	1,630,877

2002	6	8	1,246,895	1,514,723
2003	6	5	1,372,655	1,985,452
2004	6	5	1,284,121	4,987,777
2005	6	5	3,311,536	6,266,674

Recreational

One of the Massachusetts Saltwater Fishing Derby Official Weigh Stations is located at Main Bait & Tackle in Fall River.[469] This is one of 4 bait and tackle shops in Fall River. Fall River also has a jetty and a ramp with paved access, which are usable at all tides.[470] There is also a Fall River Junior Bassmasters club, though it operates out of Cambridge, MA (60 miles away).[471]

Subsistence

Hall-Arber et al. (2001) note “lots of the people who participate in recreational fishing in Tiverton are Cambodian or have other ethnic backgrounds. Some of this "recreational" activity may actually support a fisheries- based subsistence life style.”[472] Tiverton, RI is only 8 miles from Fall River and many of these Cambodian fishermen probably reside in Fall River, given Fall River’s Cambodian population and the fact that that Tiverton’s 2000 population was 98% white and the “Other Asian” category (where Cambodians would be found) was composed fewer than 5 people.

Future

“Fall River is in the final phase of its comprehensive Harbor Plan. With funding provided by the state, the city commissioned consultants to formulate a definitive marketing and development blueprint for the waterfront and downtown districts. Implementation has already begun. An extended boardwalk has been completed and the state has committed funding for the overhaul of the State Pier as a marine-related mixed use development.”[473] The Commerce Park in Fall River will soon hold large facilities for Main Street Textiles and the TJX Corporation, creating 1,600 new jobs for the city.[474]

5.0 RHODE ISLAND

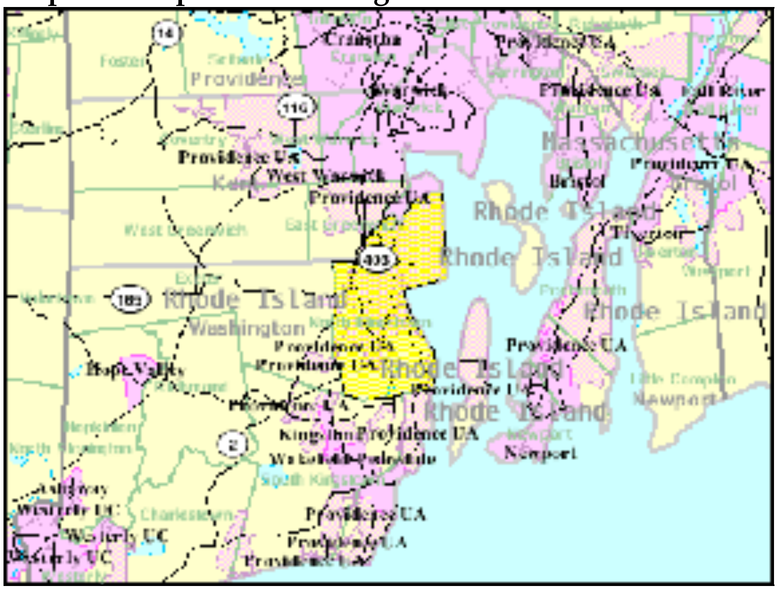
5.1 NORTH KINGSTOWN, RI

5.1.1 People and Places

Regional orientation

North Kingstown (41.55°N, 71.466°W) is located in Narragansett Bay in Washington County in the state of Rhode Island. The city is located 8.2 miles from Narragansett Pier, RI, 22.85 miles from Providence, RI, 72.54 miles from Boston, MA, and 169.8 miles from New York City, NY. It is sometimes referred to as North Kingston.

Map 18 : Map of North Kingstown's location



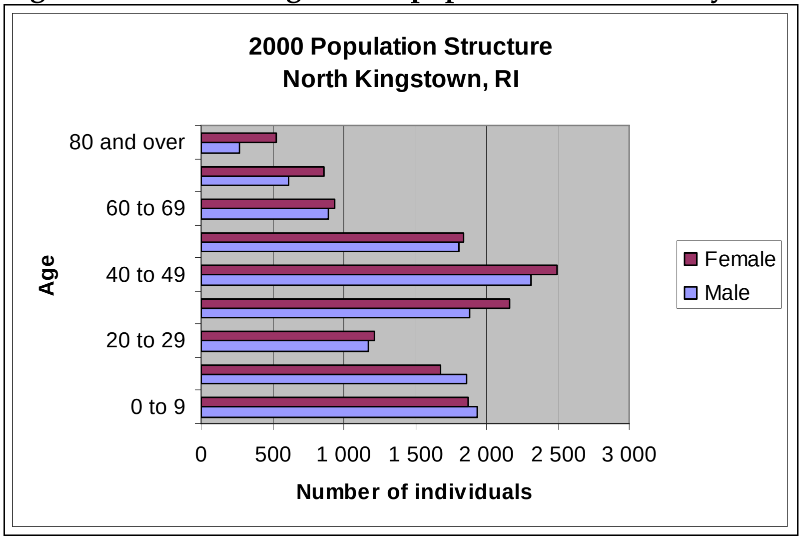
Historical/Background information

North Kingstown is a small town on the west side of Narragansett Bay. It is comprised of nine villages, with Wickford as the center of town and the seat of the local government. The city is known as Rhode Island's sea town. Kings Towne was incorporated in 1674, and included what is now known as Narragansett County. North Kingstown and South Kingstown were the same town until they split in 1723. World War II dramatically changed the economy of North Kingstown. Quonset Naval Air Station and the Davisville Construction Training Center were built in an area north of Wickford village was used as a site to protect the Northeast coast during the war. Today, North Kingstown has strong economic growth potential due to a deep-water port, rail lines, the state's longest runway, and its natural harbor and beaches which make it famous as a summer resort.[475]

Demographics

According to the Census 2000 data, the city had a population of 26,326, up from a reported population of 23,786 in 1990. Of this total in 2000, 48.4% were males and 51.6 were females. The median age was 38.7 years and 71.3% of the population was 21 years or older while 14.0% of the population was 62 or older. North Kingstown had a dip in population within the 20-29 year age group, and the largest age group was between 40-49 years.

Figure 69 : North Kingstown's population structure by sex in 2000



The majority of the population of North Kingstown in 2000 was white (95.7%) with 1.0% Black or African America, 0.6% Native American and 0.1% Asian. Of the total population, 1.8% identified themselves as Hispanic/Latino. Residents linked their heritage to a number of European ancestries including: Irish (17.8%), English (13.7%), Italian (13.4%), French (6.5%), German (5.1%), and French Canadian (4.9%). With regard to region of birth, 62.6% were born in Rhode Island, 32.8% were born in a different state and 3.4% were born outside of the U.S. (including 1.0% who were not United States citizens).[476]

Figure 70: North Kingstown's Racial Structure in 2000

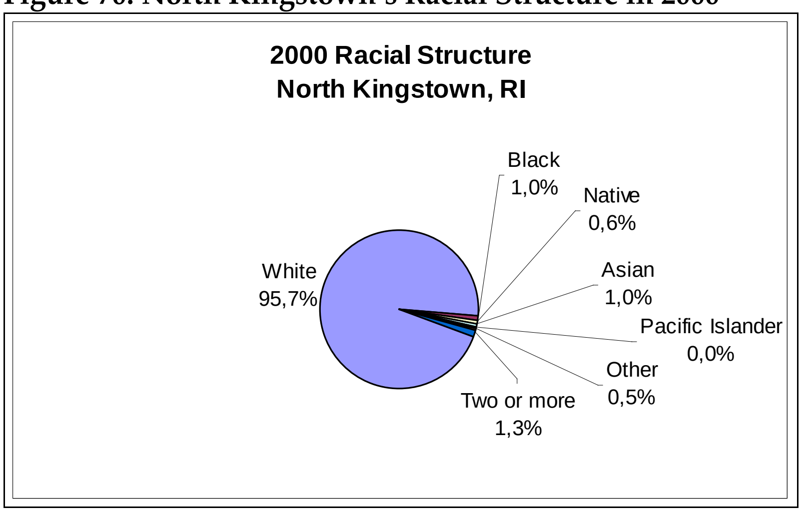
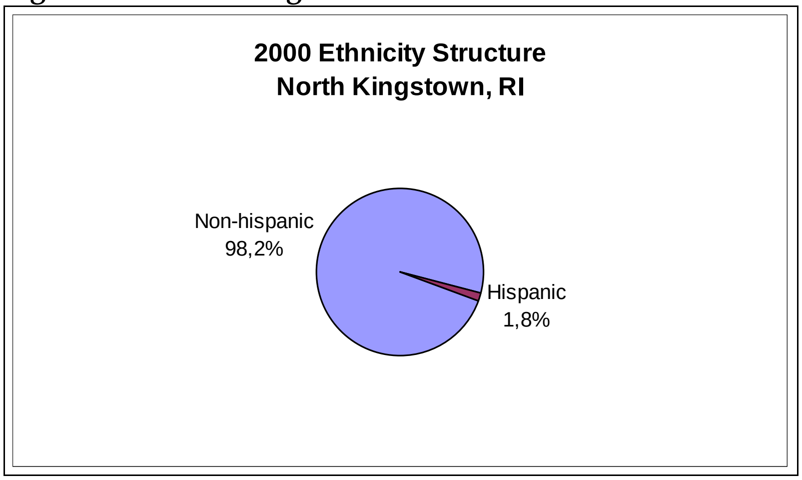


Figure 71: North Kingstown's Ethnic Structure in 2000



For 93.6% of the population, only English was spoken in the home, leaving 6.4% in homes where a language other than English was spoken, including 1.5% of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 91.5% were high school graduates or higher and 40.3% had a bachelor's degree or higher. Again of the population 25 years and over, 2.0% did not reach ninth grade, 6.5% attended some high school but did not graduate, 23.3% completed high school, 19.5% had some college with no degree, 8.4% received their associate degree, 26.4% earned their bachelor's degree, and 14.0% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive in 2000 the religions with the highest number of congregations in Washington County included Catholic (20 with 58,668 adherents), American Baptist Churches in the USA (15 with 3,022 adherents), and Episcopal Church (10 with 4,720 adherents). The total number of adherents to any religion was up 57.3% from 1990.

Issues/Processes

One ongoing concern for the fishermen in North Kingstown has been the proposed the transformation beginning in 1999 of the Quonset Naval Base into a deep water container port[477]. Once thought dead in 2003[478], the issue returned and remains a concern in 2006[479]. Concerns included: pollution from the port, noise from the ships, increased erosion from the wake of increased number of ships, greater potential for oil spills, and the introduction of invasive species from ballast water.[480] Most significantly, fishermen were concerned about a decline in fisheries that may be the result of any number of the previously mentioned effects. Additionally, many of the vessels that use this port are large vessels and require large amounts of dock space.[481] This had the possibility of depleting waterfront access to the commercial fishermen.

Cultural attributes

The 24-25th of August the Annual International Quahog Festival takes place in Wickford, North Kingstown. This event features a variety of food items featuring Rhode Island's native quahog, a hard shell clam. Amateurs and professional chefs compete in a cooking contest accompanied by children's activities and music.[482]

5.1.2 Infrastructure

Current Economy

Sea Freeze, Ltd. in North Kingstown, which began its operations in 1985, is the largest producer of sea-frozen fish on the east coast of the United States. It supplies sea-frozen and land-frozen fish to domestic and international markets, including bait products to long-line fleets. Sea Freeze owns two freezer trawlers that provide all of the catch that is stored at Sea Freeze facilities. Catch is then marketed nationally and world-wide. The plant does not include any processing facilities. Fishing operations target illex and loligo squid, mackerel, herring and to a lesser degree, butterfish. Although herring is among the least financially valuable (per pound) of the species it is nevertheless important to the business due to its year round availability and due to the fact that access to it continues after other fisheries become unavailable.

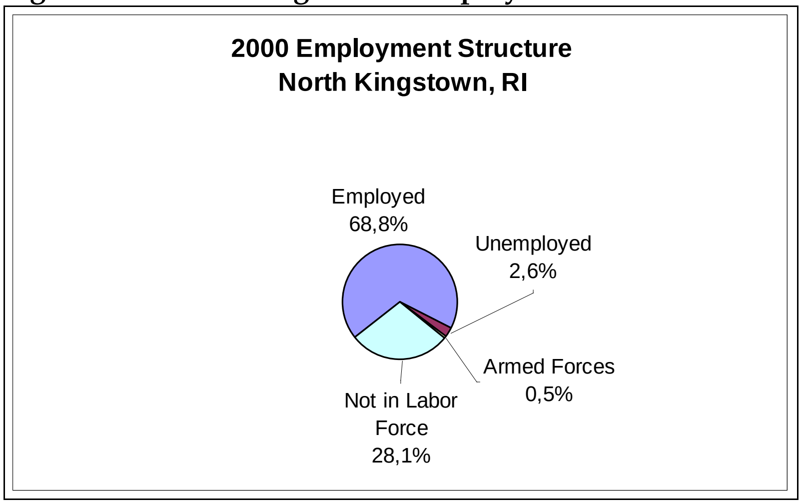
Currently, the plant employs approximately 60 people including 10 administrative and managerial staff, 20 crew working rotating shifts, and 15 individuals that work in the storage facility. However, the plant exists largely independent of the surrounding community. Employees live regionally, though not necessarily locally.[483]

Trawlworks, Inc. in North Kingstown is a supplier and distributor of marine hardware and rigging supplies for industrial, institutional, and commercial fishing for both midwater and bottom use. The corporation was formed in 1980.[484]

Some of the largest employers in North Kingstown include Toray Plastics America (plastics manufacturer), General Dynamics – Electric Boat Division (hull manufacture for submarines), and Senesco Marine (hull manufacture), all based at Quonset, as well as retail outfits such as WalMart, Home Depot, and Ocean State Job Lot.[485]

According to the U.S. Census 2000, 71.9% (114,524 individuals) of the total population 16 years of age and over were in the labor force, of which 2.6% were unemployed and 0.5% were in the Armed Forces.

Figure 72 : North Kingstown's employment structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for only 88 or 0.6% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 22 or 0.15% of the labor force. Educational health and social services (26.3 %), retail trade (13.2%), manufacturing (12.7%), and professional, scientific, management, administrative services (8.3%) were primary industries.

Median household income in North Kingstown in 2000 was $60,027
(a considerable increase from $40,419 in 1990) and median per capita income was $28,139. For full-time year round workers, men made approximately $15,269 more per year than women.

The average family in North Kingstown in 2000 consisted of 3.03 persons. With respect to poverty, 5.8% of families (up from 3.7% in 1990) and 7.1% of individuals earned below the official US Government poverty line, and 19.9% of families in 2000 earned less than $35,000 per year.

In 2000, North Kingstown had a total of 10,743 housing units of which 94.5% were occupied and 72.4% were detached one unit homes. Only 16.6% of these homes were built before 1940. Mobile homes accounted for 2.4% of the total housing units; 85.2% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $165,700. Of vacant housing units, 45.2% were used for seasonal, recreational, or occasional use. Of occupied units, 25.6% were renter occupied.

Governmental

North Kingstown has had a Council/Manager form of government since 1954. It is composed of five-member legislative body with a professional administrator. Council members are elected for two year terms. The Town Manager is the chief executive and administrative officer of the town. Appointed for an indefinite term, he is responsible to the Town Council for the proper administration of all affairs of the town.[486]

Fishery involvement in government

The town has a Harbor Planning Commission and a Conservation Commission, with members elected to 3-year terms.[487] There is also a Harbor Master with two Assistant Harbormasters, as well as an Operations Manager for the Allen Harbor Marina.[488]

Institutional

Fishing associations

Rhode Island Commercial Fishermen's Association formed in 2000 and located in Wakefield includes fishermen, dealers, suppliers and others. The goals of the association are to reach consensus on issues, improve working relationships with state and local officials, harvest fish sustainably, obtain quota for Rhode Island fishermen, and have input into management regulations. Other associations with membership in North Kingstown are Rhode Island Lobstermen's Association, Rhode Island Shellfishermen's Association, Ocean State Fisherman's Association, Ocean State Aquaculture Association, and Rhode Island Salt Water Anglers Association.[489]

Fishery assistance centers

Information on fishery assistance centers in North Kingston is either unavailable through secondary data collection or does not exist.

Other fishing related institutions

Rhode Island Seafood Council was established in 1976 as a nonprofit, statewide seafood marketing association to promote top quality seafood and seafood products.
The Bay Company was developed by the RI Seafood Council in 1999 to increase collaboration among educators and the various employers in marine-related industry.
The American Seafood Institute, an offshoot of R.I. Seafood Council, was formed in 1982 for overseas promotion and export assistance programs.[490]

Physical

Just 20 miles from the state capital of Providence, North Kingstown is easily accessed from Rte 95 to Rte 4 to two north /south arteries: Rte 1(Post Road) and Rte 2 (Quaker Lane). The city is 18 miles from the T.F. Green Airport located in Warwick. Quonset State Airport, located in North Kingstown is a reliever airport for TF Green in Warwick. The airport is also home base for the 143d Airlift Wing of the RI Air National Guard.

Quonset Davisville Port and Commerce Park in North Kingstown is one of the best-equipped industrial parks on the East Coast. A 3000 acre facility, located on a former Navy base, offers four modes of transportation: land, rail, sea & air for a wide variety of business needs. Quonset/Davisville has deep water piers (totaling 6,800 lineal feet), an airport (with an 8,000 foot runway) that can handle private Lear jets to most cargo planes and 23 miles of internal rail-lines with connections to the national freight rail system. [491]

There is a Municipal Wharf in Wickford situated among other commercial piers. This wharf hosts both fishing and recreational boats. [492]

5.1.3 Involvement in Northeast Fisheries

Commercial

In 2002 recorded annual landings for Rhode Island totaled 103.6 million pounds with a landing value of $64.2 million.[493] North Kingstown's annual landing value for 2003 was $8.5 million including an annual herring landing value of $586,058, and an annual lobster landing value of $214,523. The most valuable species landed in North Kingstown was Ilex squid, valued at $2,760,817, followed by Loligo squid ($2,053,618) and mackerel ($2,041,780).

Landings by Species

Table 41 : Dollar Value by Federally Managed Groups of Landings in North Kingstown

	Average from 1997-2004	2003 only
Squid, Mackerel, Butterfish	5,761,950	6,856,489
Herring	887,830	586,058
Lobster	295,438	214,523
Summer Flounder, Scup, Black Sea Bass	39,469	48,791
Largemesh Groundfish	6,135	2,471
Monkfish	5,661	17,533
Smallmesh Groundfish	2,593	412
Bluefish	573	713
Surf Clam, Ocean Quahog	510	0
Skate	250	482
Scallop	123	0
Dogfish	12	0
Tilefish	2	0

	Average from 1997-2004	2003 only
Other	1,217,460	730,002

Vessels by year

Table 42 : All columns represent Federal Vessel Permits or Landings Value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Home port value ($)	Landed port value ($)
1997	3	23	0	12,666,980
1998	2	20	0	9,322,636
1999	3	21	0	6,992,943
2000	3	23	0	8,522,877
2001	2	21	0	9,754,132
2002	2	22	0	7,147,266
2003	2	20	0	8,513,069

Recreational

Narragansett Bay attracts a variety of recreational fishermen. These fishermen fish a many species, but primarily quahogs and bluefish. Rhode Island recreational anglers spent $138,737,000 in 1998.[494]

Subsistence

Information on subsistence fishing in North Kingstown is either not available through secondary data collection or the practice does not exist.

Future

The 2001 Town of North Kingstown Comprehensive Plan 5-Year Update (2006 update not yet available[495]) notes that in a 1999 survey, North Kingstown residents were asked what type of additional economic development they prefer. The top four responses were : industrial development within Quonset Point Davisville 86.3%; aquaculture 78.8%; tourism-based industry 77.3% and commercial fishing 64.8%. Thus the Plan's objectives include : improved water quality for recreational and commercial fishing activities, and boating ; improvement of the Jamestown Bridge fishing pier ; and maintenance of fishing-related trades at the Quonset Point/Davisville Pier.[496]

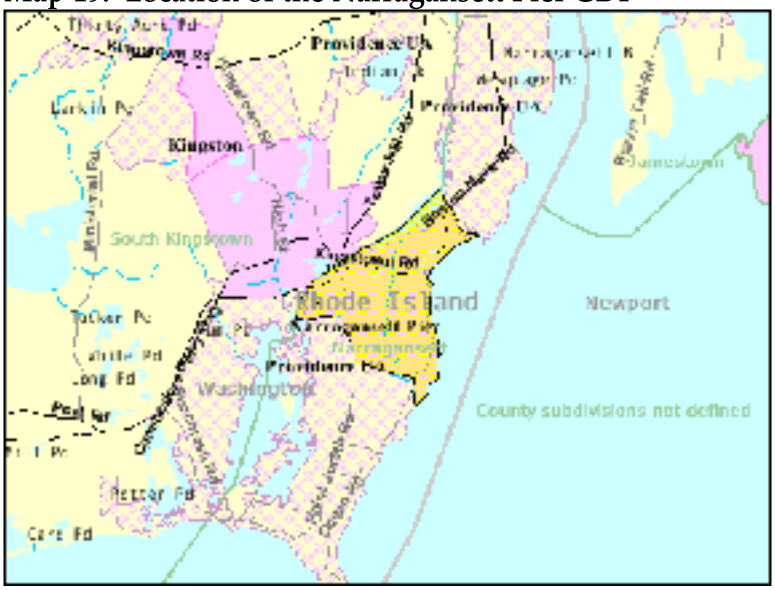
5.2 POINT JUDITH, RI

5.2.1 People and Places

Regional orientation

Narragansett (41.45°N, 71.45°W) is located in Washington County 30 miles south of Providence. Point Judith is located in Washington County 4 miles south of Narragansett along Highway 108 near Galilee State Beach, located at the western side of the mouth of Rhode Island Sound.

Map 19. Location of the Narragansett Pier CDP



Historical/Background

The land now called Narragansett was originally inhabited by the Algonquin Indians until 1659 when a group of Connecticut colonists purchased it. Over the next half-century, the Rhode Island, Connecticut and Massachusetts colonies all vied for control of Narragansett until the British crown placed the area under the control of Rhode Island.

By the 1660s, settlers put the fertile soil to use by developing agriculture in the area. Soon the area's economy depended on the export of agricultural products to markets such as Boston, Providence, and Newport. At this time, Point Judith was connected to the sea by a deep, wide breachway, which was used to ship the agricultural goods to market.

In the early 1800's Narragansett, like the rest of the country, experienced rapid industrial growth, particularly in the textile industry. By the mid 1800's the resort tourism industry developed in Narragansett including the once popular Narragansett Casino. However, most of the tourism resorts were destroyed in a fire in the early 1900s.[497]

By the 1800's many farmers began to supplement their income by fishing for bass and alewife, or digging oysters. Eventually, the Port of Galilee was established in the mid 1800's as a small fishing village. By the early 1900's Point Judith's Port of Galilee became one of the largest fishing ports on the east coast. This was largely due to a series of construction projects that included dredging the present breachway and stabilizing it with stone jetties and the construction of three miles of breakwater that provided refuge from the full force of the ocean. By the 1930's wharves were constructed to facilitate large ocean-going fishing vessels. [498] At this point the port became important to the entire region's economy.[499]

Today, Point Judith is not only an active commercial fishing port but supports a thriving tourism industry that includes restaurants, shops, whale watching, recreational fishing, and a ferry to Block Island.

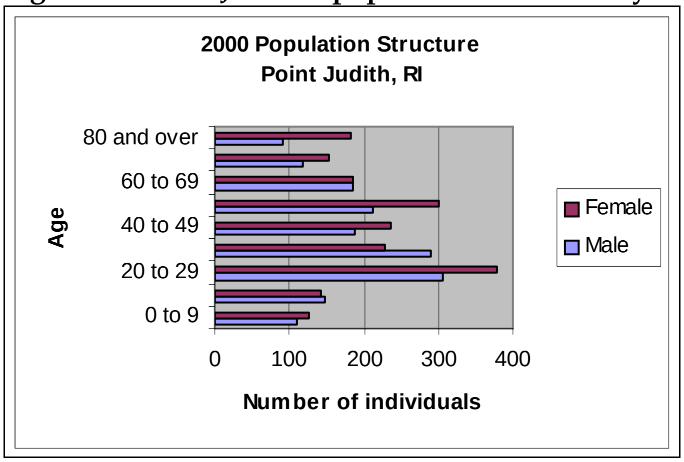
Demographics

No Census data are available for Point Judith itself, but they are available for the county subdivision "Naraganssett Pier CDP" which includes Point Judith. As Point Judith is not actually a residential area, and those who fish from Point Judith live in surrounding communities, this actually is more representative of the "fishing community" than would be any data on Point Judith alone.

According to Census 2000 data, Narragansett Pier CDP had a total population of 3,671, down from a reported population of 3,721 in 1990. Of this 2000 total, 46.3% were males and 53.7% were females. The median age was 44.5 years and 82.4% of the population was 21 years or older while 25.3% were 62 or older.

This area had an unusually high percentage of the population in the 20-29 year age group, especially for males. This may have to do with particular employment opportunities for this age group.

Figure 73: Point Judith's population structure by sex in 2000



The majority of the population in 2000 was White (92.8%), with 1.2% Black, 2.6% citing two or more races, and 0.4% other. Hispanics were identified as 1.9% of the population. Residents traced their backgrounds to a number of different ancestries: Irish (23.2%), Italian (19.3%), and English (10.7%). With regard to region of birth, 60.3% were born in Rhode Island, 36.6% were born in a different state and 3.2% were born outside of the U.S. (including 1.0% who were not United States citizens).

For 93.3% of the population in 2000, only English was spoken in the home, leaving 6.7% in homes where a language other than English was spoken, including 1.2% of the population who spoke English less than 'very well'.

Figure 74: Point Judith's Racial Structure in 2000

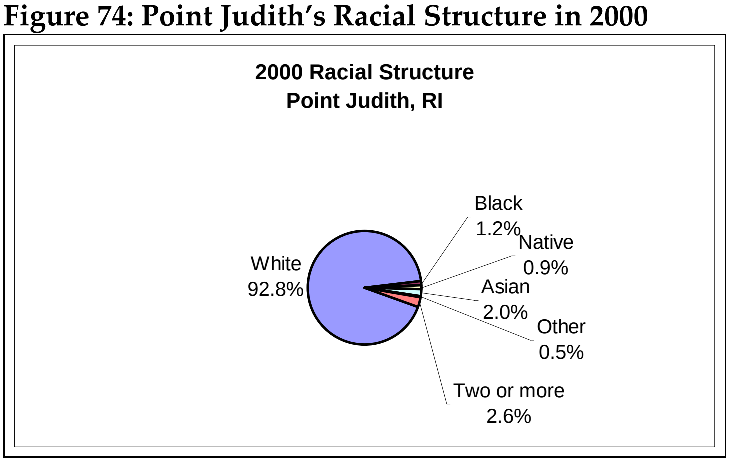
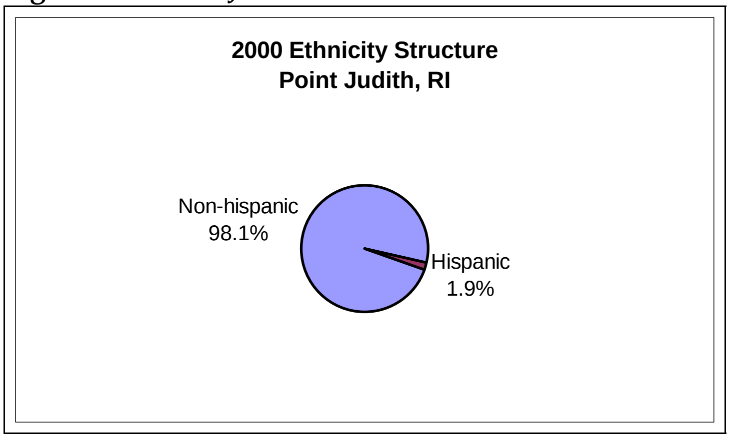


Figure 75: Point Judith's Ethnic Structure in 2000



Of the population 25 years and over in 2000, 21.1% had graduated high school, 18.6% had a Bachelors Degree and 15.5% a Masters Degree. Again of the population 25 years and over, 3.6% did not reach ninth grade, 8.9% attended some high school but did not graduate, 21.1% completed high school, 20.1% had some college with no degree, 6.9% received their associate degree, 18.6% earned their bachelor's degree, and 20.8% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive the religions with the highest number of congregations in Washington County in 2000 included American Baptist Churches (15 with 3,022 adherents), Catholic (20 with 58,668 adherents) and Episcopal (10 with 4,720 adherents). The total number of adherents to any religion was up 57.3% from 1990.

Issues/Processes

Not unlike many fishing communities in the Northeast, increasingly stringent fishing regulations could jeopardize the viability of Point Judith as a fishing port. Specifically, Point Judith processing companies have difficulty handling drastic deviations in the number of landings, commonly due to the lifting or expanding of quotas, as well as sudden changes in what species are landed. Additionally, the boom in tourism at Point Judith has had an adverse effect on the commercial fishing industry. Not only do fishermen battle parking issues but shore front rents for fish processing companies and the cost of dockage and wharfage for vessels have increased.[500]

Cultural attributes

The Narragansett/ Point Judith community celebrates its maritime history with the Blessing of the Fleet, an event that is sponsored by the Narragansett Lion's Club. The festival includes the Blessing of the Fleet Road Race of 10 miles of the surrounding area, a Seafood Festival, and rides at Veteran's Memorial Park that last the throughout the weekend.[501] The 2004 Blessing of the Fleet included approximately 20 commercial and

70 recreational vessels and gathered an estimated crowd of 200 to 300 to view the passing.

5.2.2 Infrastructure

Current Economy

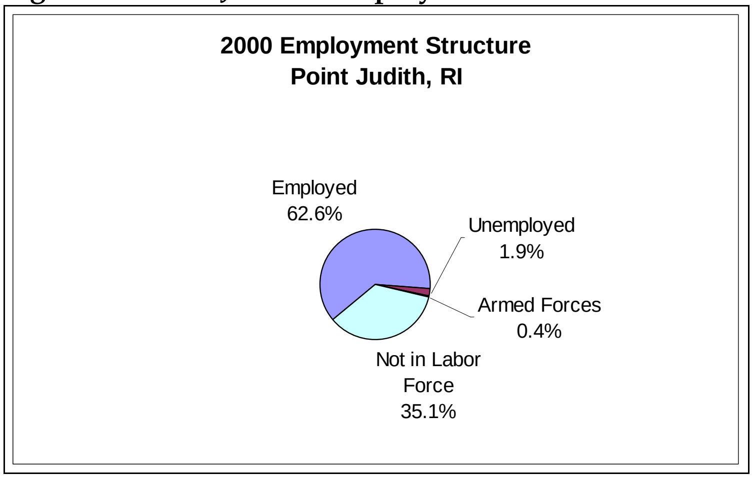
Besides an active fishing port Point Judith supports a thriving tourism industry that includes restaurants, shops, whale watching, recreational fishing, and a ferry to Block Island.[502] It also has a number of fish processing companies that do business locally, nationally, and internationally. Point Judith's largest fish processors are the Town Dock Company[503] and the Point Judith Fishermen's Company – a subsidiary of M. Slavin & Sons based in NY. [504]

Town Dock came to Point Judith in 1980 and is now one of the largest seafood processing companies in Rhode Island. Its facility supports unloading, processing, and freezing facilities under one roof and services "over half of the port's boats (approximately 30 full time deep sea fishing trawlers) as well as a large day-boat fleet . . . and handle[s] all the southern New England and Mid-Atlantic species of fish including Squid, Monkfish, Flounder, Whiting, Scup, Butterfish, and Fluke."[505]

The Point Judith Fishermen's Company (with approximately 15 employees) unloads boats and processes squid which are then taken by M. Slavin & Sons to sell wholesale at the Fulton Fish Market in NY.[506]

Seven smaller processors are also located in the Point Judith area: American Mussel Processors, Inc., Deep Sea Fish of RI, Ocean State Lobster Co., MC Fresh Inc., Narragansett Bay Lobster Co., Inc., South Pier Fish Company, and Sea Fresh America.[507] In 2003, Paiva's Shellfish quit the fillet business and relocated to Cranston as a wholesaler.[508] Economic history up to 1970 can be found in Poggie and Gersuny (1978).[509]

Figure 76: Point Judith's employment structure in 2000



According to the U.S. Census 2000, 64.0% of the total population 16 years of age and over were in the labor force, of which 1.9% are unemployed and 0.4% were in the Armed Forces. Also, jobs with agriculture, forestry, fishing and hunting accounted for 31 jobs (1.6% of the labor force). Self employed workers, a category where fishermen might be found, accounted for 171 jobs or 8.6% of the labor force. Educational, health and social services (30.9%), professional, scientific, management, administrative, and waste management services (12.1%), manufacturing (10.9%) and arts, entertainment, recreation, accommodation and food services (10.3%) were the primary industries.

Median household income in Narragansett Pier CDP in 2000 was $39,918 (up from $31,853 in 1990) and median per capita income was $26,811. For full-time year round workers, men made approximately $4,934 more per year than women.

The average family in Narragansett Pier CDP consisted of 2.7 persons. With respect to poverty, 8.8% of families (up from 2.7% in 1990) and 14.1% of individuals earned below the official US Government poverty line, and 31.3% of families in 2000 earned less than $35,000 per year.

In 2000, Narragansett Pier CDP had a total of 2,067 housing units, of which 82.1% were occupied and 52.7% were detached one unit homes. Only a quarter of these homes were built before 1940. No mobile homes or boats were reported as housing units; 85.2% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area is $195,500. Of vacant housing units, 45.2% were used for seasonal, recreational, or occasional use. Of occupied units, 25.6% were renter occupied.

Government

Narragansett's form of government is a town manager and a five-member town council, headed by a council president. Narragansett was established in 1888 and incorporated in 1901. [510]

Fishery involvement in government

There is a town Harbor Management Commission.[511]

Institutional

Fishing associations

Point Judith Fishermen's Cooperative was purchased in 1994 and is now run as an independent fish marketing organization.[512] Rhode Island Seafood Council, a not-for-profit organization established in 1976, promotes quality seafood products. The American Seafood Institute was established in 1982 in conjunction with the Rhode Island Seafood Council and provides assistance to the fishing industry in exporting product overseas. [513]

Fishing assistance centers

The Bay Company was developed under the Rhode Island Marine Trade Education Initiative and attempts to link academia to the marine industry to improve productivity and economic viability. [514]

Physical

Other than a ferry that runs from Block Island to Point Judith there is no public transportation to Point Judith.

4.2.3 Involvement in Northeast Fisheries

Commercial

The number of commercial vessels in port in 2003 was 224.[515] Vessels ranged from 45-99 feet, with most being groundfish trawlers. Of these, 55 are between 45 and 75 feet, and 17 over 75 feet.[516] In 2001, Point Judith was ranked 16th in value of landings by port (fourth on the East Coast).[517] The state's marine fisheries are divided into three major sectors: shellfish, lobster, and finfish. The shellfish sector includes oysters, soft shell clams, and most importantly, quahogs. The lobster sector is primarily comprised of the highly valued American lobster with some crabs as well. The finfish sector targets a variety of species including winter, yellowtail and summer flounder, tautog, striped bass, black sea bass, scup, bluefish, butterfish, squid, whiting, skate, and dogfish. A wide range of gear including otter trawl nets, floating fish traps, lobster traps, gill nets, fish pots, rod and reel, and clam rakes are used to harvest these species. The state currently issues about 4,500 commercial fishing licenses.[518]

Over the 7 year period from 1997-2003, the value of landings in Point Judith varied but seemed to show a declining trend from a high of just over $51 million to a low of $31 million. The landings value of most species categories was lower in 2003 than the eight year average for 1997-2004, with the notable exception of the summer flounder/scup/black sea bass category.

Landings by species

Table 43: Dollar value of landings by species in Point Judith

	Average from 1997-2004	2003 only
Lobster	11,183,490	8,909,290
Squid, Mackerel, Butterfish	9,939,082	8,199,698
Summer flounder, scup, black sea bass	3,766,712	4,200,556
Smallmesh groundfish	2,881,562	1,998,379
Monkfish	2,669,547	2,211,878
Largemesh groundfish	2,275,901	2,058,342
Other	1,919,901	2,077,514
Skate	580,759	632,957
Herring	476,874	361,180
Scallop	241,949	276,634
Bluefish	94,839	67,811
Tilefish	71,295	174,305
Dogfish	51,622	3,323
Red crab	11,991	0

Table 44: Narragansett Pier vessel permits or landings value between 1997 and 2003

Year	# vessels home ported	# vessels (owner's city)	Home port value ($)	Landed port value ($)
1997	21	61	5,629,991	0
1998	25	55	5,926,038	0
1999	27	60	7,650,042	0
2000	32	61	7,902,294	0
2001	30	62	6,194,920	0
2002	29	53	7,935,212	0
2003	30	52	9,314,990	0

Vessels by Year

Table 45: Point Judith vessel permits and landings value between 1997 and 2003

Year	# vessels home ported	# vessels (owner's city)	Home port value ($)	Landed port value ($)
1997	160	0	27,391,809	47,529,746
1998	150	0	26,944,185	42,614,448
1999	154	0	28,674,140	51,144,479
2000	152	0	26,009,364	41,399,853
2001	156	0	23,926,615	33,550,542
2002	150	0	22,079,497	31,341,472
2003	143	0	25,253,827	32,536,928

Recreational

Rhode Island marine waters also support a sizable recreational fishing sector. While complete data on this component is lacking, it is estimated that in the year 2000, some 300,000 saltwater anglers, most from out-of-state, made 1 million fishing trips.[519] This indicates that the recreational component is significant both in terms of the associated revenues generated (support industries) and harvesting capacity. Between 2001- 2005, there were 66 charter and party vessels making 7,709 total trips registered in logbook data by charter and party vessels in Point Judith carrying a total of 96,383 anglers (NMFS VTR data). A 2005 survey by the RI Dept. of Environmental Management showed Point Judith to be the most popular site in the state for shore based recreational fishing.[520]

Subsistence

No information has been obtained at this time on subsistence fishing.

Future

No information was collected on plans for the future of Point Judith. But, Point Judith fishermen are not very positive about the future of Point Judith as a fishing port. Besides the main concern of stringent fishing regulations Point Judith fishermen also must contend with the ever increasing tourism at the port. This has caused parking issues and rent increases.

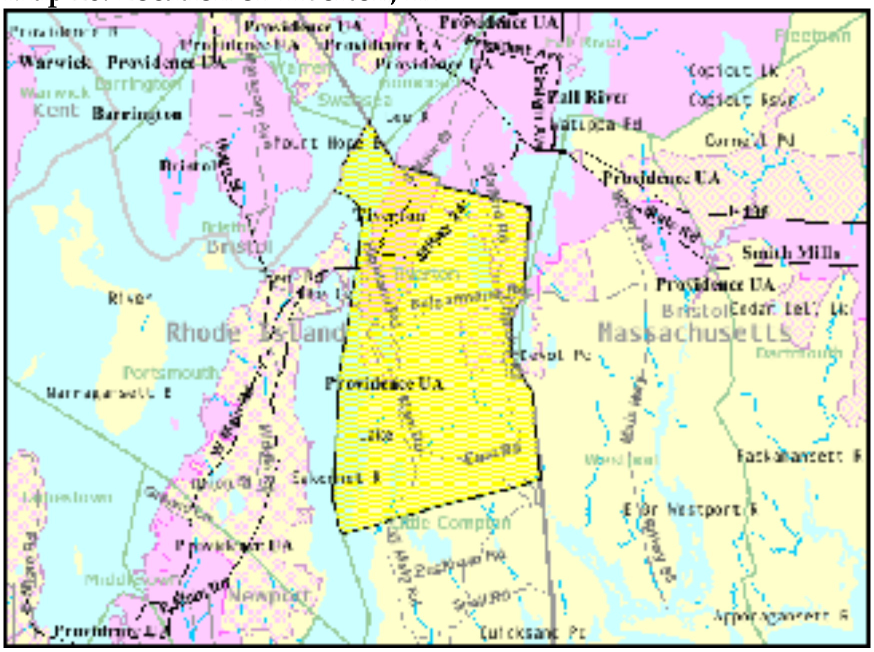
5.3 Tiverton, RI

5.3.1 People and Places

Regional orientation

The Town of Tiverton (41.63º N, 71.21º W) is located in Southeastern Rhode Island in Newport County, along the Massachusetts border. It borders Fall River and Westport, MA. The total land area of the town is 29.6 square miles. Tiverton is located along the Sakonnet River, part of Narragansett Bay.

Map 20. Location of Tiverton, RI



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Historical/Background information

The town of Tiverton was named after Tiverton, England. "Tiverton was originally incorporated in 1694, as part of the Massachusetts Bay Colony. A long boundary dispute between Rhode Island and Massachusetts was settled in 1746, and Tiverton, by Royal Decree, together with the Towns of Cumberland, Barrington, Bristol and Little Compton was annexed to Rhode Island. The town was incorporated in 1747.

For approximately three years during the Revolution when the British held Aquidneck Island, Tiverton was an asylum for Americans fleeing from British occupation, and the town became a mustering point for Colonial forces who gathered together to drive the British off the island. In its early day, Tiverton was chiefly a farming community with some fishing and boat construction. Until 1900 the manufacture of menhaden oil, a fish derivative, was one of the primary industrial pursuits. Cotton and woolen mills were established as early as 1827.

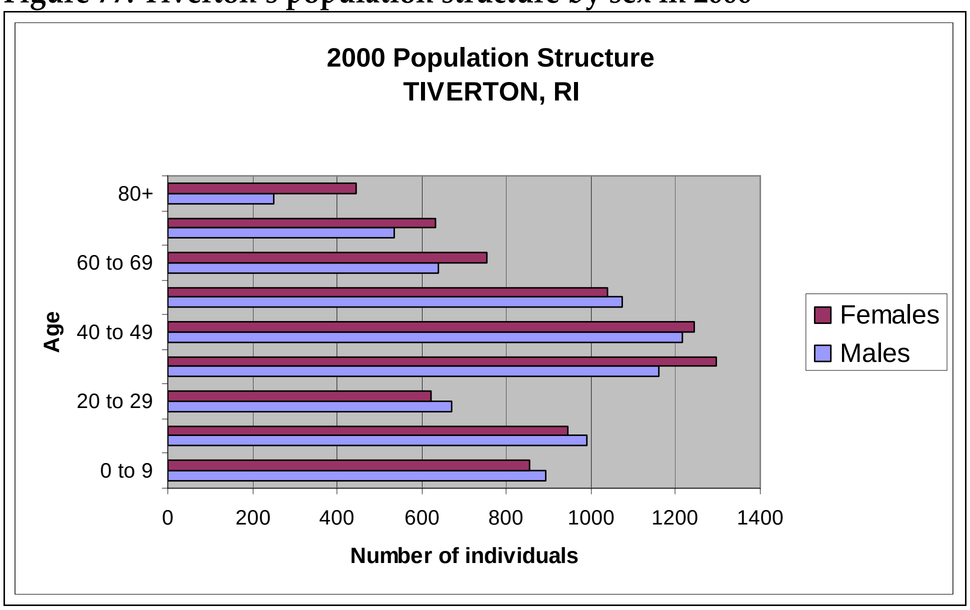
Today, trade establishments are the major employers in the town. Recent years have seen Tiverton grow as a summer resort and residential area. Development has been concentrated in the area known as North Tiverton,"[521] which borders on Fall River and is densely populated. The southern portions of the town for the most part maintain a rural character with numerous farms and open space.

Demographics

According to Census 2000 data, Tiverton had a total population of 15,260, up 110.2% from the reported population of 7,259 in 1990. Of this total in 2000, 51.3% were female and 48.7% were male. The median age was 40.8 years and 75.1% of the population was 21 years or older while 19.3% were 62 or older.

The most populous age group for both men and women in 2000 was the 40-49 year old grouping, followed closely by both the 30-39 and 50-59 age groups. The age structure showed a dip in population for both men and women in the 20-29 age bracket, indicating an out-migration of young people moving elsewhere for college and/or to seek jobs that is common in many fishing communities.

Figure 77: Tiverton's population structure by sex in 2000



The majority of the population of Tiverton in 2000 was white (97.9%), with 0.6% of residents Black or African American, 0.6% Native American, 0.6% Asian, and 0.1% Pacific Islander or Hawaiian. Only 0.7% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Portuguese (31.3%), Irish (16.3%), French (14.4%), and English (14.3%). With regard to region of birth, 19.8% were born in Rhode Island, 75.6% were born in a different state and 4.1% were born outside of the U.S. (including 1.3% who were not United States citizens).

Figure 78: Tiverton's Racial Structure in 2000

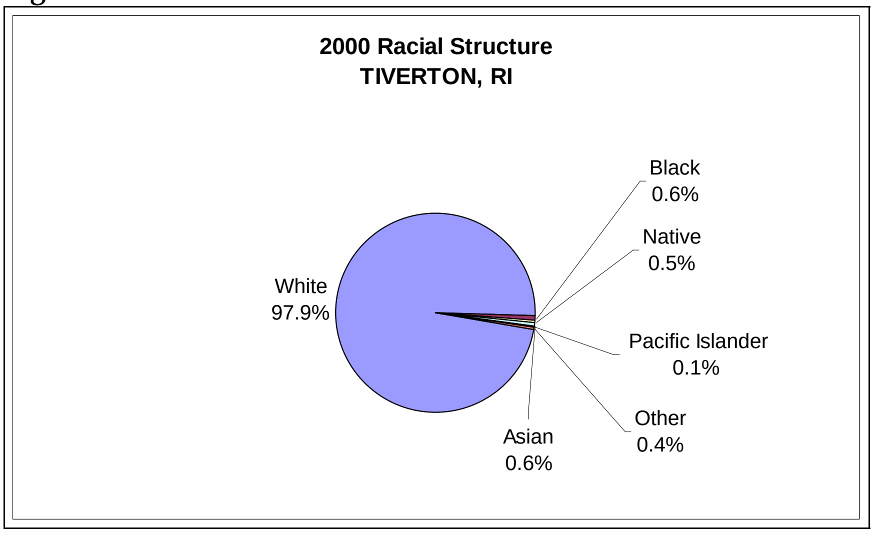
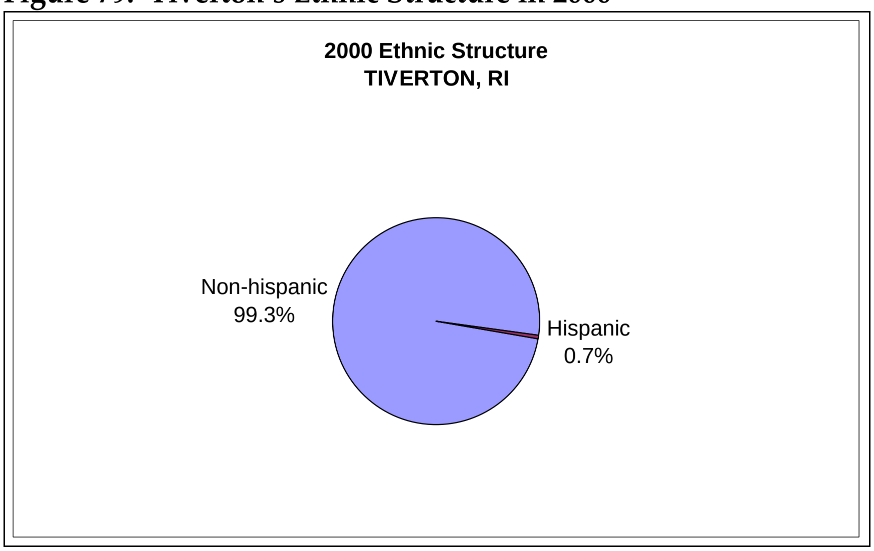


Figure 79: Tiverton's Ethnic Structure in 2000



For 89.7% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 10.3% in homes where a language other than English was spoken, and including 2.8% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 79.5% were high school graduates or higher and 24.0% had a bachelor's degree or higher. Again of the population 25 years and over, 8.5% did not reach ninth grade, 11.9% attended some high school but did not graduate, 29.6% completed high school, 18.7% had some college with no degree, 7.2% received their associate degree, 14.7% earned their bachelor's degree, and 9.3% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive the religions with the highest number of congregations in Newport County in 2000 included Catholic (13 with over 68,668 adherents), Episcopal (10 with 4,720), and American Baptist (15 with 3,022). The total number of adherents to any religion was up 57.3% from 1990. There are twelve houses of worship listed in Tiverton, of which four are Catholic, one is Mormon, and the rest are various Protestant denominations.

Issues/Processes

Like many coastal communities in the area, Tiverton has a problem with loss of waterfront access.[522] A property known as Manchester's, which has been in the past leased to fishing companies for use as a wholesale and retail market, and where a number of fishing vessels were docked, was sold in 2005 to a couple who intend to develop this area for retail and tourism.[523]

A highly controversial proposal in this area is one to bring liquid natural gas (LNG) tankers into Fall River, which borders Tiverton. These tankers would have to pass close by a segment of Tiverton's shore.[524] In addition to the safety concerns over having LNG tankers in the area, this would possibly present an access problem for fishermen in Narragansett Bay, as security regulations surrounding the tanker would restrict the use of part of the bay as the tankers are passing through. This would also require dredging parts of the bay to allow the tanker to pass through, a plan that Save the Bay, an organization dedicated to the protection of Narragansett Bay, claims would hurt the area's already sensitive fisheries.[525]

The community is also contending with a couple of proposed large-scale retail developments in the town, and many residents are concerned about this and future plans for developing here, and their potential to change the character of the community.[526] The Stone Bridge, formerly a bridge and currently used as a fishing pier, was damaged in a 2005 storm. The town received federal funding to repair the structure, which protects Tiverton Basin (where the town's harbor is located) from storm waves coming up the length of the Sakonnet River.[527]

Cultural attributes

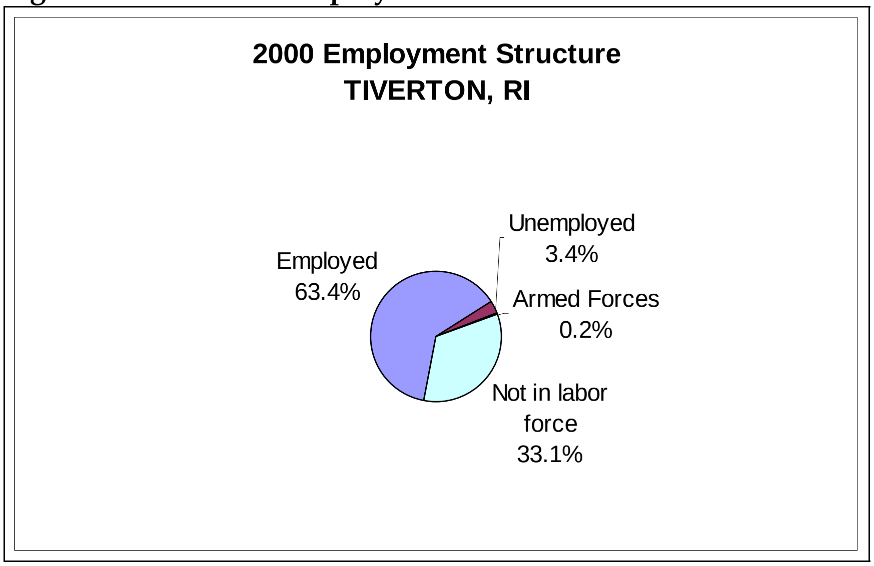
The Tiverton Four Corners village hosts a number of art-related festivals throughout the year,[528] but little in the way of fishing related cultural events.

5.3.2 <u>Infrastructure</u>

Current Economy

According to the U.S. Census 2000, 63.4% (8,247 individuals) of the total population 16 years of age and over were in the labor force, of which 3.4% were unemployed and 0.2% were in the Armed Forces.

Figure 80: Tiverton's Employment Structure in 2000



The largest employers in Tiverton in 2004 were the Town of Tiverton, with 400 employees, and LIFE, with 235 employees, which provides group home support for persons with disabilities.[529]

Tiverton had an aquaculture facility, Eastern Fish, which closed in 2000; the facility mostly produced hydroponically grown lettuce, however.[530] Most of the seafood landed in processed in Tiverton is shipped elsewhere, to Boston, New York, or across the country.[531]

According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 94 positions or 1.2% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 426 positions or 5.5% of jobs. Education, health, and social services (23.8%), manufacturing (12.7%), and retail trade (12.4%) were the primary industries.

Median household income in Tiverton was $49,977 (up 43.7% from $34,787 in 1990) and per capita income was $22,866. For full-time year round workers, menmade approximately 40.5% more per year than women.

The average family in Tiverton in 2000 consisted of 2.95 persons. With respect to poverty, 2.9% of families (down from 3.2% in 1990) and 4.5% of individuals earned below the official US Government poverty line, while 22.6% of families in 2000 earned less than $35,000 per year.

In 2000, Tiverton had a total of 6,474 housing units of which 93.3% were occupied and 77.6% were detached one unit homes. Just over 20% of these homes were built before 1940. There were a number of mobile homes in this area, accounting for 4.2% of the total housing units; 91.0% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $144,400. Of vacant housing units, 48.1% were used for seasonal, recreational, or occasional use. Of occupied units 20.1% were renter occupied.

Governmental

Tiverton has a Town Meeting form of government with a seven-member Town Council and a Town Clerk.[532]

Fishery involvement in government

Tiverton has a Harbor & Coastal Waters Management Commission which always includes a member of the Planning Board,[533] and also has waterfront zoning for water-dependent commercial uses.[534]

Fishery associations

The Rhode Island Saltwater Anglers' Association is dedicated to conservation of the marine environment and of fisheries, and to protecting the rights of saltwater recreational fishermen in Rhode Island.[535] Rhode Island has several other fishery associations to which fishermen in Tiverton might belong, including: the Ocean State Fishermen's Association, the Rhode Island Shellfishermen's Association, the Rhode Island Inshore Fishermen's Association, and the Rhode Island Commercial Fishermen's Association.[536]

Fishery Assistance Centers

No information has been found for Fishery Assistance Centers in Tiverton.

Other fishing-related institutions

Save the Bay is a non-profit organization dedicated to restoring and protecting the environmental quality of Narragansett Bay. The organization works towards this goal by monitoring the health of the Bay, initiating action to clean up the Bay, and through advocacy and education programs.[537]

Physical

Tiverton is roughly 20 miles away from New Bedford by car, and about 25 miles from Providence. The closest airport is T.F. Green Airport in Warwick, RI, roughly 32 miles away. Providence. One highway, Route 24, runs through North Tiverton.

Many of Tiverton's fishing boats were previously found tied along a property known as Manchester's in a sheltered cove just outside Nanaquaket Pond. However, this property was purchased in 2005 for development and fishermen are no longer allowed to tie up here.[538] Other fishing vessels are found in Tiverton Basin, an area of the Sakonnet River protected on one side by the Sakonnet River Bridge and on the other side by the Old Stone Bridge that serves as the town's harbor. Tiverton has two boat ramps, one at Sapowet Point and one at Fogland, and one boat yard, Standish Boat Yard.[539] There is also a herring ladder in the town.[540]

5.3.3 Involvement in Northeast Fisheries

Commercial

Tiverton has a relatively large lobster fishery, as well as a small niche conch fishery. Tiverton also has a red crab fishery, identified in the Red Crab FMP.[541] In 2001 Tiverton had 122-150 lobster boats, 12-15 conch boats, and 16 finfish boats.[542] Bridgeport Seafood in Tiverton is both a retail and wholesale operation.

According to NMFS landings data Tiverton has a highly diversified fishery, with landings in almost every category. The most valuable landings by species is monkfish, followed by quahog (which is apparently listed in the 'other' category instead of surf clam and ocean quahog), and then summer flounder. The value of many of the landings categories in 2003 was lower than or roughly equal to the average for 1997-2004. The summer flounder and skate categories increased in value slightly, as did the value of red crab. The total value of landings in Tiverton increased sharply between 1997-1999, from under $700,000 to over $3.8 million in just two years, declining again in 2003. The value of home port fishing varied with no significant pattern over the 1997-2003 period, as did the number of vessels.

Landings by Species

Table 46: Dollar value of Federally Managed Groups of landing in Tiverton, RI

	Average from 1997-2004	2003 only
Other	919,542	666,454
Monkfish	661,412	641,473
Lobster	298,844	150,650
Summer flounder, scup, black sea bass	245,787	280,357
Skate	135,563	164,737
Largemesh groundfish	99,999	44,106
Redcrab	26,032	44,179
Surf clams, ocean quahogs	13,522	0

Squid, Mackerel, butterfish	8,726	3,436
Smallmesh groundfish	6,988	0
Scallop	5,326	20
Dogfish	1,259	0
Bluefish	1,062	3,244
Tilefish	101	253
Herring	76	0

Vessels by Year

Table 47: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	12	19	913,030	694,108
1998	12	15	1,160,773	1,667,604
1999	10	15	792,614	3,804,918
2000	17	20	1,336,589	3,884,386
2001	16	17	2,052,306	3,801,533
2002	13	13	1,058,026	3,117,234
2003	14	17	1,698,912	1,998,909

Recreational

Recreational fishing is a popular activity in Tiverton. The town's Old Stone Bridge fishing pier is the remainder of an old bridge and is a popular spot for fishing from shore, although it was recently closed for safety reasons after a storm damaged the remaining structure.[543] Tiverton also has at least two locally based fishing charters.[544]

Subsistence

Hall-Arber et al. (2001)[545] note: "Lots of the people who participate in recreational fishing in Tiverton are Cambodian or have other ethnic backgrounds. Some of this "recreational" activity may actually support a fisheries- based subsistence life style." However, no firm data on subsistence fishing in Tiverton have yet been found.

Future

A facility which formerly housed a wholesale and retail company and was used by a number of vessels has been recently purchased with plans to convert the property into an inn, spa, restaurant, and retail outlets, with a charter fishing company present here as well.[546] A number of new slips are proposed for a marina in Tiverton. There are also controversial plans to bring LNG tankers into neighboring Fall River, passing by Tiverton, and to develop large-scale retail facilities in the town. No information has been found on the perception of the future in Tiverton.

5.4 Wakefield, RI

5.4.1 People and Places

Regional orientation

Wakefield (41.437N, -71.501W.) is located, along with Peacedale and several other villages, in Washington County 25 miles southeast of Providence, and is roughly 4 miles north of Point Judith. For U.S. Census purposes Wakefield and Peacedale are combined into a single Census Designated Place or CDP, as neither village is incorporated as a separate town. In fact, Wakefield and Peacedale (along with the villages of Curtis Corner, Green Hill, Indian Lake Shore, Kingston, Matunuck, Middlebridge, Perryville, Rocky Brook, Snug Harbor, Tuckertown, Usquepaugh, and West Kingston) are actually part of the town of South Kingstown.[547]

Map 21. Map of the Wakefield- Peacedale CDP

Historical/Background

In 1674, King's Town was founded and included the present towns of Narragansett, North Kingstown, and South Kingstown.[548] Narragansett Indians hunted, fished, and raised corn in this area. The first settlement was in South Kingstown. Colonial soldiers from Rhode Island, Massachusetts and Connecticut defeated King Philip there during the Great Swamp Fight, in 1675. Farming was the most common occupation during this time. By 1800, many people were employed by the Wakefield

Manufacturing Company, or the Peace Dale Mill, which became one of the town's largest industries. [549]

The village of Peace Dale was founded about that time by Rowland Hazard, the owner of the Peace Dale Mill, who named the village after his wife, Mary Peace. Around 1820 Hazard renamed the nearby industrial village of Wakefield after the town and family of the same name in England, who were friends of his.[550]

The Rhode Island College of Agriculture and Mechanic Arts was founded in 1892, near the Village of Kingston. This was an important milestone in the history of the area. Rhode Island College became the University of Rhode Island and now this institution plays a key role in the economy and the cultural life of the area.

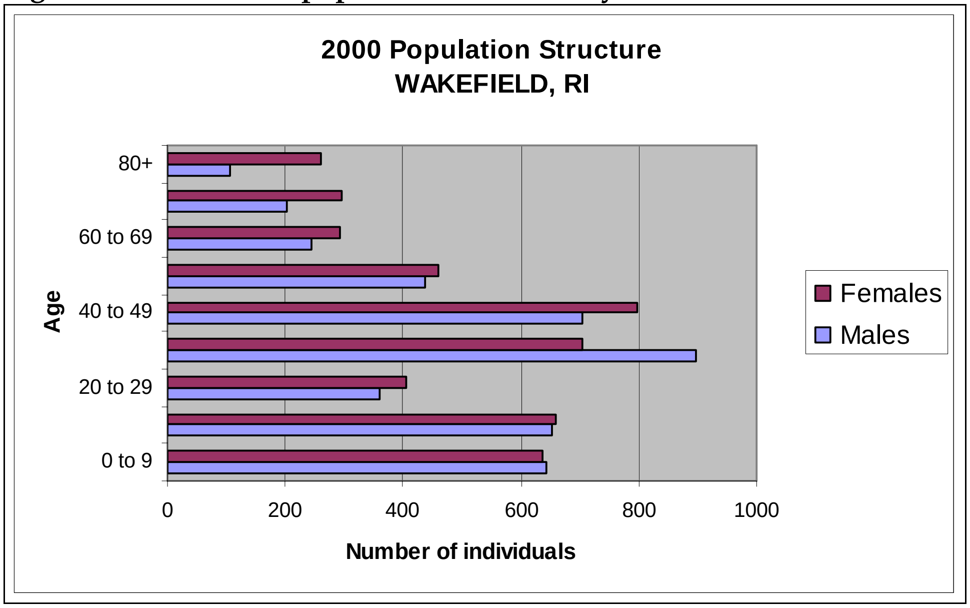
In recent years, small industries have replaced the town's previous chief textile manufacturers. For many years, the J.P. Stevens Company operated in the Peace Dale Mill, until the textile industry and sales declined at the end of World War II. The South Kingstown shoreline and beach areas have increased residency, as well as developed summer resort and tourist facilities[551].

Demographics

According to Census 2000 data, Wakefield- Peacedale CDP had a total population of 8,468, up from a reported population of 7,134 in 1990. Of this 2000 total, 46.7% were males and 53.3% were females. The median age was 37 years and 68.6% of the population was 21 years or older while 15.1% were 62 or older.

The population structure for Wakefield shows a community with many families and children. The largest percentage of the population was between the ages of 30-39, followed by 40-49, with many children age 0-9 and 10-19 as well. Like many fishing communities, Wakefield experienced a decline in the population of residents between the ages of 20-29.

Figure 81:Wakefield's population structure by sex in 2000



The majority of the population in 2000 was White (89.1%), with 3.6% Black, 4.7% American Indian and Alaska Native, 1.5% Asian, and 0.0% Pacific Islander. Hispanics were identified as 1.6% of the population. Residents traced their backgrounds to a number of different ancestries including: Irish (23%), Italian (17.2%), and English (17.2%). With regard to region of birth, 66.7% were born in Rhode Island, 29.9% were born in a different state and 3.1% were born outside of the U.S. (including 1.4% who were not United States citizens).

Figure 82: Wakefield's Racial Structure in 2000 (U.S. Census 2000)

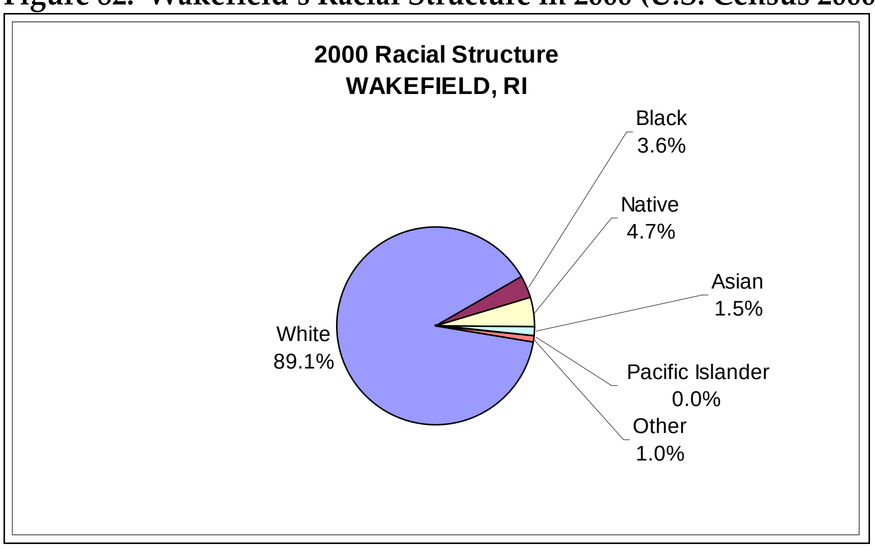
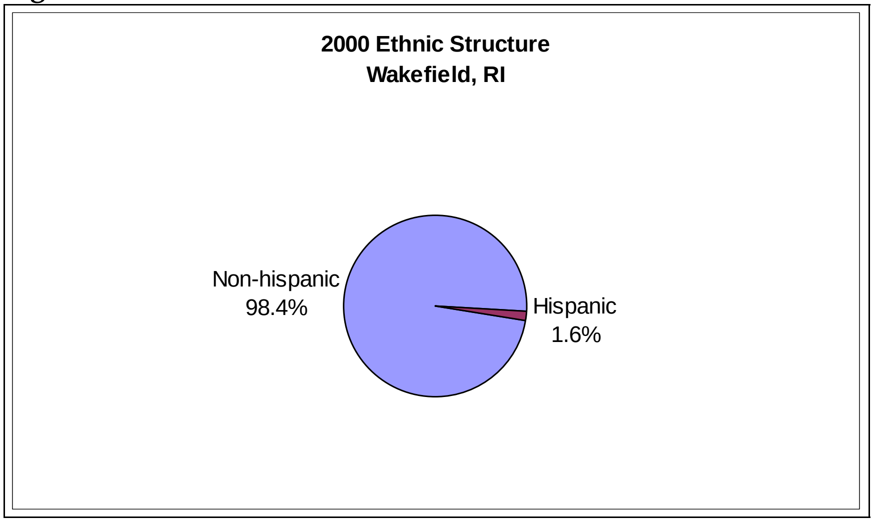


Figure 83: Wakefield's Ethnic Structure in 2000



For 94.1% of the population in 2000, only English was spoken in the home, leaving 5.9% in homes where a language other than English was spoken, including 1.2% of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 81.8% were high school graduates or higher and 41.9% had a bachelor's degree or higher. Again of the population 25 years and over, 3% did not reach ninth grade, 7.2% attended some high school but did not graduate, 25.9% had completed high school, 15.9% had some college with no degree, 6.1% received their associate degree, 25.3% earned their bachelor's degree, and 16.6% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive in 2000 the religions with the highest number of congregations in Washington County included American Baptist Churches (15 with 3,022 adherents), Catholic (20 with 58,668 adherents) and Episcopal (10 with 4,720 adherents). The total number of adherents to any religion was up 57.3% from 1990.

Issues/Processes

No information on issues/processes in Wakefield could be found at this time, though at least some Wakefield fishermen fish out of Point Judith and would share the concerns for that port.

Cultural Attributes

Snug Harbor Marina in Wakefield hosts three fishing tournaments; a shark fishing tournament, a striped bass tournament, and a bass and bluefish tournament.[552]

5.4.2 Infrastructure

Current Economy

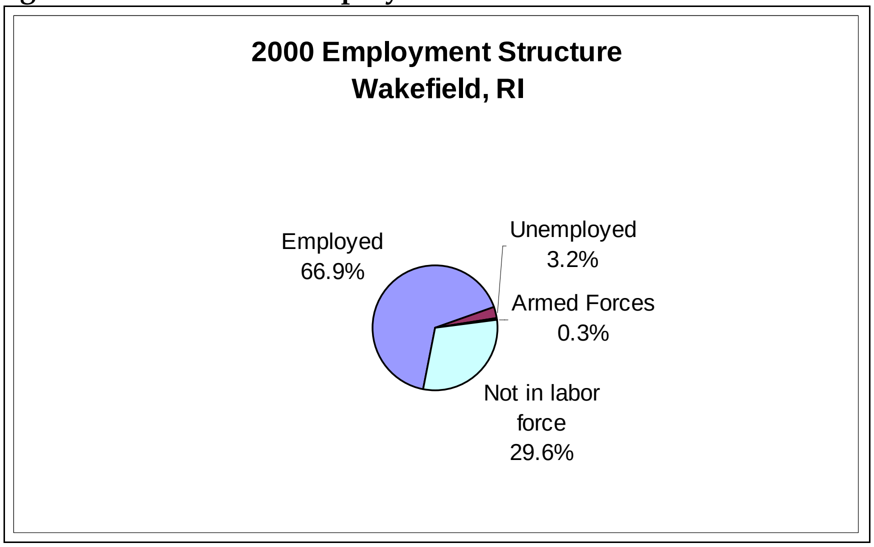
The economy in Wakefield has been slowly recovering since the 1990s. According to South Kingstown's Chamber of Commerce, the local economic base is strong because it doesn't rely on one industry. The local economy is supported by businesses of all sizes and a number of industries. There are more than 10,000 businesses in and around South Kingstown.[553]

Education, government, and health care account for the majority of the local economy. In recent years, companies, including APC, have invested millions of dollars in property, buildings, and equipment in the South Kingstown area, creating many job opportunities. Small and medium-sized businesses are the most prominent in South Kingstown. Most of the area businesses employ fewer than 20 workers. These businesses include specialty retail shops, financial service firms, management consultancies, and fitness firms. Tourism is also a substantial aspect of the economy of South Kingstown.

In addition to these aspects of economy, the South Kingstown area is home to multiple fish processing and wholesaling companies. In Wakefield itself, Deep Sea Fish of Rhode Island Inc. is a wholesale supplier and exporter of Southern New England seafood that receives fish from independently owned and operated fishing vessels. Deep Sea Fish then ships the fish to auctions and wholesalers worldwide.[554] Four Sisters Lobster Company, was located in Wakefield, delivers live, fresh lobsters throughout the United States[555], but has apparently closed by 2007. Additional companies include Stone Cove Marina, Inc., Salt Pond Marine Railway, Inc., Ocean State Marine Railway, Inc., Channel Marina Snug Harbor, Kenport Marina Fish Market, Main Street Fish Market, and Moonstone Oysters.

According to the U.S. Census 2000, 70.4% (4,488 individuals) of the total population 16 years of age and over are in the labor force, of which 3.2% are unemployed and 0.3% are in the Armed Forces.

Figure 84: Wakefield's employment structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 32 or 0.7% of all jobs. Self employed workers, a category where fishermen might be found, accounts for 426 or 10% of the labor force. Educational, health and social services (34%), professional, scientific, management, administrative, and waste management services (9.2%), manufacturing (9.4%) and arts, entertainment, recreation, accommodation and food services (9.2%) were the primary industries.

Median household income in Wakefield- Peacedale CDP was $50,313 (up from $34,748 in 1990) and median per capita income was $24,191. For full-time year round workers, men made approximately $20,548 more per year than women.

The average family in Wakefield-Peacedale CDP in 2000 consisted of 3.14 persons. With respect to poverty, 3.9% of families (up from 3.6% in 1990) and 5.4% of individuals earned below the official US Government poverty line, and 32.3% of families in 2000 earned less than $35,000 per year.

In 2000, Wakefield-Peacedale CDP had a total of 3,381 housing units of which 95.2% were occupied and 69.5% were detached one unit homes. Slightly more than a third of these homes were built before 1940. Mobile homes comprised of only 0.3% of reported housing units and no boats were reported as residences; 89.8% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $151,700.[556] Of vacant housing units, 1.3% were used for seasonal, recreational, or occasional use. Of occupied units, 28.7% were renter occupied.

Government

Wakefield's government is the same as the town of South Kingstown, as it is a village of South Kingstown. The South Kingstown government consists of a Town Manager and a

Town Council. The Town Council has five members elected at large in November of even- numbered years. The Town Council meets regularly on the second and fourth Monday of each month in the Town Council Chambers, at 180 High Street, in Wakefield.[557]

Fishery Involvement in Government

The Waterfront Advisory Commission of South Kingstown advises the Town Council on issues concerning the preservation and development of South Kingstown's property in the shoreline area and the management of commercial and recreational waterfront activities, the conservation of existing coastal access and the increase of physical access and enjoyment of the coast by the public, and commercial fisheries practices which directly or indirectly limit or impede the public's use of ponds and tidal waters.[558] The Rhode Island Department of Environmental Management, Division of Fish and Wildlife, is based in Wakefield.[559]

Institutional

<u>Fishing associations</u>

No fishing associations were found in Wakefield itself, however associations were located in surrounding areas such as Point Judith and Narragansett. The Rhode Island Seafood Council, a not-for-profit organization established in 1976, promotes quality seafood products. The American Seafood Institute was established in 1982 in conjunction with the Rhode Island Seafood Council and provides assistance to the fishing industry in exporting product overseas.[560] The Rhode Island Lobstermen's Association is located in Narragansett and since 1980 has promoted the economic and biological health in Rhode Island fisheries.[561]

<u>Fishing assistance centers</u>

There were no fishing assistance centers found in the Wakefield area, but The Bay Company in Point Judith was developed under the Rhode Island Marine Trade Education Initiative attempts to link academia to the marine industry to improve productivity and economic viability.[562]

<u>Other fishing related organizations</u>

The Rhode Island Sea Grant College Program is based at the University of Rhode Island's Graduate School of Oceanography in Narragansett. They design and support research, education, and other programs that foster stewardship of coastal and marine resources.[563]

Physical

Wakefield is part of the town of South Kingstown, located in the southern part of Rhode Island and bordering the Atlantic Ocean. Wakefield itself is not on the ocean, but sits at the north end of Point Judith Pond, which provides access to the Atlantic. There are buses from Wakefield to Providence, Newport, and T.F. Green Airport run by the Rhode Island Public Transit Authority.[564] Amtrak trains stop at nearby Kingston while running between Boston and New York.[565] Wakefield is 6 miles from Point Judith, 18 miles from Newport, and 163 miles from New York City.

The charter fishing fleet in Wakefield is based at Snug Harbor Marina.[566] Billington Cove Marina in Wakefield provides full service to boats.[567] Point Judith Marina is another full-service marina located in Wakefield.[568] There are several other marinas listed for Wakefield which provide services to recreational boaters, including Gooseberry Marina, Kenport Marina, Ram Point Marina, Marina Bay Docking, Silver Spring Marine, and Stone Cove Marina.[569]

5.4.3 Involvement in Northeast Fisheries

Commercial

Wakefield is not actually a commercial fishing port. However, members of this community fish commercially from neighboring ports including Narragansett and Point Judith. For more information please refer to the Point Judith community profile.

Table 48: Wakefield vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	26	95	4,019,707	0
1998	31	88	3,951,249	0
1999	31	94	3,734,059	0
2000	31	93	3,874,318	0
2001	28	94	3,007,981	0
2002	27	92	2,825,931	0
2003	20	86	2,833,778	0

Recreational

Rhode Island marine waters also support a sizable recreational fishing sector. While accurate data on this component is lacking, it is estimated that in the year 2000, some 300,000 saltwater anglers, most from out-of-state, made 1 million fishing trips.[570] This indicates that the recreational component is significant both in terms of the associated revenues generated (support industries) and harvesting capacity.

South Kingstown is home to the Frances Fleet charter fishing excursions, as well as Old Salt Charters. Snug Harbor Marina in Wakefield also has charter boat bookings for Rhode Island. Charter boats here take passengers both on inshore trips and offshore big game excursions, and have the opportunity to catch more than 30 species of fish.[571] Miller Time Charters offers fishing for bluefish, striped bass, sea bass, flounder, tuna, and shark.[572] Snappa Charters targets shark, tuna, sea bass, porgies, dolphin fish, cod, bonito, and other species, as well as shark cage diving trips.[573]

Subsistence

No information has been obtained at this time on recreational fishing.

Future

No information was collected on plans or perspectives for the future of Wakefield specifically. A drive for industrial growth is currently underway in South Kingstown. The town has experienced significant residential expansion, and development of its summer resort and tourist facilities due to its shoreline and beach areas. Increasing tourism at the port of Point Judith has caused parking issues and rent increases. As values of local dock space and land increase, further declines in fishing infrastructure may follow. [574]

6.0 CONNECTICUT

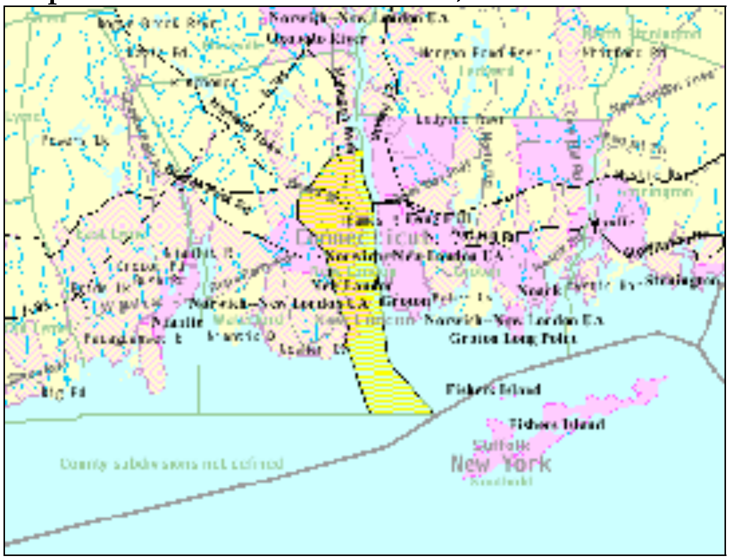
6.1 NEW LONDON, CT

6.1.1 People and Places

Regional Orientation

The city of New London, Connecticut (41.355°N, 72.1W°) is a part of New London County. It is bordered by Waterford on the north and west, by the Thames River to the east and Long Island Sound to the south[575]. It covers 5.5 square miles and is located adjacent to I-95.

Map 22. Location of New London, CT



Historical/Background Information

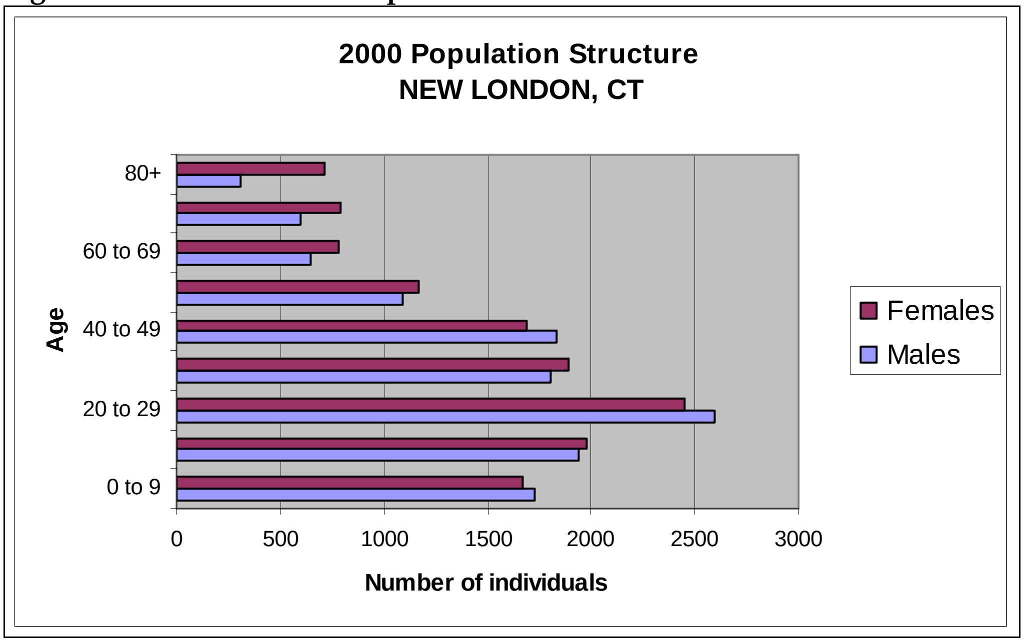
New London was first settled in 1646 by John Winthrop, the younger. His father, John Winthrop led a Puritan immigration from England. The town was named in 1658 and was finally incorporated in 1784. It was an important area in terms of ship building and remains a fishing community even today. Over the years, many sections of New London broke off and became different towns. Today the City of New London is much smaller than it was originally[576]. New London has been an important town since the beginning of our country. It was attractive to the early colonists because of its waterways. It has a deep harbor and provides direct access to the Atlantic Ocean. The whaling industry began here and many other industries like ship building and fishing were essential to the area's economic growth and development. Additionally, it was part of the Revolutionary war. Benedict Arnold and his troops burned down the city in 1781.[577] New London is also home to the Customs House, the country's oldest operating customs office. This is where the slave ship the Amistad was docked for a year after the slaves overthrew the crew.[578]

Demographics

According to Census 2000 data, New London had a total population of 25,671, down from the reported population of 28,540 in 1990. Of this total population in 2000, 51.1% were female and 48.9% were male. The median age was 31.2 years and 68.3% of the population was 21 years or older while 13.7% were 62 years or older.

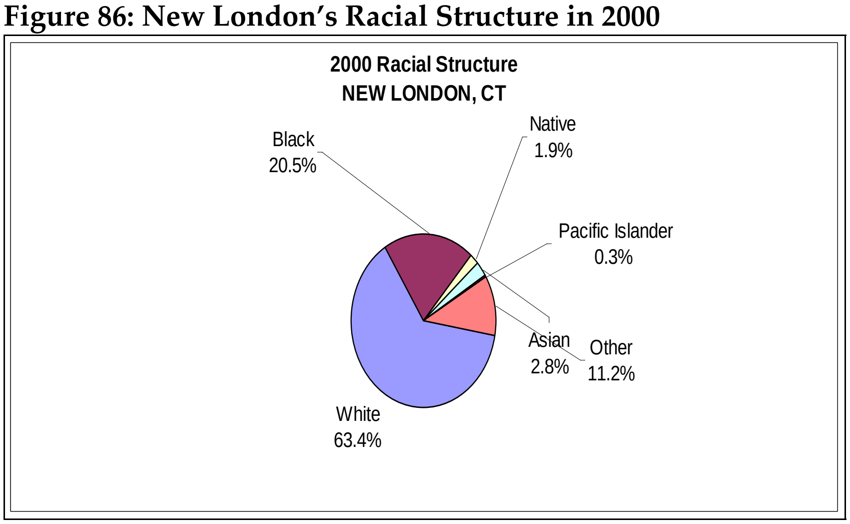
The age structure for New London was different than that of most other fishing communities. Here, the greatest percentage of the population was between the ages of 20-29. This may reflect the presence of several colleges and universities in New London, or perhaps young adults are moving to New London for jobs. Overall, New London had a young population, with high numbers of residents between the ages of 10-19 and 30-39; the population fell off significantly for residents 60 years old and older.

Figure 85: New London's Population Structure in 2000



The majority of the population in New London in 2000 was white (67.6%). Relative to other New England towns, a larger than average percentage of the population (21.8%) was Black or African American; 2.3% were American Indian or Alaskan Native, 2.9% were Asian, and 0.3% were Native Hawaiian or other Pacific Islander. Of the total population, 19.7% were Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (13.9%), Italian (11.7%), English (8.6%), and German (7.3%). With regard to region of birth, 46.8% were born in Connecticut, 35.8% were born in a different state and 9.7% were born outside the U.S. (including 5.8% who were not United States citizens).

Figure 86: New London's Racial Structure in 2000



For 76.4% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 23.6% in homes where a language other than English was spoken, and including 9.1% of the population who spoke English less than 'very well'.

Of the population 25 years and older, 78.4% were high school graduates or higher and 19.6% had a bachelor's degree or higher. Again, of the population 25 years and over, 8.2% did not reach ninth grade, 13.5% attended some high school but did not graduate, 33.2% completed high school, 19.3% had some college with no degree, 6.3% received their associate degree, 10.6% earned their bachelor's degree, and 9.0% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in New London County was Catholic with 33 congregations and 80,563 adherents. Other prominent congregations in the county were American Baptist (with 19 congregations and 6,502 adherents) and United Church of Christ (with 20 congregations and 6,809 adherents). The total number of adherents to any religion was down 0.3% from 1990.

Issues/ Processes

The lobster fishing industry in New London was not affected by the 1999 lobster die-off to the extent that other ports to the west were, but now they face competition from lobstermen coming from Norwalk, Bridgeport, and other places that were affected by the die-off. Newcomers must find their own spots to fish (which usually yield a smaller catch) or risk getting the lines to their traps cut by the local fishermen. This, among other things, makes it difficult for someone to get started in the business.[579]

Also, New London has been experiencing an overpopulation of striped bass. In the 1980s they were overfished and were becoming scarce, so strict commercial catch regulations were put in place. Today though, they have made such a comeback that it is negatively affecting the areas they are found in. They are one of the top three recreational fish in the area and are the prey of sharks, but still their population is growing. They can live up to thirty years and can grow to 100 pounds. Their appetite, in conjunction with their population size, is killing off other fish very rapidly. Currently, they are a recreational species only; they are not allowed to be fished commercially.[580] Groton's naval submarine base managed to avoid closure in 2005 when it was taken off a list of military facilities slated for elimination, which would have cost the state an estimated 31,000 jobs, but there are always concerns about future closure attempts.[581] Electric Boat in Groton in 2006 laid off close to 600 employees, and there was talk of eliminating between 1,400 and 1,700 additional jobs because of a decline in the submarine industry.[582] Pfizer also has layoffs planned for the area, as it stops all drug manufacturing in Groton, eliminating another 300 jobs.[583] Since the early 1990s, Southeastern Connecticut has lost about 20,000 jobs from cutbacks in the defense industry, and gained an equal number in the casino gambling industry. Foxwoods and Mohegan Sun both have significant expansions planned. However, the newly created jobs are generally entry-level positions with a much lower pay.[584]

Cultural Attributes

There are many festivals in and around New London. The Sea Harvest Festival in nearby Mystic is a popular attraction for New London's residents. Also in Mystic is the annual Chowderfest which lasts for three days in October and includes a shipbuilding exhibit, many historical ships to see and many booths run by local fishing related companies to give the visitors a chance to see what fishing life is all about. Of course, there is also lots of local seafood for people to enjoy.[585]

6.1.2 Infrastructure

Current Economy

Major industries in the New London area which employ large numbers of residents are the defense industry, based in nearby Groton as well as New London, and the gaming industry, with two large casinos (Foxwoods and Mohegan Sun) located a short distance away. The major employers for New London County are as follows (data not available for New London city):

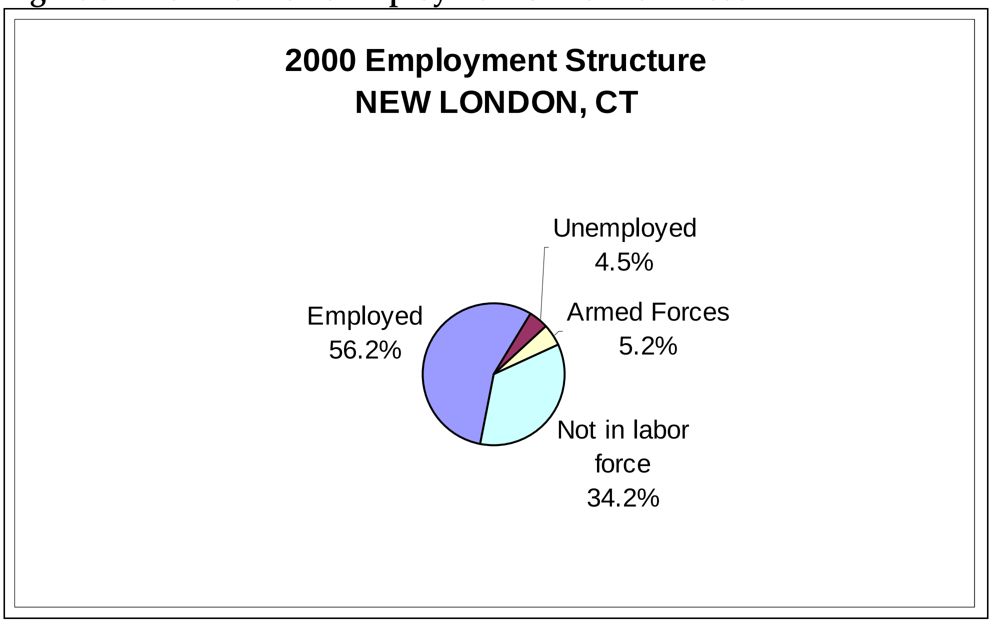
Table 49: Top Employers in New London County[586]

Company	Number of Employees
Foxwoods	11,000
U.S. Naval Sub Base	10,500
Mohegan Sun	10,500
General Dynamics/Electric Boat	8,800
Pfizer	6,000
Lawrence and Memorial Hospital	2,200
Millstone Station/Dominion Inc.	1,880
W. Wm. Backus Hospital	1,600
U.S. Coast Guard Academy	900
Connecticut College	845
Waterford Hotel Group	756
Davis Standard	650
Computer Sciences Corp.	600
Franklin Farms	600
SBC/SNET	550
S&S Worldwide	400

Company	Number of Employees
The New London Day	400
Mystic Seaport	350
Cross Sound Ferry	325
Wyman Gordon	315

According to the U.S. Census 2000, 65.8% (13,438 individuals) of the total population 16 years of age or over were in the labor force, of which 4.5% were unemployed and 5.2% were in the Armed Forces.

Figure 87: New London's Employment Structure in 2000



According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 10 positions or 0.1% of all jobs. Self-employed workers, a category where fishermen might be found, accounted for 630 positions or 3.1% of all jobs. Arts, entertainment, recreation, accommodation, and food services (18.0%), manufacturing (11.5%), educational, health, and social services (25.1%) and retail trade (12.6%) were the primary industries.

Median household income in New London was $33,809 (up 7.8% from 1990) and per capita income was $18,437. For full-time year-round workers, men made approximately 20% more than women.

The average family in New London in 2000 consisted of 3.0 persons. With respect to poverty, 13.4% of families (up 1.5% from 1990) and 15.8% of individuals earned below the official US Government poverty line, while 44.8% of families in 2000 earned less than $35,000 per year.

In 2000, New London had a total of 11,560 housing units, of which 88.1% were occupied and 31.7% were detached one unit homes.[587] Just under half (47.6%) of these homes were built before 1940. There were a number of mobile homes/vans/boats in this area, accounting for 0.3% of the total housing units; 90.6% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $107,900. Of vacant housing units, 1.1% were used for seasonal, recreational, or occasional use, while of occupied units 62.1% were renter occupied.

Governmental

New London is run by a City Council. There are seven councilors including the mayor. They all serve two-year terms. The City manager is responsible for many of the day to day activities of the town such as budgeting, overall planning, staffing, and organizing.[588]

Fishery involvement in government

No information has been obtained at this time on fishery involvement in the government in New London.

Institutional

Fishery associations

No information has been obtained at this time on fishery associations in New London.

Fishery assistance centers

The SouthEastern Connecticut Fisherman's Loan and Technical Assistance Program offers loans that average $50,000 to fishermen. These loans can be used for purchasing equipment, converting to alternative employment, developing alternative species or aquaculture projects and converting vessels for alternative uses. Assistance from fishing and marine science specialists is provided to help the fishermen with applications, business plans, market research, etc. This program was developed to help the commercial fishing industry. Applicants must be commercial fishermen or must be involved in "marine related" business. They also must be located in southeastern Connecticut.[589]

Other fishing-related institutions

No information has been obtained at this time on other fishing-related institutions in New London.

Physical

New London is located in south eastern Connecticut. There are many ways for people to travel to and from New London. It is located on the Thames River and there are ferries that provide transportation to Long Island, Block Island and Fishers Island. [590] It has excellent railroad access to major cities; one can take Amtrak, the Central Vermont Railroad, or the Shoreline East Commuter Train, which is a commuter service between New London and New Haven.[591] By air, the Hartford/Springfield- Bradley International Airport is 1 hour and 15 minutes away, the Providence- TF Green International Airport is 1 hour away, the Groton-New London Regional Airport is 15 minutes away, and the New Haven- Tweed Regional Airport is 45 minutes away. In addition, I-95 runs through New London. New London is about 2 hours away from both New York and Boston and is about 1 hour from Hartford and 45 minutes from New Haven.

New London Harbor has more than 30 wharves and piers available for fishermen. They are used for everything from recreational vessels to commercial use to tugs and barges. The depths range from 10 to 30 feet. Piers are owned by a variety of companies. The Coast Guard, Hess Oil, and Electric Boat all own docks in this area.

Other docks are located at Green's Harbor which has depths of 6 to 17 feet and can accommodate small crafts. It is located north of the New London Harbor entrance. Small Cove is a dredged basin for small craft located between the Coast Guard Station and the downtown New London wharves. Winthrop Cove is located at the north part of the downtown New London wharf area it is mostly for ferry boats. [592] Crocker's Boatyard located in Shaw's Cove has 230 floating slips and has a dockage depth of 12 feet.[593] The Thamesport Marina has 110 slips and can accommodate a variety of sizes of vessels.[594] Other marinas located in the area are AW Marina, Burr's Marina, City Pier and Fort Trumbull Marina Railway.[595]

6.1.3 <u>Involvement in Northeast Fisheries</u>

Commercial

Commercial fishermen in New London seem to be mostly fishing for lobster. All lobstering is done near the shore with the maximum distance away from shore being 8 miles. Lobster fishermen have complained that overfishing has caused the lobster population decline, making it more difficult to catch enough. They have to put out more traps to keep their catch stable. Competition is fierce and the fishermen tend to be very territorial. People how have been fishing the area for a long time (up to three generations) have the best spots and if a newcomer oversteps his bounds, often he will find his lines have been cut.

There are also three whiting boats in the area which fish out to Georges Bank. They are all owned by the same company and go out for 3-5 day trips. They box their catch immediately on board and ship directly to a dealer at Fulton's (New York).

The fishermen in the area are generally dispersed among the small marinas that are on the mouth of the Thames River. They are mixed in among the recreational fishermen.[596] These marinas are located amongst many places for repair and supplies.[597]

Concerning the species that are fished, the dollar amount for scallops caught in 2003 was almost double the 1997-2004 average. This is a significant difference. Also the amount of butterfish, mackerel, and squid more than doubled in 2003 compared to the 1997-2004 average. The amount of lobster caught went down, the 2003 average is $200,000 less than the 1997-2004 average. The most significant difference though can be seen in herring. The 2003 average was $149,702 compared to the 1997-2004 average of $22,411.

Many of the fishermen who dock their boats in New London do not actually live in the city. Also, the number of boats docked has gone up from a low of 14 in 1997 to a high of 21 in 2001. The value of fishing for boats that make their home port in New London is significantly lower than the total landings in New London. This indicates that many people come to unload their catches in New London who do not actually make their home in New London.

Landings by Species

Table 50: Dollar value by Federally Managed Groups of landings in New London

	Average from 1997-2004	**2003 only**
Smallmesh Groundfish	1,304,714	1,488,684
Scallop	560,728	1,025,901
Squid, Mackerel, Butterfish	481,062	1,364,145
Lobster	356,462	155,464
Monkfish	265,872	395,284
Summer Flounder, Scup, Black Sea Bass	32,567	23,761
Herring	22,411	149,702
Largemesh Groundfish	8,540	1,776
Skate	3,746	13,366
Tilefish	1,514	77
Bluefish	1,399	366
Redcrab	944	0
Dogfish	1	0

	Average from 1997-2004	2003 only
Other	95,615	73,396

Table 51: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	14	2	56,204	2,980,500
1998	15	3	146,100	2,639,813
1999	15	4	353,680	3,854,100
2000	15	4	455,254	2,835,704
2001	21	5	507,482	3,521,294
2002	20	4	127,221	4,036,575
2003	19	2	810,561	4,691,922

Recreational

There are many places in New London to fish recreationally. Fort Trumbull State Park has over 500 feet of shorefront access to the water for game fishing. They are open 24 hours a day, 365 days a year so recreational fishermen can go there any time. The pier also has bright lighting and pole holders. Sport fish usually caught there include striped bass, bluefish, weakfish and tautog.[598] One website lists eleven different charter sportfishing businesses for New London.[599] The Connecticut Charter and Party Boat Association represents eighteen boats in the Groton/New London area.[600] Charter boats generally offer full or half-day charters. Most boats fish inshore for striped bass, bluefish, fluke, sea bass, scup, and blackfish, while some venture offshore for tuna and shark.[601] In addition, there are many marine supply shops and bait shops in the area.[602] Between 2001-2005 there were a total of 14 charter and party boats which logged trips in New London, carrying a total of 10,398 anglers on 1,885 different trips (NMFS VTR data).

Subsistence

No information has been obtained at this time on subsistence fishing in New London.

Future

There are currently many plans for development in New London. Pfizer, the pharmaceuticals company, is working in 2006 on construction of their new Global

Development facility here and this will likely bring in many new jobs for the people living in and around New London.[603]

The New London Development Corporation (NLCD) is specifically centered around bringing in new economic development for the city and is dedicated to making it bigger with more jobs and more recreational activities. They are a non-profit group comprised of citizens, business owners, and community leaders in the city.

One of the current projects of the NLDC is the expansion of Fort Trumbull State Park. Fort Trumbull is a 90 acre peninsula located near Pfizer's new building. The corporation is working on expanding the park to include a Coast Guard Museum, a Riverwalk stretching along the whole waterfront with pedestrian and bicycle pathways, and new streets. They are also working on maritime development. New London has one of the longest coastlines of any town in the state and the NLDC is working to create more recreational boating, improved marinas, upgraded facilities, more amenities and more docking.[604]

7.0 NEW YORK

7.1 MONTAUK, NY

7.1.1 People and Places

Regional orientation
Montauk (41.0.N71.57W) is located in Suffolk County at the eastern tip of the South Fork of Long Island in New York. It is situated between the Atlantic Ocean to the south, and Block Island Sound to the north.

Map 23: Census reference map of the location of Montauk

Historical/Background information

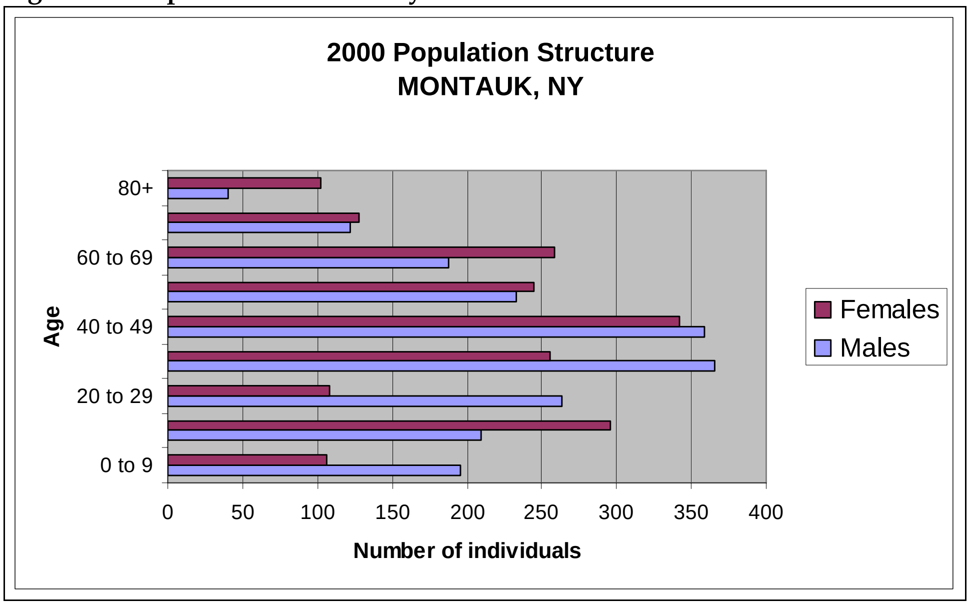
Montauk was originally inhabited by the Montauket tribe, who granted early settlers permission to pasture livestock here, essentially the only function of this area until the late 1800s. The owner of the Long Island Railroad extended the rail line here in 1895, hoping to develop Montauk "the first port of landing on the East Coast, from which goods and passengers would be transported to New York via the rail. While his grandiose vision was not fulfilled, the rail provided the necessary infrastructure for the transportation of seafood, and Montauk soon became the principal commercial fishing port on the East End. In the early 1900s, the railroad also brought recreational fishermen to the area from the city by the car-load aboard the 'Fishermen's Special', depositing them right at the dock where they could board sportfishing charter and party boats." Montauk developed into a tourist destination around that time, and much of the tourism has catered to the sportfishing industry.[605]

Demographics

According to Census 2000 data, Montauk had a total population of 3,851, up 28.3% from 1990. Of this total in 2000, 48.7% were female and 51.3% were male. The median age was 39.3 years and 77.4% of the population was 21 years or older while 17.7% were 62 or older.

Montauk's age structure showed large variation between sexes in different age groups. It is important to note that the differences appear dramatic because this population is small. In the age group including people from 20 to 29 years old, there were more than twice as many males as females in Montauk. A similar pattern exists in the 30 to 39 year age group. This is probably because males come to the area to work after high school for demanding labor jobs such as landscaping and construction. Females do not as frequently seek after these types of jobs that are available in Montauk.

Figure 88: Population structure by sex in 2000



The majority of the population of Montauk in 2000 was white (86.6%), with 1.2% of residents Black or African American, 0.6% Native American, 1.1% Asian, 0.1% Pacific Islander or Hawaiian, and 10.5% listed as "other". A reported 23.9% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (26.5%), German (17.3%) and Italian (13.1%). With regard to region of birth, 61.1% were born in New York, 11.1% were born in a different state and 27.0% were born outside of the U.S. (including 21.2% who were not United States citizens).

Figure 89: Racial Structure in 2000

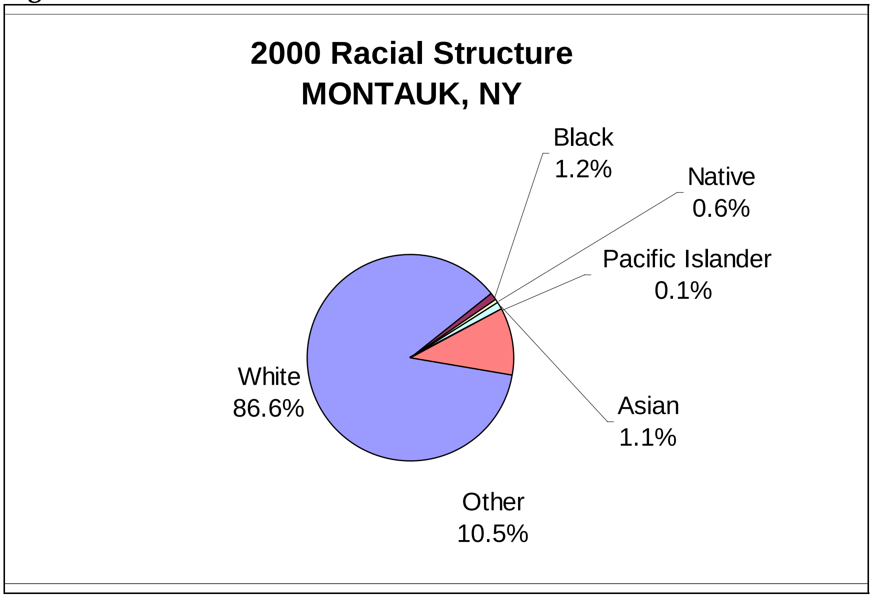
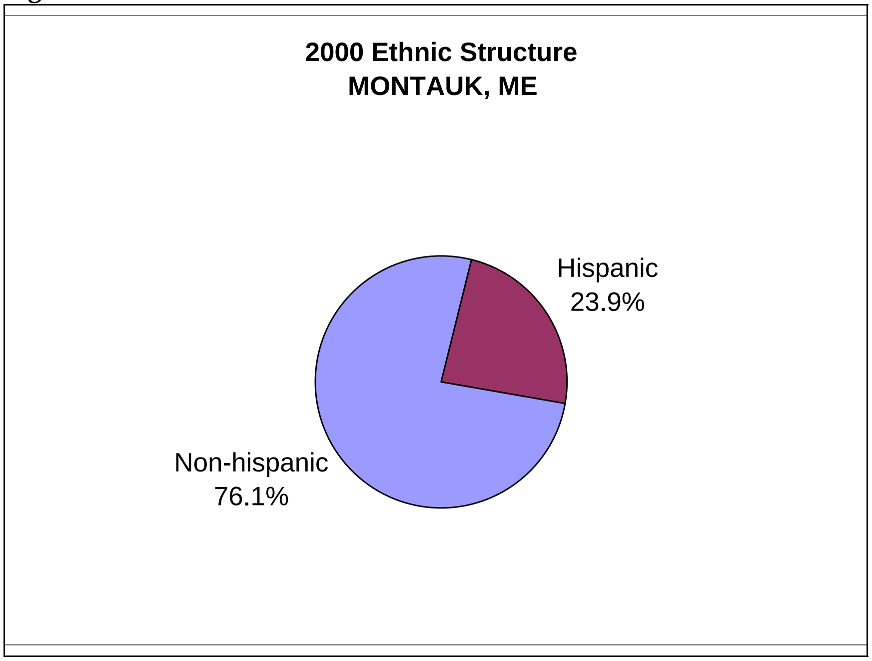


Figure 90: Ethnic Structure in 2000 (U.S. Census 2000)



For 69.7% of the population 5 years old and higher in 2000, only English was spoken in the home. This leaves 30.3% in homes where a language other than English was spoken; of these 15.6% of the population spoke English less than 'very well' and 25% spoke Spanish.

Of the population 25 years and over, 84% were high school graduates or higher and 24.8% had a bachelor's degree or higher. Again of the population 25 years and over, 7.6% did not reach ninth grade, 8.4% attended some high school but did not graduate, 31.9% completed high school, 19.6% had some college with no degree, 7.8% received

their associate degree, 17.0% earned their bachelor's degree, and 7.8% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Suffolk County was Catholic with 72 congregations and 734,147 adherents. Other prominent congregations in the county were Jewish (48 with 100,000 adherents), United Methodist (47 with 22,448 adherents), Episcopal (40 with 16,234 adherents), Evangelical Lutheran Church (26 with 19,378 adherents), and Muslim (9 with 12,139). The total number of adherents to any religion was up 3.8% from 1990.

Issues/Processes

Some fishermen are concerned about the accuracy of their assigned historical landings by species for fisheries (often used for promulgating new regulations), as the method used to land fish in New York varies from that in most other states. Called the "box method" it involves fish being boxed at sea, then landed at a consignment dock and from there shipped to Fulton Fish Market in New York City. Prior to the implementation of dealer electronic reporting, NMFS port agents counted the number of boxes landed from each vessel and received a species breakdown from the dock manager (who did not open the boxes but rather based the breakdown on his knowledge of the vessel's general fishing patterns). This system allowed greater potential for accidental mis-reporting. Now, the boxes are landed at the consignment dock and immediately shipped to Fulton, where the dealer opens the boxes and reports the landings.

While this method is more accurate in terms of the number and type of fish landed, it can still lead to another type of accidental reporting error. That is, landings are assigned to the incorrect state. This can have inequitable effects on states should an allocation scheme be developed, such as the one for summer flounder, that bases a state's allocation on the landings of a particular species in that state.

The docks make money by charging $10-12 per box (2007 prices) and by selling fuel. Catch limits and trip limits reduce the number of boxes to be shipped, and have made it very difficult for the docks to stay in business. New York is losing much of its infrastructure, and many of the docks have closed or changed hands in recent years.[606]

Inlet Seafood, the largest seafood packing operation in the state, recently expanded their facility and to include a restaurant and convenience store, which met with considerable opposition from those living in the surrounding neighborhood, concerned about a resulting increase in traffic.[607] There are very strict zoning regulations in the town, which make it very difficult for any industry located on the waterfront to expand.[608] There was also a bill proposed recently to limit beach access by vehicles in areas where coastal erosion is a problem, which would restrict access to many of the spots favored by surf casters in Montauk.[609] There is also concern that recent regulations reducing allowable catches of certain species by recreational fishermen will have a negative impact on the party and charter fishing industry.[610]

The Long Island Power Authority is seeking permission to construct a wind farm off Long Island, a proposal which has met with opposition from commercial fishermen in Montauk and elsewhere on the island, because the turbines will block access to a highly productive squid fishery.[611] The lobstermen working out of Montauk have seen their industry decline largely because of the prevalence of shell disease in lobsters taken from Long Island Sound.[612]

Cultural attributes

Montauk has several annual festivities that celebrate sport fishing and one that celebrates commercial fishing. The Blessing of the Montauk Fleet takes place in June. The Grand Slam Fishing Tournament has been in Montauk since 2002. The Harbor Festival at Sag Harbor, which is located next to Montauk, is celebrated in September. There is also a Redbone Fishing Tournament, the Annual Striped Bass Derby (13th year in 2005), and the Annual Fall Festival (24th year in 2005), which is includes shellfish related activities such as a clam chowder festival and clam shucking.[613] There is also a monument in Montauk dedicated to over 100 commercial fishermen from the East End who have lost their lives at sea over the years.[614]

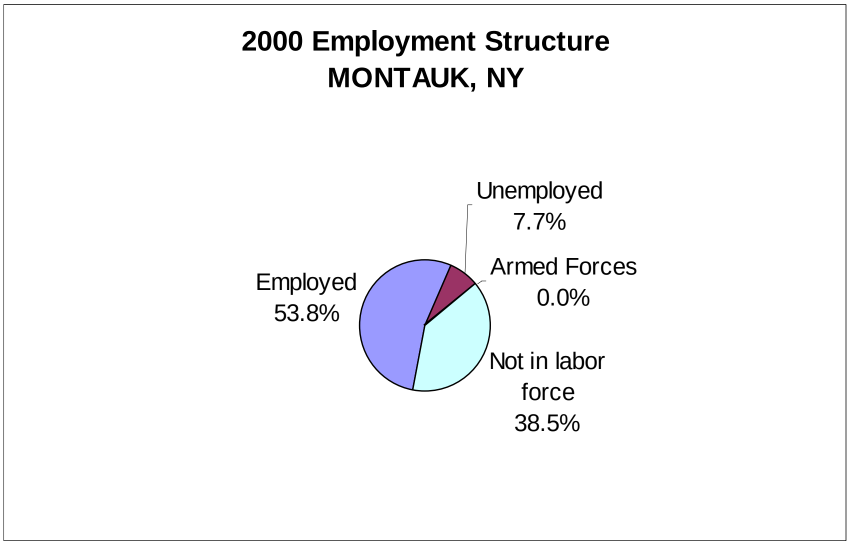
7.1.2 Infrastructure

Current Economy

The majority of the employers in Montauk area seasonal and dependent on the tourist industry, including restaurants and hotels. Probably the largest seasonal employer is Gurney's Inn, which is a resort hotel, spa, and conference center, open year round, with 350 employees during the summer months.[615] "With the exception of a few resorts and retail businesses, (Inlet Seafood) is one of the only full-time, year-round employers in Montauk, employing between four and six dock workers, a secretary, and a manager. All of the employees live in Montauk or East Hampton, but housing is a problem due to the high cost of living in the area. Labor turnover is low due to the ability of the dock to provide equitable wages and predictable pay throughout the year. The dock does compete with landscaping and construction companies for labor, especially from among immigrant populations. All of the dock workers are immigrants from Central and South America".[616] Erik Braun, NFMS Port Agent, said many of the fishermen have had to learn Spanish to communicate with the dock workers. This has been a dramatic change within the last 5 years, he said. He also stated that there are no new fishermen starting up, and the children of fishermen, even those that are doing well, are not encouraged to enter into this business.[617] The marinas here also employ a large number of people, including Montauk Marine Basin, with 21 employees during the summer months.[618]

According to the U.S. Census 2000, 61.5% (1,944 individuals) of the total population 16 years of age and over are in the labor force, of which 7.7% are unemployed and no residents are in the Armed Forces.

Figure 91. Employment Structure in 2000



According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 103 positions or 6.1% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 314 positions or 18.5% of jobs. Arts, entertainment, recreation, accommodation and food services (20.3%), construction (18.5%) and retail trade (10.1%) were the primary industries.

Median household income in Montauk was $42,329 (up from 32.9% from 1990) and per capita income was $23,875. For full-time year round workers, males made approximately 41.6% more per year than females.

The average family in Montauk consists of 2.90 persons. With respect to poverty, 8.3% of families (up from 0% in 1990) and 10.6% of individuals earn below the official US Government poverty line, while 40.0% of families in 2000 earned less than $35,000 per year.

In 2000, Montauk had a total of 4,815 housing units of which 33.1% were occupied and 61.7% were detached one unit homes. Less than 10% (9.4%) of these homes were built before 1940. There are a number of mobile homes/vans/boats in this area, accounting for 4.0% of the total housing units; 84.1% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area was $290,400. Of vacant housing units, 62.9% were used for seasonal, recreational, or occasional use, while of occupied units 34.3% were renter occupied.

Governmental

Montauk is an unincorporated village within East Hampton Township. The Town Board runs the town.[619] The town was established in 1788. Although Montauk is not incorporated, there is one incorporated village situated within the East Hampton's borders, the Village of East Hampton, and part of a second village, Sag Harbor.[620]

Fishery involvement in government

The Town Board of East Hampton organized a "Fishing Committee" to represent the fishing industry's interests in the development of the town's comprehensive plan.[621]

Institutions

Fishing Organizations

The Long Island Commercial Fishing Association, located in Montauk, promotes commercial fishing throughout Long Island.[622]

Fishery Assistance Centers

No fishery assistance centers have been identified through secondary data sources.

Other fishing-related institutions

The New York Seafood Council, located in Hampton Bays, is a non-profit membership organization made up of individuals, businesses, and organizations involved in the fishing industry whether through harvesting, processing, distribution or service. The council has over 200 members and their primary goal is to promote seafood and the seafood industry.[623]

The Montauk Boatmen's and Captain's Association has a membership of over 100 captains of charter and party boats, and is one of the only organized, politically active charter boat associations in New York.[624] The Montauk Surfcasters Association is an organization of surf fishermen with over 900 members who wish to preserve their access to surf casting on the East End beaches of Long Island. They hold beach clean-ups and educate the public about the proper use of the beach.[625]

Physical

The fishing fleet is located in Lake Montauk, which opens to the north onto Block Island Sound. "Montauk is connected to points west via Route 27, and the Metropolitan Transportation Authority's Long Island Rail Road."[626] On the easternmost tip of Long Island, Montauk is roughly 117 miles from New York City, but only about 20 miles by boat from New London, CT. There is one small airport in Montauk, and Long Island Islip MacArthur Airport is 67 miles away.[627] During the summers, a ferry service runs between Montauk and New London on weekends, daily to Block Island, RI, and occasionally to Martha's Vineyard.[628] There are also three different ferry services that run between New London and nearby Sag Harbor.[629] Most fish landed in Montauk is sold at the Fulton Fish Market in New York City.[630]

The infrastructure needed for a commercial and sport fishing fleet is available in the village,[631] including docks with off-loading facilities and other services that commercial fishermen need to land their catch.[632] Montauk used to have five docks used by the commercial fishing industry for packing out fish, but they now only have two.[633] Inlet Seafood Company, a corporation owned by six Montauk fishermen,[634] includes a dock with unloading and other services, and is the largest fish packing facility in the state.[635] There is another dock servicing commercial fishermen, but this dock is barely surviving financially.[636] There are also at least fourteen marinas used by the sportfishing industry.[637]

7.1.2 <u>Involvement in Northeast Fisheries</u>

Commercial

The village of Montauk is the largest fishing port in the state of New York. As noted in the History/Background section, Montauk's main industry has been fishing since colonial times, and it continues to be an important part of its economy and traditions.[638] Montauk is the only port in New York still holding on to a commercial fishing industry. [639]Montauk's location naturally provides a large protected harbor on Lake Montauk and is close to important fishing grounds for both commercial and recreational fishermen.

Montauk has a very diverse fishery, using a number of different gear types and catching a variety of species; in 1998, there were a total of 90 species landed in Montauk.[640] According to NMFS Landings Data, the top three valued fisheries in 2003 were Squid ($2.3million), Silver Hake ($2.1million), and Golden Tilefish ($2.1million). In 2003, the landings values for most species categories were lower than or about equal to the average values for 1997-2004. The biggest exceptions are the "other" category and monkfish, both of which saw large increases in value in 2003. Overall, the value of fish landed in Montauk saw a slight decrease from 1997-2003, while the value of fish landed by vessels homeported in Montauk saw a slight increase for the same time period. Significant increases from the eight-year average were apparent in 2003 for tilefish and for monkfish.

There used to be a number of longline vessels that fish out of Montauk, including 4-5 fishing for tilefish and up to 8 fishing for tuna and swordfish. Additionally, a number of longline vessels from elsewhere in New York State and New Jersey would sometimes land their catch at Montauk.[641] However, today there are just 1-2 longliners in

Montauk.[642] There are also 35-40 trawlers based in Montauk, with a number of others that unload their catch here, and between 10-15 lobster vessels.[643] The six owners of Inlet Seafood each own 1-2 trawlers.[644] There are also a number of baymen working in the bays around Montauk catching clams, scallops, conch, eels, and crab as well as some that may fish for bluefish and striped bass. However, these baymen may move from one area to another depending on the season and fishery, and as a result may not be a part of the permanent fleet here.[645]

Landings by Species

Table 52. Dollar value of Federally Managed Groups of landing in Montauk

	Average from 1997-2004	2003 only
Squid, Mackerel, Butterfish	2,801,956	2,468,112
Other	2,774,332	1,174,834
Smallmesh groundfish[646]	1,995,959	2,287,420
Summer Flounder, Scup, Black Sea Bass	1,305,416	1,494,652
Tilefish	982,492	2,083,544
Largemesh groundfish[647]	686,748	473,652
Lobster	538,379	325,764
Monkfish	246,137	629,210
Bluefish	75,915	61,472
Skate	27,228	30,634
Dogfish	10,996	3,249
Scallop	3,980	784
Herring	368	39
Red Crab	4	0
Surf Clams, Ocean Quahogs	1	0

Vessels by Year

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	165	89	9,222,288	13,556,572
1998	146	88	9,652,978	12,080,693
1999	158	98	10,863,508	12,124,707
2000	166	103	10,286,306	13,139,382
2001	160	103	12,302,916	13,231,619
2002	153	99	11,981,882	11,131,789
2003	152	104	12,405,663	11,033,366

Recreational

Montauk is the home port of a large charter and party boat fleet, and a major site of recreational fishing activity.[648] The facilities supporting the recreational fishing industry include six bait and tackle shops and 19 fishing guide and charter businesses.

According to one website there are at least 27 fishing charters in Montauk. Montauk has been called the "sport fishing capital of the world", and even has its own magazine dedicated to Montauk sportfishing.[649] Between 2001- 2005, there were 122 charter and party vessels making 18,345 total trips registered in logbook data by charter and party vessels in Montauk carrying a total of 185,164 anglers.

Subsistence

No information has been found in secondary sources for subsistence fishing in Montauk.

Future

The comprehensive plan for the town of East Hampton recognizes the importance of the commercial and recreational fishing industries here, and includes a commitment to supporting and retaining this traditional industry.[650] There has been discussion of developing a large wholesale seafood market on Long Island similar to the Fulton Fish Market so that fish caught here could be sold directly on Long Island rather than being shipped to New York.[651]

Erik Braun, the port agent for this part of New York, was not hopeful about the future of the fishing industry. He said there are no new fishermen getting into commercial fishing, and that even those who have done well are not encouraging their children to get into the industry. Much of the fishing infrastructure is disappearing, and those who own docks can make much more by turning them into restaurants. Montauk is the one port still holding on to a commercial fishing industry, however.[652]

7.2 HAMPTON BAYS-SHINNECOCK, NY

7.2.1 People and Places

Regional orientation

Hampton Bays and Shinnecock here are considered to be the same community. Shinnecock is the name of the fishing port located in Hampton Bays on the barrier island next to Shinnecock Inlet, and does not actually refer to a geopolitical entity. Fishermen use either port name in reporting their catch, but they are considered to be the same physical place.

The hamlet of Hampton Bays is located on the southern coast of Long Island, NY in the town of Southampton. It is roughly 30 miles from Montauk, NY on the eastern tip of Long Island, and about 90 miles from New York City.[653] Southampton is a very large township, encompassing 128 square miles.[654] Hampton Bays is the most populous of eighteen unincorporated hamlets within Southampton.[655] Hampton Bays is on the west side of Shinnecock Bay, a bay protected from the Atlantic by a barrier island and accessed through Shinnecock Inlet. The Shinnecock Canal connects Shinnecock Bay with Great Peconic Bay to the north, allowing vessels to pass between the southern and northern sides of Long Island without having to travel east around Montauk.[656]

Map 24: Census reference map of the location of Hampton Bays

Historical/Background information

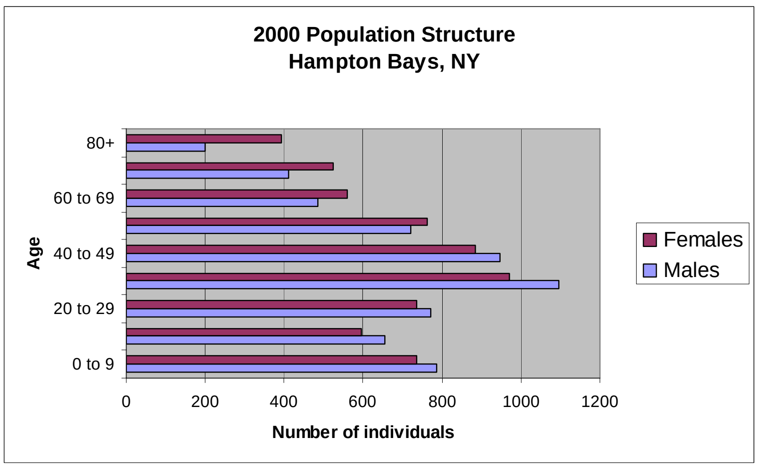
The first inhabitants of this area were Native Americans from the Shinnecock tribe, people who still reside in Southampton today on the Shinnecock Reservation. The first European settlers arrived here in 1640, from Lynn, Massachusetts. Sag Harbor in Southampton was an important whaling port early on, and along with agriculture was the town's primary industry. Starting in the 18th century, residents would dig inlets between Shinnecock Bay and the Atlantic Ocean to allow water in the Bay to circulate, and to increase fish and shellfish productivity in the bay. The Shinnecock Canal, connecting Shinnecock Bay with Peconic Bay, was built in 1892.[657] During the 1870s, as the Long Island Railroad running between New York City and Montauk was completed, the communities in Southampton became important tourist destinations where New York City residents built their summer homes, and it retains this distinction today as a vacation destination for New Yorkers. The population of Southampton grows considerably during the summer months, and at its peak is nearly triple the winter population.[658]

Demographics

According to Census 2000 data, Hampton Bays had a total population of 12,236, up 55.0% from 7,893 in 1990. Of this total in 2000, 50.4% were female and 49.6% were male. The median age was 38.8 years and 76.3% of the population was 21 years or older while 19.1% were 62 or older.

Hampton Bays' age structure showed the majority of residents to be in the 30-39 and 40-49 year old age categories. There is a relatively even distribution of men and women in all age categories. A slight dip in the number of 10-19 year olds probably indicates students leaving for college at this time, but there is nothing to demonstrate significant migration either in or out of Hampton Bays.

Figure 92: Population structure by sex in 2000



The majority of the population of Hampton Bays in 2000 was white (92.8%), with 1.1% of residents Black or African American, 0.4% Native American, 0.9% Asian, and 0.1% Pacific Islander or Hawaiian. A total of 12.5% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (25.7%), Italian (21.6%), German (17.3%), and English (11.6%). With regard to region of birth, 74.7% were born in New York, 10.8% were born in a different state and 13.4% were born outside of the U.S. (including 8.7% who were not United States citizens).

Figure 93: Racial Structure in 2000

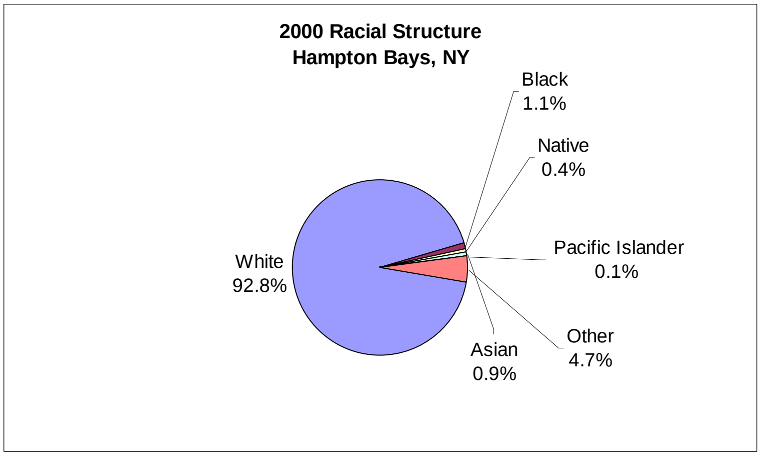
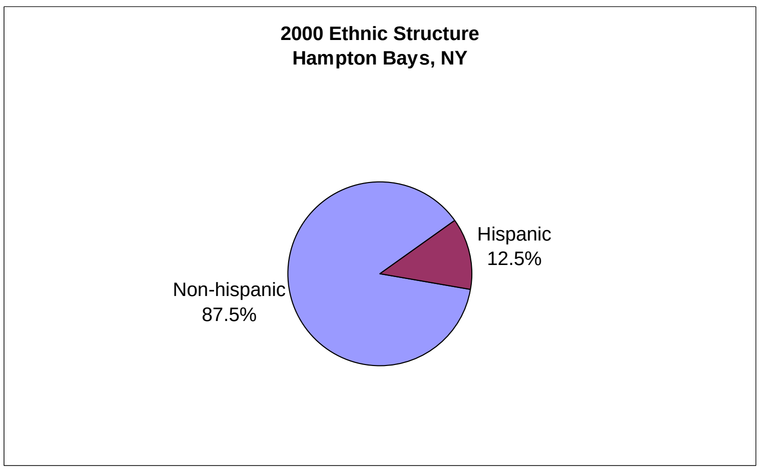


Figure 94: Ethnic Structure in 2000



For 82.8% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 17.2% in homes where a language other than English was spoken, and including 9.2% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 86.6% were high school graduates or higher and 25.9% had a bachelor's degree or higher. Again of the population 25 years and over, 5.3% did not reach ninth grade, 8.0% attended some high school but did not graduate, 33.2% completed high school, 20.8% had some college with no degree, 6.7% received their associate degree, 16.0% earned their bachelor's degree, and 9.9% received either their graduate or professional degree.

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16,234 adherents), Evangelical Lutheran Church (26 with 19,378 adherents), and Muslim (9 with 12,139). The total number of adherents to any religion was up 3.8% from 1990.

Issues/Processes

The population of the town of Southampton has been growing steadily, and a number of seasonal home owners are choosing to live here year round. This is changing the population structure and dynamics of the town, and is likely to cause house prices to increase in an area where affordability is already a problem. The area around Shinnecock Inlet is one where much growth is expected to occur.[659] As in many other coastal communities with a fishing industry, the soaring costs of waterfront property make it very difficult for fishermen and others in the industry to afford or retain necessary waterfront property for water access.[660]

Most of the infrastructure at Shinnecock has disappeared in the last few years; where there were at one time three docks for commercial fishermen to pack out at, now only one remains. In New York the fish is packed into boxes on board the vessels rather than at the dock, and the function of the dock is to unload the boxes off the vessels and truck them to Fulton Fish Market in New York City. The docks make money by charging $8-$9 per box and by selling fuel. Catch limits and trip limits reduce the number of boxes to be shipped, and has made it very difficult for the docks to stay in business. New York is losing much of its infrastructure, and many of the docks have closed or changed hands in recent years.[661]

Some fishermen are concerned about the accuracy of their assigned historical landings by species for fisheries (often used for promulgating new regulations), as the method used to land fish in New York varies from that in most other states. Called the "box method" it involves fish being boxed at sea, then landed at a consignment dock and from there shipped to Fulton Fish Market in New York City. Prior to the implementation of dealer electronic reporting, NMFS port agents counted the number of boxes landed from each vessel and received a species breakdown from the dock manager (who did not open the boxes but rather based the breakdown on his knowledge of the vessel's general fishing patterns). This system allowed greater potential for accidental mis-reporting. Now, the boxes are landed at the consignment dock and immediately shipped to Fulton, where the dealer opens the boxes and reports the landings.

While this method is more accurate in terms of the number and type of fish landed, it can still lead to another type of accidental reporting error. That is, landings are assigned to the incorrect state. This can have inequitable effects on states should an allocation scheme be developed, such as the one for summer flounder, that bases a state's allocation on the landings of a particular species in that state.

The docks make money by charging $10-$12 per box (2007 prices) and by selling fuel.

Catch limits and trip limits reduce the number of boxes to be shipped, and have made it very difficult for the docks to stay in business. New York is losing much of its infrastructure, and many of the docks have closed or changed hands in recent years.[662]

In recent years some vessels have been repossessed, which signifies a great change in a fishery where there was always money to be made at one time. The rest of the fleet is aging badly, but fishermen cannot afford new vessels.[663]

As in many other areas of Long Island where clams and other shellfish are a significant part of the fishing industry, water quality is a consistent problem in the increasingly populated shallow bays where the clams are dug.[664] The bays have had several problems with algal blooms of *Aureococcus anafagefferens*, or brown tide, which killed off bay scallop populations here, and is believed to be related to nutrient depletion in the bay.[665]

Shinnecock Inlet needs to be dredged consistently because of siltation to allow commercial fishermen and recreational vessels to pass in and out of the inlet into the Atlantic Ocean, which is a costly process.[666] The Long Island Power Authority is seeking permission to construct a wind farm off Long Island, a proposal which has met with opposition from commercial fishermen in Hampton Bays and elsewhere on the island, because the turbines will block access to a highly productive squid fishery.[667]

Cultural attributes

Sportfishing tournaments are a popular event in this area.[668]

7.2.2 Infrastructure

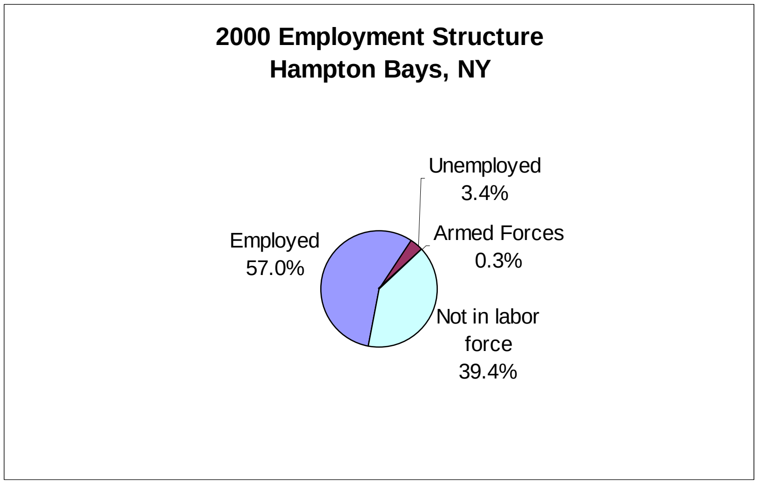
Current Economy

The largest employer in Southampton Town is Southampton Hospital, which employs over 100 people. Other significant sources of employment for residents are in businesses related to tourism or the second home industry, including landscaping, pool maintenance, and construction.[669]

Many employers in the fishing industry have noted the difficulty in attracting employees here when many can make more money in the landscaping business, which has a high demand for laborers, particularly from April through November.[670] Erik Braun said there has been an influx of Hispanic dock workers, and many of the fishermen have had to learn Spanish to communicate with them. This has been a dramatic change within the last 5 years, he said. He also stated that there are no new fishermen starting up, and the children of fishermen, even those that are doing well, are not encouraged to enter into this business.[671]

According to the U.S. Census 2000, 60.6% (6028 individuals) of the total population 16 years of age and over were in the labor force, of which 3.4% were unemployed and 0.3% were in the Armed Forces.

Figure 95: Employment Structure in 2000



According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 95 positions or 1.7% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 789 positions or 13.9% of jobs. Educational, health and social services (20.3%), construction (18.9%), and retail trade (14.4%) were the primary industries.
Median household income in Hampton Bays in 2000 was $50,161 (up 40.0% from $35,736 in 1990) and per capita income was $27,027. For full-time year round workers, men made approximately 56.6% more per year than women.

The average family in Hampton Bays consisted of 3.0 persons. With respect to poverty, 6.7% of families (up from 2.4% in 1990) and 10.7% of individuals earned below the official US Government poverty line, while 23.2% of families in 2000 earned less than $35,000 per year.

In 2000, Hampton Bays had a total of 6,881 housing units of which 70.9% were occupied and 86.3% were detached one unit homes. Less than 10% (7.1%) of these homes were built before 1940. There were a few mobile homes in this area, accounting for 1.7% of the total housing units; 93.9% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $178,000. Of vacant housing units, 84.3% were used for seasonal, recreational, or occasional use. Of occupied units 29.8% were renter occupied.

Governmental

A five-person Town Board governs the town of Southampton. There is one supervisor, elected to a two-year term, and the rest of the board is elected to staggered four-year terms.[672]

Fishery involvement in the government

In addition to the Town Board, the town of Southampton has a Board of Trustees made up of five elected members, which is responsible for governing the laws of the waters and bay bottoms. Their jurisdiction includes boating activities, shellfishing licenses, shoreline protection, and docks and other marine infrastructure. The laws of the Board of Trustees are enforced by the Bay Constables.[673]

Institutional

Fishing associations

The New York Seafood Council, located in Hampton Bays, is a non-profit organization made up of individuals, businesses, and organizations involved in the fishing industry whether through harvesting, processing, distribution or service. The council has over 200 members and their primary goal is to promote seafood and the seafood industry.[674] The Southampton Town Baymen's Association serves the interests of the inshore watermen utilizing Shinnecock Bay and the other bays within the town of Southampton. Also relevant to this area is the Long Island Commercial Fishing Association, which promotes commercial fishing throughout Long Island.[675] The Shinnecock Co-op dock was in operation for 30 years, but went bankrupt and closed two years ago.[676] There was also an organization called the Concerned Wives of Shinnecock Fishermen, that ceased to exist about 15 years ago.[677]

Other fishing related organizations

The Shinnecock Marlin and Tuna Club is a recreational fishing club that sponsors tournaments. They also represent the interests of sportfishermen at meetings and fight for the improvement of Shinnecock Inlet and the preservation of local waters.[678]

Physical

Hampton Bays is strategically positioned on Shinnecock Bay, protected from the Atlantic by a barrier island and accessed through Shinnecock Inlet. This allows fishermen access to both productive coastal and offshore fishing, and its proximity to markets in New York City is also important.[679] The Francis Gabreski Airport in Westhampton Beach is 10 miles away, Long Island Islip MacArthur Airport is 36 miles away, and JFK International Airport is 77 miles from Hampton Bays[680]. The Long Island Railroad stops in Hampton Bays and travels directly into New York City, approximately 90 miles away. Roughly 80% of the finfish landed in Hampton Bays/Shinnecock is sold at Fulton's Fish Market in New York City.[681]

The commercial fishing industry for Hampton Bays/Shinnecock is located on a thin strip of sand on the barrier island by Shinnecock Inlet, allowing the vessels to easily pass out of the Inlet into the sea, physically isolated from the rest of the town. Until recently (2005), there were three docks in Shinnecock including the Shinnecock Fish Dock, the fishermen's cooperative dock, which provided labor, ice, boxes, and trucking for its members, as well as low-cost fuel, and one private dock.[682] These docks are still present, but only the private dock is still operating and packing out fish. The other docks are abandoned; vessels still tie up to them but cannot receive any services. The cooperative dock has been turned into a restaurant.[683]

The majority of marinas and other infrastructure for recreational fishing as well as recreational boating within the town of Southampton are located in the Hampton Bays area alongside the Shinnecock Canal.[684] The Shinnecock Canal County Marina is a publicly-owned marina along the canal,[685] but it does not allow commercial vessels to tie up here.[686] There are at least two bait and tackle shops located in Hampton Bays, and several others within Southampton.[687] There are also six fish retail markets located in Hampton Bays.[688]

7.2.3 <u>Involvement in Northeast Fisheries</u>

Commercial

Hampton Bays/Shinnecock is generally considered the second largest fishing port in New York after Montauk. The combined ports of Hampton Bays/Shinnecock had more landings of fish and shellfish in 1994 than at any other commercial fishing port in New York. Combined landings of surf clams and ocean quahogs were worth roughly $1.6 million in 1994, and squid was at the time the most valuable species here.[689] A 1996 report from the New York Seafood Council listed the following vessels for the combined port of Hampton Bays/Shinnecock: 30-35 trawlers, 2-8 clam dredge vessels, 1-2 longline vessels, 1-3 lobster boats, 4-5 gillnetters, as well as 10-15 fulltime baymen and at least 100 part-time baymen.[690] As of 2005 there was one longline vessel here and many of the trawlers were gone.[691]

Hampton Bays/Shinnecock had at one time a significant surf clam and ocean quahog fishery, evident in the 1997 data, which by 2003 had completely disappeared. Oles notes that surf clam and ocean quahog landings in the past had been from transient vessels landing their catch here.[692] The level of home port fishing declined over the period from 1997 – 2003 for vessels listed with either Hampton Bays or Shinnecock as their home port, as did the combined landings for the port (Shinnecock saw a slight increase in landings, but Hampton Bays saw a sharp decrease which is just a difference in reporting). In 2003, the value of landings by species was either less than or roughly equal to the eight year average for 1997-2004, with the exception of the "other" category and of tilefish, which was much higher in 2003 than the eight-year average.

The highest valued species landed in Hampton Bays in 2003 was loligo squid, which brought in $1,731,568. Summer flounder was worth $ 840,875 and silver hake (whiting) was worth $752,227. The most important fishery for vessels with Shinnecock listed as the home port in 2003 was tautog, which brought in $15,484.

There are a number of baymen who work in Shinnecock Bay, through permits granted by the town of Southampton, fishing for eels, conch, razor clams, scallops, and oysters, among other species.[693] The Shinnecock Indians had an aquaculture facility for cultivating oysters in the bay, but the oyster beds were largely destroyed through pollution and nutrient-loading; they are once again starting to recreate the oyster beds.[694]

Landings by Species

Hampton Bays

Table 53: Dollar value by Federally Managed Groups of landings for Hampton Bays

	Average from 1997-2004	2003 only
Squid, Mackerel, Butterfish	2,701,881	1,788,942
Smallmesh groundfish	1,195,042	774,054
Summer flounder, Scup, Black Sea Bass	1,042,305	1,334,308
Monkfish	640,950	467,556
Largemesh groundfish	542,073	337,619
Tilefish	256,131	651,623
Bluefish	206,929	211,820
Scallop	151,810	164,842
Skate	78,524	56,353
Dogfish	60,702	2,849
Lobster	22,842	16,407
Herring	71	23
Other	1,049,426	705,905

Vessels by Year

Table 54: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	22	38	3,369,876	9,165,830
1998	24	30	4,141,886	9,658,169
1999	24	32	4,040,706	8,442,274
2000	22	31	3,242,978	9,471,461

2001	20	36	2,543,274	9,219,923
2002	18	35	2,139,557	8,290,341
2003	16	33	1,495,549	6,512,301

Shinnecock

Landings by Species

Table 55: Dollar value by Federally Managed Groups of landings for Shinnecock

Species	Average from 1997-2004	2003 only
Surf Clams, Ocean Quahog	70,831	0
Bluefish	2	19
Other	7748	16,139

Vessels by year

Table 56: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	43	0	4,825,722	588,841
1998	36	0	3,898,164	13,523
1999	34	0	5,132,086	3100
2000	36	0	5,118,783	1270
2001	37	0	5,055,134	1560
2002	33	0	4,857,274	4202
2003	33	0	3,795,887	16,158

Recreational

Recreational fishing is an important part of the tourist industry in Hampton Bays. The marinas here are well positioned for both inshore fishing in Shinnecock Bay and offshore fishing, and there are numerous charter and party boats that go fishing in both areas.[695] Many of those who own second homes in Southampton also own private boats for recreational fishing, and this contributed substantially to the marinas and other marine industries.[696] A website dedicated to fishing striped bass lists a number of locations in Hampton Bays for catching striped bass from on shore.[697] One report estimated the value of recreational fishing at between $32 million and $66.8 million for the town of Southampton, which far exceeds the value of commercial fishing here. Recreational shellfishing is a popular activity in the area; at one time it was estimated that 50 percent of shellfishing in Southampton was done recreationally, both by residents and tourists.[698]

Subsistence
Bryan Oles noted in his report on the Hampton Bays/Shinnecock community that the recreational fishery has shifted from one focused on bagging as many fish as possible for consumption to one focused on catch-and-release, as many of those fishing in the area can easily afford to buy fish.[699]

Future

The master plan for the Town of Southampton includes a commitment to preserving the town's fisheries by protecting the industry from growth and development pressures,[700] recognizing the importance of fisheries to both the economy and character of the area.[701] The Master Plan, adopted in 1999, includes a plan to expand the town's commercial fishing dock.[702]

"The resilience of the commercial fishing industry in Hampton Bays is threatened by the cumulative effects of fisheries management and the forces of gentrification that are sweeping the area".[703] One potentially positive note for the fishing industry is that the barrier island and beach where the commercial fishing industry is located are owned by Suffolk County and cannot be developed, so there is less direct competition for space here.[704]

Erik Braun, the port agent for this part of New York, was not hopeful about the future of the fishing industry. He said there are no new fishermen getting into commercial fishing, and that even those who have done well are not encouraging their children to get into the industry. The fleet is badly aging and much of it is in disrepair. Much of the infrastructure here is also gone, and those who own docks can make much more by turning them into restaurants.[705]

8.0 NEW JERSEY

8.1 BARNEGAT LIGHT/LONG BEACH, NJ

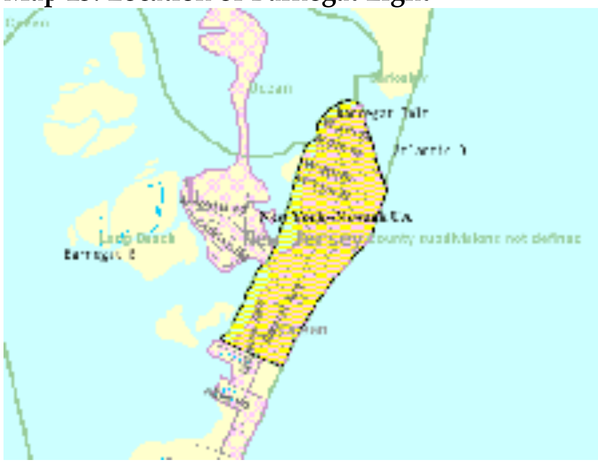
8.1.1 People and Places

Regional orientation

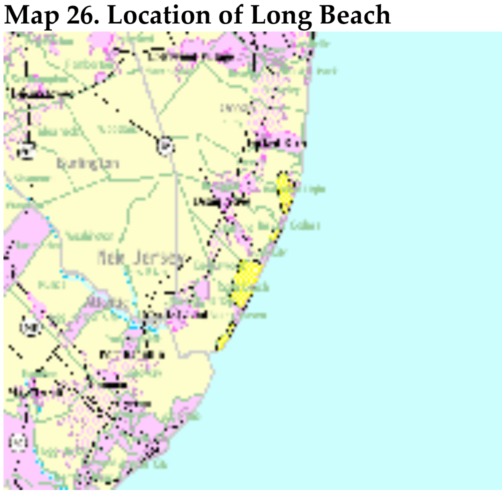
Long Beach Island is an 18-mile barrier beach on New Jersey's eastern shore, about 4 to 6 miles from mainland New Jersey,[706] within Ocean County. It is made up of the Township of Long Beach (39.69°N, 74.14°W), along with five independent boroughs: Barnegat Light, Beach Haven, Harvey Cedars, Ship Bottom, and Surf City. The city of Barnegat Light (39.75°N, 74.11°W) is a major commercial port, while much of the rest of the island specializes in recreational fishing. Barnegat Light is 16.2 miles from Toms

River, NJ, 67.2 miles from Jersey City, NJ, and 67.2 miles from New York, NY. Barnegat Light contains 0.7 square miles of land area.[707]

Map 25. Location of Barnegat Light



Map 26. Location of Long Beach



Historical/Background information

The Dutch explorer Captain Cornelius Jacobsen May landed on Long Beach Island in the early 1600s. The island was long known for its many shipwrecks from the strong tides here, so a number of lifesaving stations were constructed along its length, including the Barnegat Light lighthouse. Long Beach Island was at one time an important fishing and whaling center, although it was accessible only by boat. Later it became a hunting and fishing playground for wealthy gentlemen. The island became more accessible in 1886 when a railroad trestle was built connecting it with the mainland. Long Beach Island consists of a number of communities[708]; in 1899 several of these communities were combined into the township of Long Beach; the rest remained as independent boroughs.[709]

Barnegat Light is one of the 11 municipalities on Long Beach Island. A small town of less than one square mile in area, it is found at the northern tip of the barrier island. The town is named after the lighthouse located here, which has guided ships along the New Jersey coast for generations.

Until the 1995 construction of a jetty by the Army Corps of Engineers, boats on the other side of the island had to pass through one of several narrow and often dangerous inlets. This difficulty limited the growth of maritime industries along this part of the New Jersey shore, in contrast with the tourism industry, which has taken advantage of the area's numerous sandy beaches. Along with the jetty, the Corps project also produced a three-quarter-mile beach and a fishing pier, further developing the tourist appeal of Barnegat Light. Commercial and recreational fishing have a long tradition in this area, and both industries are still strong today.[710]

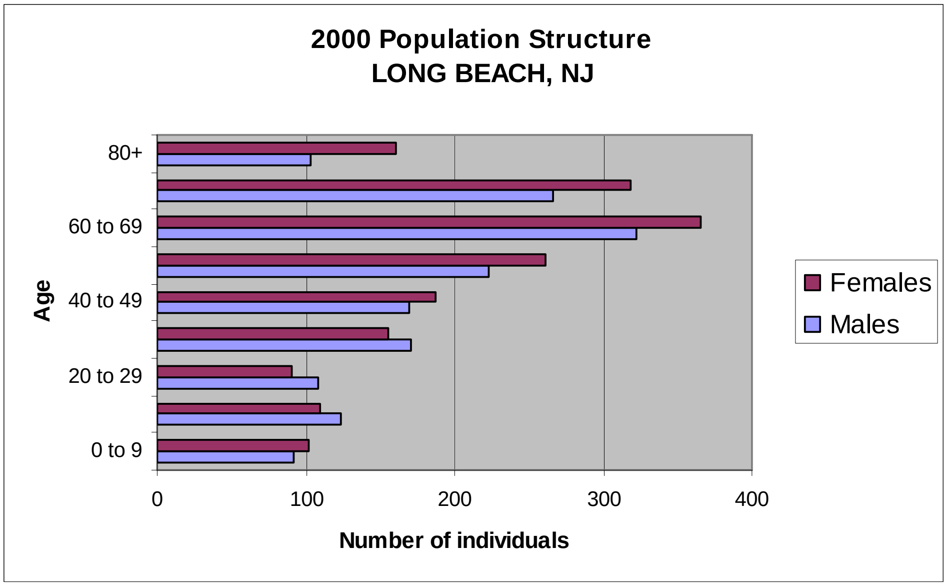
Demographic Profile

Long Beach Township

According to Census 2000 data, Long Beach had a total population of 3,329, down 3.6% from 3,452 in 1990. Of this total in 2000, 52.6% were female and 47.4% were male. The median age was 57.3 years and 86.6% of the population was 21 years or older while 42.7% were 62 or older. The population here can swell to more than 100,000 on a hot summer day.[711]

Long Beach's age structure in 2000 showed an aging population, with a preponderance of residents in the 60 to 69 years age group, followed by the 70-79 years age group, indicating a large retirement population. There were few residents here under the age of 30, and more women over the age of 80 than in any category from age 0-40.

Figure 96: Long Beach's population structure by sex in 2000



The majority of the population of Long Beach in 2000 was white (98.5%), with 0.4% of residents Black or African American, 0.1% Native American, 0.4% Asian, and 0.1% Pacific Islander or Hawaiian. Only 2.1% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (25.0%), German (24.5%), English (16.5%), Italian (14.7%), and Polish (10.3%). With regard to region of birth, 56.8% were born in New Jersey, 39.2% were born in a different state and 3.7% were born outside of the U.S. (including 1.4% who were not United States citizens).

Figure 97: Long Beach's Racial Structure in 2000

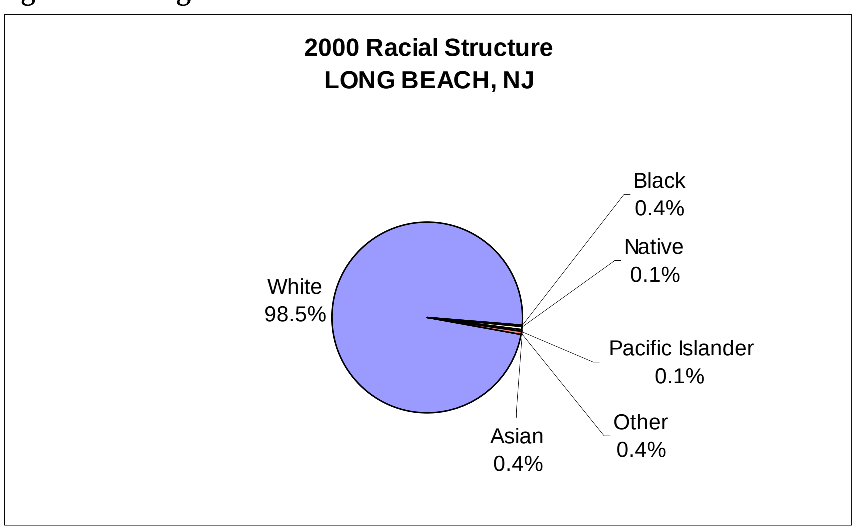
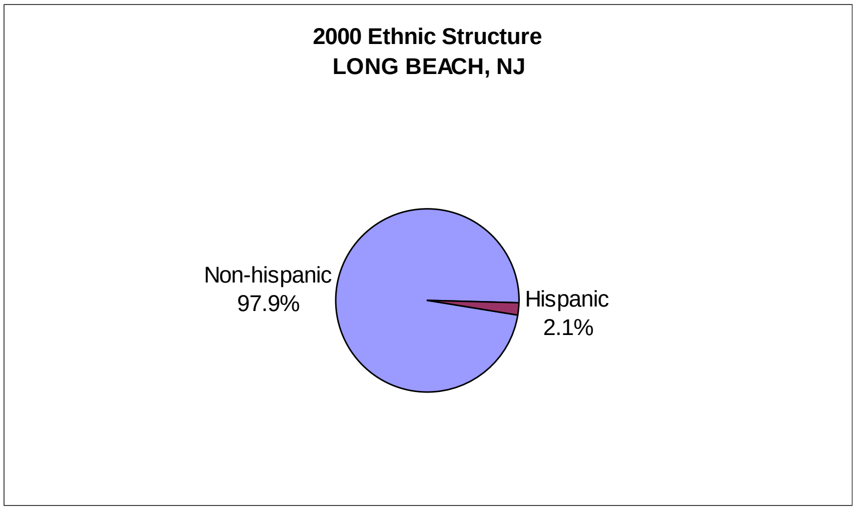


Figure 98: Long Beach's Ethnic Structure



For 92.4% of the population 5 years old and higher in 2000 only English was spoken in the home, leaving 7.6% in homes where a language other than English was spoken, including 1.8% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 92.0% were high school graduates or higher and 36.7% had a bachelor's degree or higher. Again of the population 25 years and over, 2.0% did not reach ninth grade, 5.9% attended some high school but did not graduate, 28.8% completed high school, 21.8% had some college with no degree, 4.7% received their associate degree, 23.9% earned their bachelor's degree, and 12.8% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Ocean County was Catholic with 33 congregations and 212,482 adherents. Other prominent congregations in the county were Jewish (35 with 11,500 adherents), and The United Methodist Church (28 with 9,534 adherents). The total number of adherents to any religion was up 21.9% from 1990.

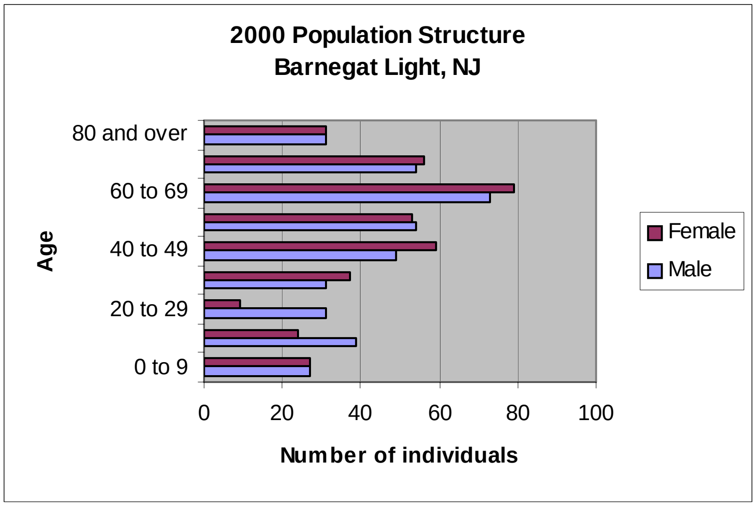
There are seventeen houses of worship listed on Long Beach Island, including six in Long Island Township, of which four are Catholic and one is Jewish, and the rest are Protestant.[712]

<u>Barnegat Light</u>

According to Census 2000 data, Barnegat Light had a total population of 764, up 13.2% from 1990. Of this total in 000, 49.1% were female and 50.9% were male. The median age was 54.9 years and 83.9% of the population was 21 years or older while 39.5% were 62 or older.

Barnegat Light's age structure showed a preponderance of 60 to 69 years age group, indicating a large retirement population. In a perhaps related phenomenon, the age group of 20-29 is very small, with almost no females. Among the already small numbers of children and young people, young females are apparently almost uniformly leaving the community after high school.

Figure 99: Barnegat Light's population structure by sex in 2000



The majority of the population of Barnegat Light in 2000 was white (98.3%), with 0.5% of residents Black or African American, 0% Native American, 0.3% Asian, and 0.3% Pacific Islander or Hawaiian. Only 0.8% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (28%), German (23.2%), English (17.4%), and Italian (14.6%). With regard to region of birth, 55.7% were born in New Jersey, 39.8% were born in a different state and 3.2% were born outside of the U.S. (including 0.4% who were not United States citizens).

Figure 100: Barnegat Light's Racial Structure in 2000

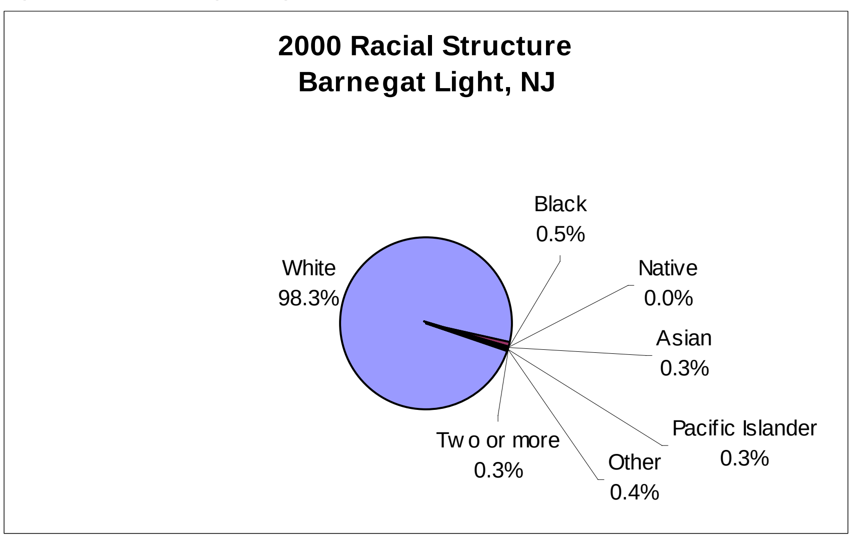
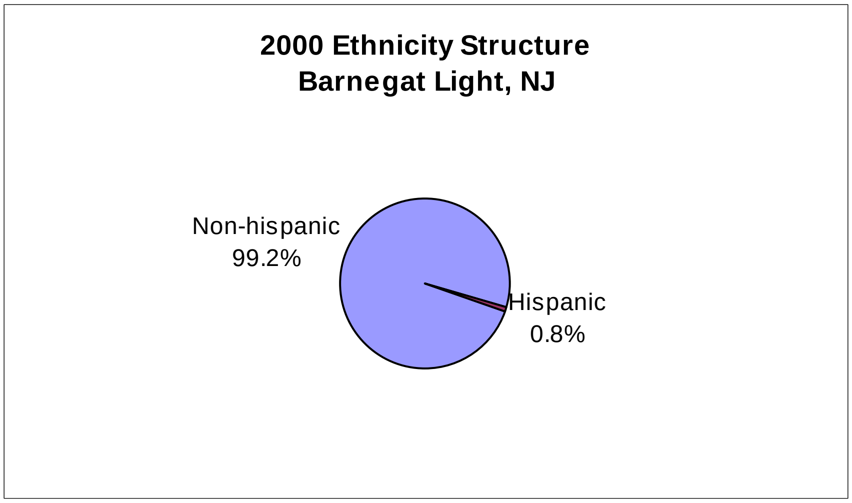


Figure 101: Barnegat Light's Ethnic Structure



For 92.7% of the population 5 years old and higher in 2000 only English was spoken in the home, leaving 7.3% in homes where a language other than English was spoken, including 1.5% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 92.1% were high school graduates or higher and 38.9% had a bachelor's degree or higher. Again of the population 25 years and over, 2% did not reach ninth grade, 5.9% attended some high school but did not graduate, 29.3% completed high school, 17% had some college with no degree, 6.9% received their associate degree, 21.5% earned their bachelor's degree, and 17.4% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Ocean County was Catholic with 33 congregations and 212,482 adherents. Other prominent congregations in the county were Jewish (35 with 11,500 adherents), and The United Methodist Church (28 with 9,534 adherents). The total number of adherents to any religion was up 21.9% from 1990.

Issues/Processes

As of 2006 the Army Corps of Engineers wished to begin a beach nourishment project on Long Beach Island to restore the eroding beaches here, but is meeting with resistance from homeowners, who are concerned that the planned dunes will obstruct their water view, and that more beach space will mean more beach goers in front of their homes. The government would require easements from property owners to access the shore for construction, and the home owners are reluctant to provide them. If the beach nourishment project does not take place, the beach and the waterfront homes may soon be lost.[713]

One emerging trend (as of 2006) on Long Beach Island and in other similar summer resort areas is that as real estate prices soar, many year-round residents are selling their homes for bigger homes on the mainland, tempted by the large price they can get. These homes are bought up by those using them as summer homes. The result is dwindling year-round populations on places like Long Beach Island, and a resulting loss in year-round businesses and students in local schools.[714]

Like many other coastal communities, Barnegat Light must deal with the forces of rapidly increasing home prices and the resulting gentrification. Because the community is physically so small, there is very little land area for development, and the development of condominiums or other properties generally involves land in existing use. The high housing costs are encouraging many families to move to the mainland, and many of those employed in the commercial fishing industry now do not reside in Barnegat Light.[715]

Some beach areas on Long Beach are closed during the summers for piping plover nesting; local anglers complain this restricts them from prime beach area from which to cast.[716]

Cultural attributes

There are a number of events throughout the summer held all over Long Beach Island. Long Beach Island Surf Fishing Tournament is an annual competition that has been held for over fifty years. It takes place throughout most of October and November, with cash prizes and trophies being awarded in angling competitions for bluefish and striped bass, and includes a popular surfcasting seminar. Chowderfest is an annual event that is held in Beach Haven in early October and features a competition between all the restaurants on Long Beach Island as they vie for the honor of creating the tastiest chowder.[717] The Alliance for a Living Ocean hosts beach seining events and the annual FantaSea Festival to educate the public about the coastal resources surrounding Long Beach Island.[718] Barnegat Light holds an annual Blessing of the Fleet in the Barnegat Light Yacht Basin each June to pray for the community's commercial fishermen.[719]

8.1.2 Infrastructure

Current Economy

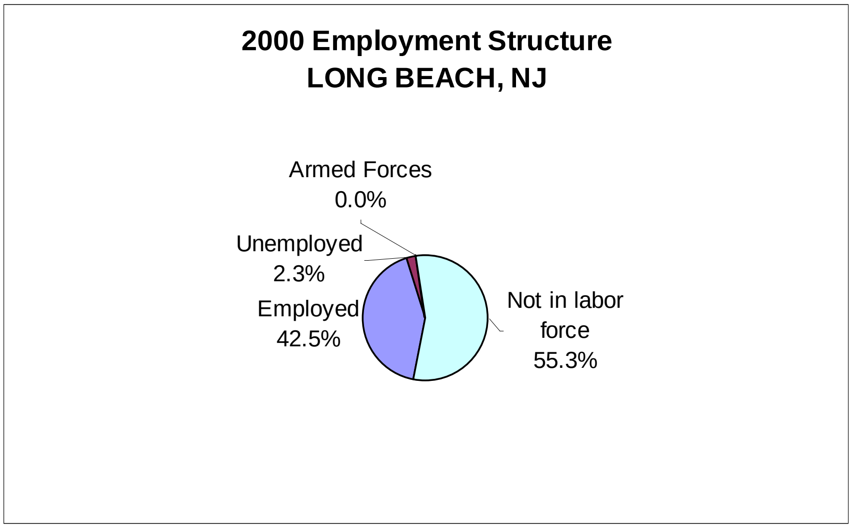
Long Beach Township

Tourism and real estate are the two major industries in Long Beach.[720] Total property values on the island exceed $11 billion.[721]

According to the U.S. Census 2000, 44.7% (1,351 individuals) of the total population 16 years of age and over were in the labor force, of which 2.3% were unemployed and 0.0%

were in the Armed Forces. It should be noted that 55.3% of the population 16 and over were not in the labor force at all. This high percentage relative to other locations further reinforces the nature of Long Beach as a retirement community.

Figure 102: Long Beach's employment structure in 2000 (U.S. Census 2000)



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 10 positions or 0.8% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 141 positions or 11.0% of the labor force. Educational health and social services (18.2%), arts, entertainment, recreation, accommodation and food services (17.1%), construction (14.6%), and retail trade (11.5%) were the primary industries.

Median household income in Long Beach was $48,697 (up 53.3% from $31,775 in 1990) and median per capita income was $33,404. For full-time year round workers, men made approximately 33.2% more per year than women.

The average family in Long Beach consisted of 2.50 persons. With respect to poverty, 3.8% of families (down from 4.2% in 1990) and 5.1% of individuals earned below the official US Government poverty line, while 18.4% of families in 2000 earned less than $35,000 per year.

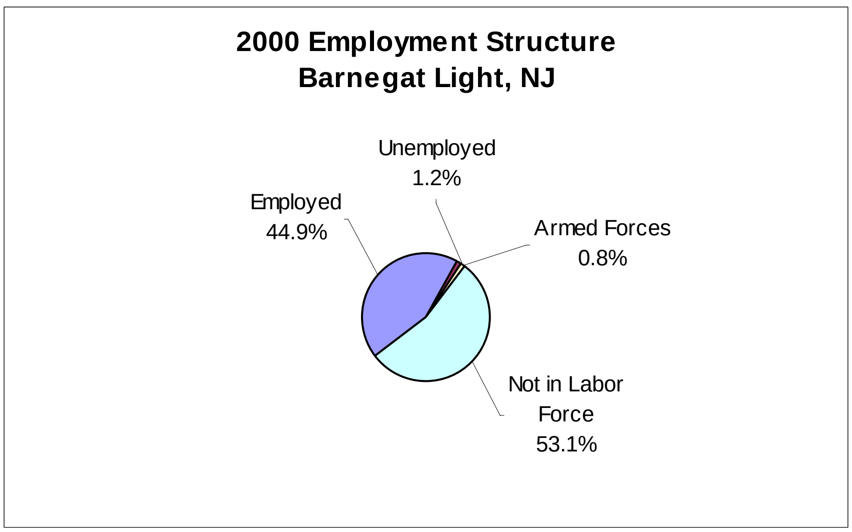
In 2000, Long Beach had a total of 9,023 housing units of which 18.4% were occupied and 74.1% were detached one unit homes. Only 5.0% of these homes were built before 1940. There were a number of mobile homes/vans/boats in this area, accounting for 4.3% of the total housing units; 88.6% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $334,400. Of vacant housing units, 83.3% were used for seasonal, recreational, or occasional use. Of occupied units, 13.9% were renter occupied.

Barnegat Light

The small businesses of Barnegat Light are very reliant on the summer tourist economy and the year round fishing industry. The town relies heavily on its commercial fishing industry year round, but in winter it becomes the economic mainstay for the town – employing as many as 150 local people to work at the marinas.[722] The most significant sources of employment in the town are the fishing industry and real estate.[723]

According to the U.S. Census 2000, 46.9% (305 individuals) of the total population 16 years of age and over are in the labor force, of which 1.2% are unemployed and 0.8% are in the Armed Forces. It should be noted that 53.1% of the population 16 and over are not in the labor force at all. This high percentage relative to other locations further reinforces the nature of Barnegat Light as a retirement community.

Figure 103: Barnegat Light's employment structure in 2000 (U.S. Census 2000 website)



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 24 positions or 8.2% of all jobs. Self employed workers, a category where fishermen might be found, accounts for 55 positions or 18.8% of the labor force. Educational health and social services (16.8%), arts, entertainment, recreation, accommodation and food services (11%), construction (10.3%), finance, insurance, real estate and rental and leasing (10.3%), and professional, scientific, management, administrative and waste management services (9.2%) were the primary industries.

Median household income in Barnegat Light was $52,361(up 17.3% from 1990) and median per capita income was $34,599. For full-time year round workers, males made approximately 17.6% more per year than females. The average family in Barnegat Light consists of 2.6 persons. With respect to poverty, 2.6% of families (down from 4.2% in 1990) and 4.7% of individuals earn below the official US Government poverty line, while 33.7% of families in 2000 earned less than $35,000 per year.

In 2000, Barnegat Light had a total of 1,207 housing units of which 30.7% were occupied and 88.4% were detached one unit homes. Only 3.6% of these homes were built before 1940. There are a number of mobile homes/vans/boats in this area, accounting for 0.2% of the total housing units; 86.4% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area was $299,400. Of vacant housing units, 93.4% were used for seasonal, recreational, or occasional use. Of occupied units, 12.1% were renter occupied.

Governmental

The township of Long Beach is located in Ocean County and is governed by a board of three commissioners, one of whom is the mayor.[724] An elected mayor and a six-person borough council run Barnegat Light's local governance.[725]

Fishery involvement in government

The local government is not directly involved in the fishing industry in Barnegat Light. However, the mayor himself owns several scallop boats.[726] The Barnegat Bay National Estuary Program is one of 28 estuaries of "national significance" designated and federally funded by the US EPA. It is a partnership of federal, state, and municipal agencies as well as non-profit organizations and businesses working together to protect this estuary.[727]

Institutional

Fishing associations

The Beach Haven Charter Fishing Association represents charter boats in the borough of Beach Haven and around Long Beach Island.[728] Blue Water Fishermen's Association is located in Barnegat Light. This association is made up of tuna and swordfishermen as well as others involved in the commercial fishery of highly migratory species.[729]

Fishery assistance centers

No fishing assistance centers were identified through secondary data sources.

Other fishing related institutions

The Alliance for a Living Ocean on Long Beach Island is focused on promoting and maintaining clean water and a healthy coastal environment. They host a number of educational events including eco tours, beach walks, and seining, and also hold an annual festival.[730]

The Jersey Coast Anglers Association (JCAA) located in nearby Toms River NJ, is an association of more than 75 saltwater fishing clubs, with a combined membership exceeding 30,000.[731] The Recreational Fishing Alliance, a national lobbying group, is headquartered near Barnegat Light.[732]

Physical

Long Beach Island is a barrier island with the Atlantic Ocean on one side, and Barnegat Bay and Little Egg Harbor on the other. Ocean County has three general aviation airports: Eagles Nest Airport at West Creek, Lakewood Airport at Lakewood, and Robert J. Miller Airpark in Berkeley Township. But none of these has regularly scheduled service[733] Barnegat Light is at 52 miles from Atlantic City International Airport, 72 miles from Trenton Mercer Airport, 78 miles from the Philadelphia International Airport and 98 miles from the Newark Liberty International Airport. Toms River is 29 miles from Long Beach and Atlantic City is 47 miles away. New York City is about 102 miles by car. Route 72 is the only road connecting Long Beach Island with the New Jersey mainland; it connects Ship Bottom with Beach Haven West and Manahawkin.

Long Beach Island has a number of bait and tackle shops including Jingles Bait and Tackle, Surf City Bait and Tackle[734], and Fisherman's Headquarters.[735] There are also a number of marinas located along the island.[736] Sportsman's Marina bills itself as a fishing and crabbing marina, and also offers boat rentals.[737] Ocean County lists seven marinas in Long Beach Township and at least 30 more along the island.[738] Hagler's Marina is one in Brant's Beach with 66 slips offering gas, bait, tackle, ice, and supplies; another is Escape Harbor Marina. There are also four boat ramps listed for Long Beach Island.[739]

Barnegat Light is one of the most important fishing ports in Ocean County. Barnegat Light port has a significant offshore longline fishery, targeting tuna species (especially yellow fin and big eye) for most of the year, and swordfish part of the year.

Docking is available through five marinas in Barnegat Light. The two largest docks have 36 full-time resident commercial boats, working year round, as well as recreational vessels and transient vessels. One of these two largest docks is completely occupied by commercial boats; the owners are also commercial fishermen. These commercial boats include seven scallopers, ten longliners that fish for tuna, swordfish, and tilefish, and about nine inshore-fishing net boats. The dock also has three offloading stations. The second of the largest docks accommodates ten commercial boats, fifteen charter boats, and twenty-five recreational vessels. The three remaining docks can each accommodate approximately 30- 35 boats, most of which are recreational boats and charter boats. Most of the recreational and sport fishing boats that utilize this port are here for part of the year, usually from May or June through early October.[740]

8.1.3 Involvement in Northeast Fisheries

Commercial

Barnegat Light, on the north end of Long Beach Island, is one of New Jersey's largest commercial fishing ports. However, to avoid confidentiality issues due to a small number of dealers, all Barnegat Light/Long Beach landings are combined.

Located adjacent to the formerly infamous Barnegat Inlet, Barnegat Light's two commercial docks host a range of vessels from small, local day boats to globe spanning longliners. Several fishermen in Barnegat Light pioneered the deep water tilefish fishery back in the 1970s, successfully marketing this fish as the "poor man's lobster". "Barnegat Light is the home port of many members of the East Coast's longline fleet. Targeting several species of tuna as well as swordfish, on their several week or longer trips Barnegat Light longliners routinely fish from the high seas from hundreds to thousands of miles away. Barnegat Light is also home to several state-of-the-art scallop vessels and a fleet of smaller, inshore gillnetters."[741] The scallop fleet is made up both of larger vessels which may spend several days at sea at a time, fishing for scallops throughout the Mid-Atlantic, and several vessels which engage in "day trip" scalloping closer to the coast. The day trips can also be an important means for full-time scallopers and some other fishermen to subsidize their catch, as scallop vessels do not need to use their days at sea to fish for scallops inshore.[742]

The most valuable fisheries in Barnegat Light in 2003 were sea scallops ($9,493,730), monkfish ($4,389,185), and swordfish ($715,289), according to NMFS landings data. Both scallop and monkfish catches were above the 8-year average in 2003. Tilefish was also an important species in 2003, with an increase in value from the 1997-2004 average. Overall, the value of the catch, both that of vessels with their home port in Barnegat Light and those landing their catch here, increased over the 7-year period. The number of vessels in Barnegat Light also increased over the same period.

Viking Village, one of Barnegat Light's two commercial docks, is one of the largest suppliers of fish and seafood on the Eastern Seaboard. Each year over 4 million pounds of seafood are packed out over the commercial dock of Viking Village and shipped locally and internationally. Viking Village is homeport to seven scallopers, ten longliners and about nine inshore-fishing net boats, which fish blues, weakfish, monkfish, dogfish and shad. Each boat is independently owned and uses Viking Village for pack-out, marketing and sale of the catch. Some local restaurants and seafood dealers purchase products from Viking Village directly, including Wida's, Surf City Fishery, Beach Haven Fishery and Cassidy's Fish Market. Viking Village and the boats docked there employ about 200 people.[743] There are also a number of bait and tackle retailers located in town, such as Barnegat Light Bait and Tackle[744] and Eric's Bait and Boat[745].

Landings by Species

Table 57: Dollar value of Federally Managed Groups of landings in Barnegat Light

Species	Average from 1997-2003	2003 only
Scallop	5,498,710	9,493,730
Monkfish	3,287,025	4,389,185
Bluefish	255,794	210,437
Dogfish	197,054	0
Tilefish	150,205	626,946
Skate	111,925	74,534
Squid, Mackerel, Butterfish	63,815	20,138
Summer Flounder, Scup, Black Sea Bass	57,945	71,825
Largemesh groundfish	4,559	519
Smallmesh groundfish	1,871	333
Lobster	1,010	0
Herring	11	0
Other	2,544,127	1,494,125

Vessels by year

Table 58: All columns represent vessel permits or landings value combined between 1997-2003.

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	43	28	6,144,679	10,303,886
1998	38	27	6,054,709	10,171,814
1999	54	32	11,127,349	12,124,531
2000	65	38	14,417,637	14,594,799
2001	71	39	14,709,246	14,387,998
2002	72	38	14,657,863	14,568,116
2003	81	39	16,623,969	16,381,772

Recreational

Just a glance at the large number of marinas, charter operations, bait and tackle shops, and boat ramps on Long Beach Island makes it clear that recreational fishing is important here (see above). Between 2001- 2005, there were 40 charter and party vessels making 7,189 total trips registered in logbook data by charter and party vessels in Long Beach carrying a total of 172,212 anglers (NMFS VTR data). Hot Tuna Charters is one charter boat in Long Beach that specifically targets tuna, and offers both inshore and canyon fishing.[746] Jersey Girl Sport Fishing is another charter company with both inshore trolling and wreck fishing for tuna, skipjack, mahi mahi, seabass, croaker, fluke, porgies, and more.[747] The Beach Haven Charter Fishing Association represents several different boats in Beach Haven and Long Beach.[748] Many recreational and charter fishing boats can be found in Barnegat Light, along with marinas, boat rental facilities, and bait and tackle shops.[749]

Subsistence

No information has been obtained at this time through secondary sources on subsistence fishing.

Future

As of 2005 the New Jersey State Department of Transportation had plans to build a second bridge alongside the existing one to Long Beach Island, to address the poor structural conditions of the existing bridge. This would not affect the amount of traffic able to travel to the island.[750] Also as of 2005, if the necessary easements are signed by property owners on the island, the Army Corps of Engineering will soon begin a $75 million beach renourishment project expected to last 50 years.[751] Information has not yet been obtained regarding people's perception of the future in Long Beach.

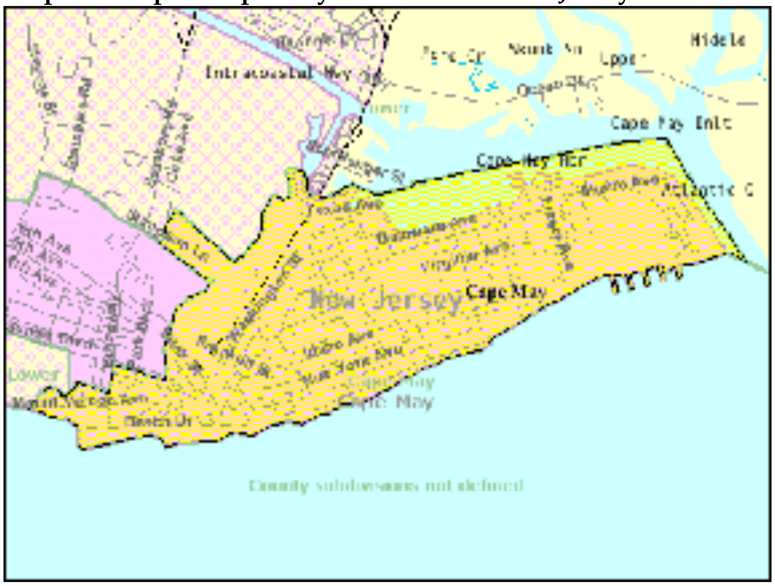
8.2 CAPE MAY, NJ

8.2.1 People and Places

Regional orientation

The city of Cape May, New Jersey (38.935°N, 74.9064°W), is located in Cape May County. It is 48 miles from Atlantic City, NJ, 87 miles from Philadelphia, PA, and 169 miles from New York City.

Map 27: Map of Cape May's location in New Jersey



Historical/Background information

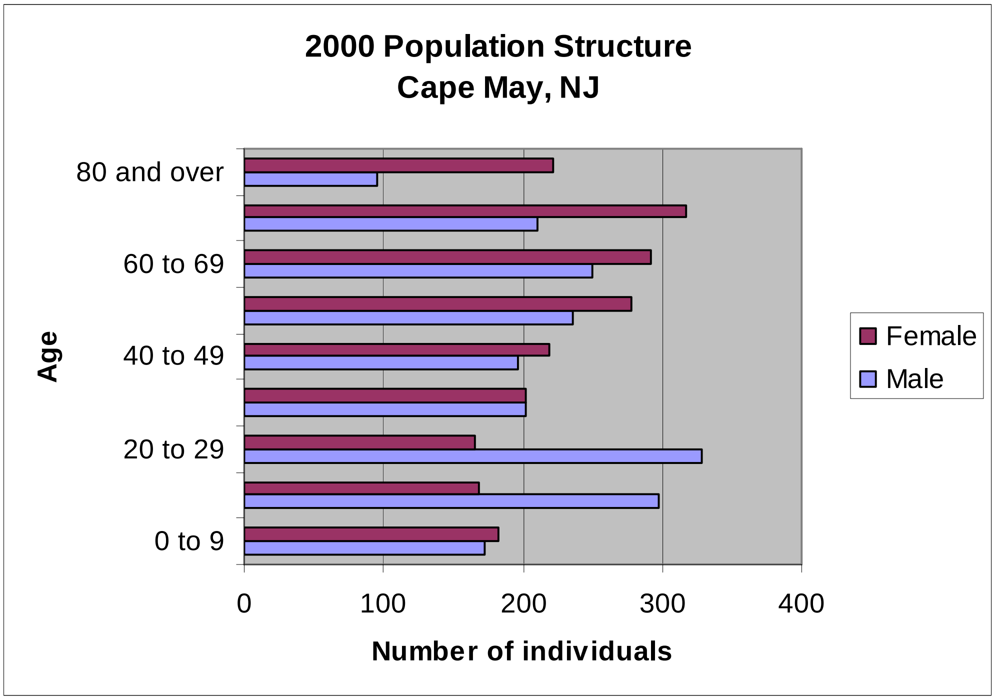
Cape May is part of Cape Island at the southern tip of Cape May Peninsula. The island was artificially created in 1942 when the U.S. Army Corps of Engineers dredged a canal that passes through to the Delaware Bay.[752] Fishing and farming have been important in this area since its beginnings, and whaling, introduced by the Dutch, was a significant industry in Cape May for roughly a century beginning in the mid-1600s. In the 18th century, this area became a summer resort for wealthy residents of Philadelphia wishing to escape the crowded city during the summer months, and is known as "America's oldest seaside resort". Because of this history and because of a fire that destroyed much of the city in 1878, Cape May has numerous Victorian homes and hotels, and was declared a National Historic Landmark City in 1976.[753] "Today commercial fishing is still the backbone of the county and is the second largest industry in Cape May County. The port of Cape May is considered one of the largest and busiest seaports along the eastern seaboard and generates more than $500 million annually."[754]

Demographic Profile

According to the Census 2000 data, Cape May had a total population of 4,034, down from a reported population of 4,668 in 1990. Of this total in 2000, 49.3% were males and 50.7% were females. The median age was 47.4 years and 77.7% of the population was 21 years or older while 32.4% were 62 or older.

Cape May's population structure by age group was similar for all age categories. However, men were dominant for the population between 0 and 29 years, and then the population for male and female was the same until age 40 when it switched to female dominance through 80 years and over. Further, unlike the U.S. as a whole, the middle years are overall in lower percentages than the youngest and oldest. This large number of males in the 20-29 age bracket followed by a drop in the ages 30-59 is also very unlike most other fishing communities.

Figure 104: Cape May's population structure by sex in 2000



The vast majority of the population of Cape May in 2000 was white (91.3%), with 5.3% Black or African American, 0.2% Native American or Alaskan, 0.4% Asian and 0% Pacific Islander or native Hawaiian. Of the total population, 3.8% identified themselves as Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (26.9%), German (21.9%), English (16.2%), Italian (14.2%), Polish (6.9%), French (3.5%), and Scottish (2.7%). With regard to region of birth, 25.6% of residents were born in New Jersey, 66.9% were born in a different state, and 6.1% were born outside the U.S. (including 2.4% who were not US citizens).

Figure 105: Cape May's Racial Structure in 2000

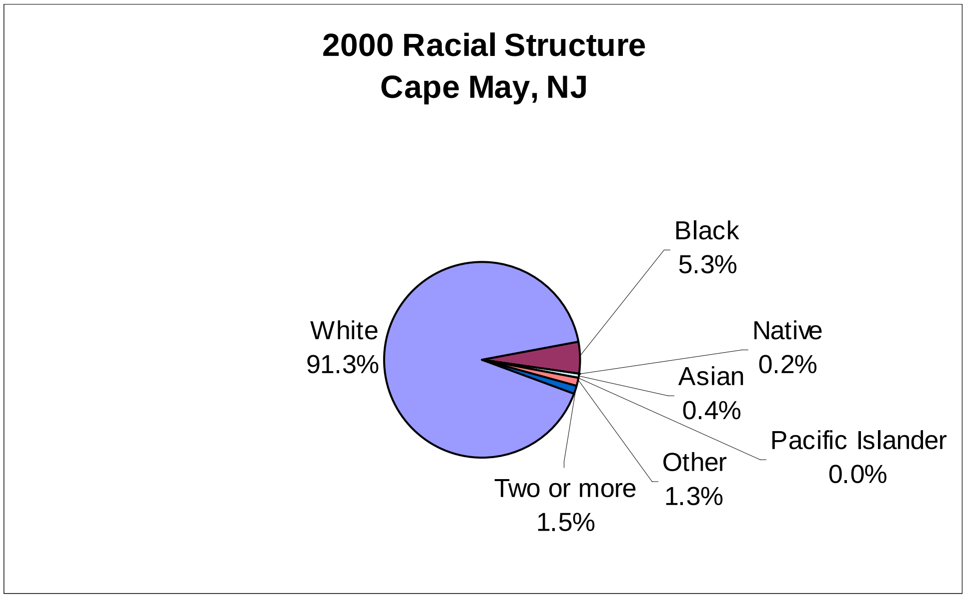
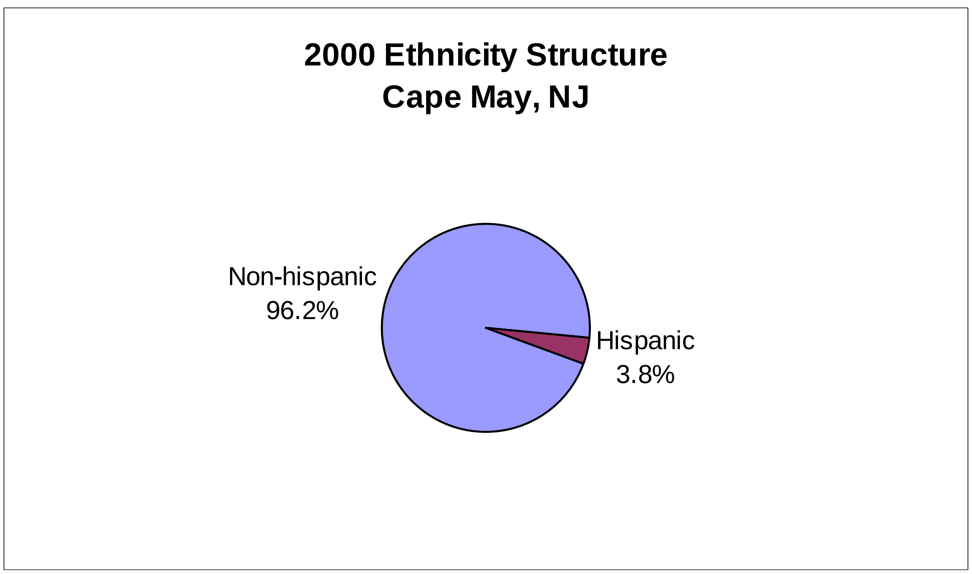


Figure 106: Cape May's Ethnic Structure in 2000



For 91.1% of the population in 2000, only English was spoken in the home, leaving 8.9% in homes where a language other than English was spoken, including 2.9% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 87.6% were high school graduates or higher and 30.8% had a bachelor's degree or higher. Again of the population 25 years and over, 2.6% did not reach ninth grade, 9.8% attended some high school but did not graduate, 30.5% completed high school, 20.1% had some college with no degree, 6.2% received their associate degree, 19.0% earned their bachelor's degree, and 11.8% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive in 2000 the religions with the highest number of congregations in Cape May County included Catholic (15 with 32,307 adherents), United Methodist (25 with 5,133 adherents), Episcopal (6 with 1,588 adherents) and Evangelical Lutheran Church in America (6 with 2,142 adherents). The total number of adherents to any religion was up 15% from 1990.

Issues/Processes

Offshore wind farms have been proposed for four locations off of Cape May County, and fishermen are concerned about the impact wind turbines could potentially have on the fish or on their access to the fisheries.[755] In 2006, rising fuel costs were having a detrimental effect on the charter fishing industry, especially on those boats going further out to go canyon fishing. The boat owners have been forced to raise their prices, and many potential customers were thinking twice about taking a trip offshore.[756]

Cultural attributes

The Fisherman's Wharf runs regular tours of the facility to teach visitors about the seafood industry in Cape May. The Cape May County Fishing Tournament is one of the longest continuously running fishing tournaments on the East Coast.[757]

8.2.2 Infrastructure

Current Economy

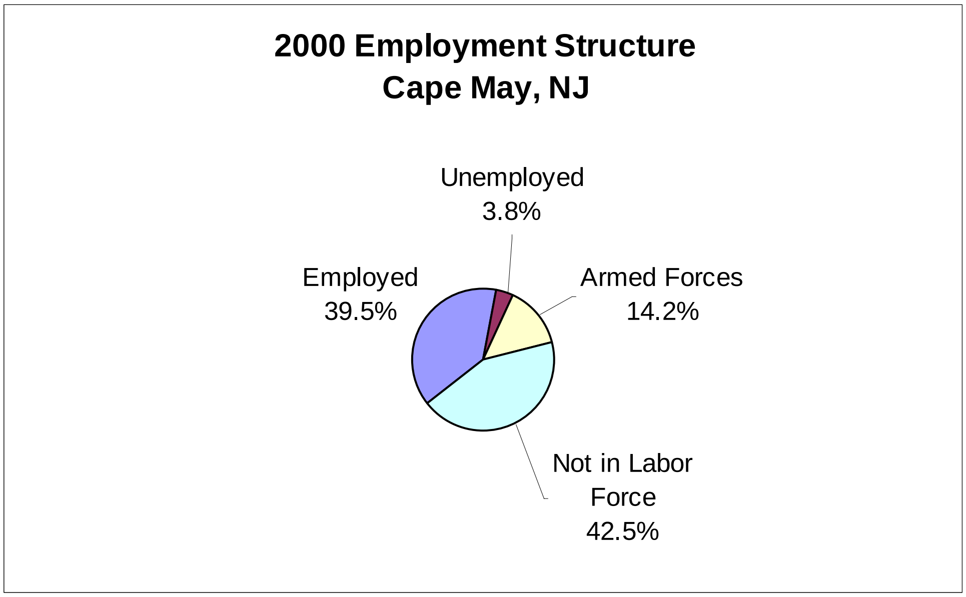
Established in 1954 in Cape May, Lund's Fisheries, Inc. is a freezer plant and a primary producer of various species of fish found along the Eastern Seaboard of the USA. It is also a member of the Garden State Seafood Association.[758]

There are also two other exporters of seafood in Cape May, the Atlantic Cape Fisheries Inc. exporting marine fish and shellfish, oysters, scallops, clams and squids, and the Axelsson and Johnson Fish Company Inc. exporting shad, marine fish, conch, American lobster, lobster tails, scallops and whole squid.[759]

The tenth largest employer (140 employees) in Cape May County is Snow's/Doxsee Inc.,[760] with an 86,000 square-foot plant in Cape May that produces clam products including chowder, soups, canned clams, clam juice, and seafood sauces.[761] Snow's/Doxsee is the only domestic manufacturer to harvest its own clams, and the company maintains the largest allocation for fishing and harvesting ocean clams in the United States.[762] Cold Spring Fish and Supply employs 500 people, and is the third largest employer in the county. Other top employers in the county include Burdette Tomlin Memorial Hospital (1100), Acme Markets (600), WaWa (485), Holy Redeemer Visiting Nurse (250), and Super Fresh (250).[763]

Of the total population over 16 years of age and over in 2000, 1,985 or 57.5% were in the labor force, 3.8% were unemployed, and 14.2% were in the armed forces.

Figure 107: Cape May's employment structure in 2000 (U.S. Census 2000 website)



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 5 jobs ,or 0.4% of all jobs. Self employed workers, a category where fishermen might be found, accounts for 205 or 15% of the labor force. Arts, entertainment, recreation, accommodation and food services (21.1%), and finance, insurance, real estate and rental and leasing (10.6%), retail trade (16.4%), and educational, health and social services (13.6 %) were the primary industries.

Median household income in Cape May in 2000 was $33,462 (up from 1$27,560 in 1990) and median per capita income was $29,902. For full-time year round workers, men made approximately $3,352 more per year than women.

The average family in Cape May in 2000 consisted of 2.69 persons. With respect to poverty, 7.7% of families (up from 2.7% in 1990) and 9.1% of individuals earned below the official US Government poverty line, and 36.7% of families in Cape May in 2000 earned less than $35,000 per year.

In 2000, Cape May had a total of 4,064 housing units, of which 44.8% were occupied and 40.8% were detached one unit homes. Fewer than a third (29.1%) of these homes were built before 1940. Mobile homes and boats accounted for only 0.3% of the total housing units; 82.3% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $212,900. Of vacant housing units, 93.1% were used for seasonal, recreational, or occasional use. Of occupied units, 43.2% were renter occupied.

Governmental

The City of Cape May operates under the Council/Manager form of government. Cape May voters directly elect the Mayor. The person elected serves a four year term. The mayor presides over the council and has a vote. There are four members of Council, in addition to the Mayor. Their terms are staggered, where the members of the first council draw lots to determine who serves a four year term. The remaining three will serve a two year term. Subsequently, all councilmen elected serve for four years.[764]

Fishery involvement in government

The Cape May County Planning Board expresses in its comprehensive plan its policies regarding commercial fishing, which include promoting and encouraging land use policies which benefit the commercial fishing industry and protecting the fishing industry from economic or environmental harm by opposing projects which may have a negative effect.[765]

Institutional

Fishing associations

Garden State Seafood Association in Trenton is a statewide organization of commercial fishermen and fishing companies, related businesses and individuals working in common cause to promote the interests of the commercial fishing industry and seafood consumers in New Jersey.[766]

Fishery assistance centers

The Cape May County government, along with the State of New Jersey, developed the Cape May County Revolving Fishing Loan Program. Instituted in 1984, it is designed "to help commercial, charter and party boat fishermen with low interest loans for safety and maintenance of fishing vessels." More than $2.5 million has been loaned to date. [767]

Other fishing related institutions

The Cape May County Party and Charter Boat Association is an organization of small recreational fishing boats located along the coast of Southern New Jersey.[768]

Physical

Cape May, like all of New Jersey's seafood industry, is within easy reach of airports in Newark, New York and Philadelphia. All these offer next-day service for fresh seafood to virtually every major market in the world. The container port in Newark/Elizabeth handles hundreds of thousands of shipping containers each month, many of them packed with chilled or frozen food products.[769] Cape May also has extensive bus service to the surrounding area as well as Philadelphia and Atlantic City.[770] There is also a ferry terminal connecting Cape May to Lewes, DE.[771]

8.2.3 Involvement in Northeast Fisheries

Commercial

At the Southernmost tip of New Jersey - and almost as far South as Washington, DC - the combined port of Cape May/Wildwood is the largest in New Jersey and one of the largest on the East Coast. The center of fish processing and freezing in New Jersey, Cape May/Wildwood is the home port to some of the largest vessels fishing on the Atlantic coast and has led the way in developing new fisheries and new domestic and international markets for New Jersey seafood. Major Cape May fisheries focus on squid, mackerel, fluke, sea bass, porgies, lobsters and menhaden. In addition to these, Wildwood boats are also in the surf clam/ocean quohog fisheries. Like many Jersey Shore communities, much of Cape May's and Wildwood's economies are dependent on seasonal tourism - which is dependent both on the weather and the overall state of the economy. The year-round character of commercial fishing is a major factor in keeping these communities going in the off-season.[772]

Cape May annual landing value for 2003 was $36.4 million including an annual scallop landing value of $27.6 million. The value of the scallop fishery in 2003 was nearly double the average value for 1997-2004. Many of Cape May's other significant fisheries, including the butterfish, mackerel, and squid grouping, the summer flounder, scup, and black sea bass grouping, and the surf clam and ocean quahog grouping, had decreased in value in 2003 from the eight-year average. After sea scallops, the most valuable landings in Cape May were Atlantic mackerel ($2,791,667) and Loligo squid ($1,002,958). Between 1997 and 2003 homeported vessels number increased from 109 to 129.

Landings by Species

Table 59: Dollar value of Federally Managed Groups of landings for Cape May

	Average from 1997-2004	2003 only
Scallop	13,909,428	27,651,212
Squid, Mackerel, Butterfish	5,994,683	4,460,073
Summer Flounder, Scup, Black Sea Bass	2,000,912	1,858,000
Surf Clams, Ocean Quahogs	700,740	399,781
Lobster	506,282	352,671
Monkfish	293,493	210,092
Herring	116,245	142,896
Redcrab	44,135	0
Smallmesh groundfish	29,029	1,814
Bluefish	22,889	7,821

Skate	9,815	34,579
Dogfish	8,218	0
Largemesh groundfish	4,828	700
Tilefish	59	0
Other	1,671,519	1,249,059

Vessels by year

Table 60: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# Vessels (owner's city)	Home port value ($)	Landed port value ($)
1997	109	73	27,687,667	23,636,983
1998	105	68	27,614,763	25,770,007
1999	106	72	29,153,706	22,353,284
2000	116	74	30,488,271	23,936,235
2001	116	71	32,923,798	27,155,864
2002	118	72	34,529,920	28,312,296
2003	129	78	42,696,341	36,368,698

Recreational

The Cape May County Party and Charter Boat Association lists several dozen charter and party vessels based out of the City of Cape May.[773] Between 2001- 2005, there were 56 charter and party vessels making 6,599 total trips registered in NMFS logbook data by charter and party vessels in Cape May, carrying a total of 116,917 anglers.

Subsistence

Information on subsistence fishing in Cape May is either available through secondary data collection or the practice does not exist.

Future

Information has not yet been obtained through secondary data sources regarding plans or perceptions for the future in Cape May.

8.3 POINT PLEASANT, NJ

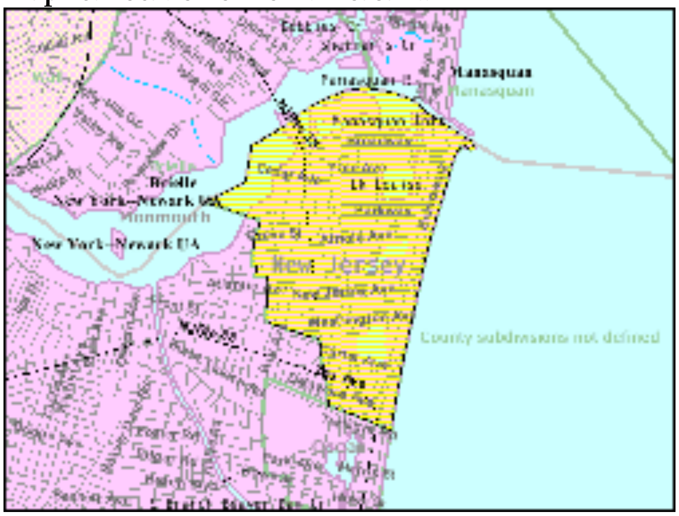
8.3.1 People and Places

Regional orientation

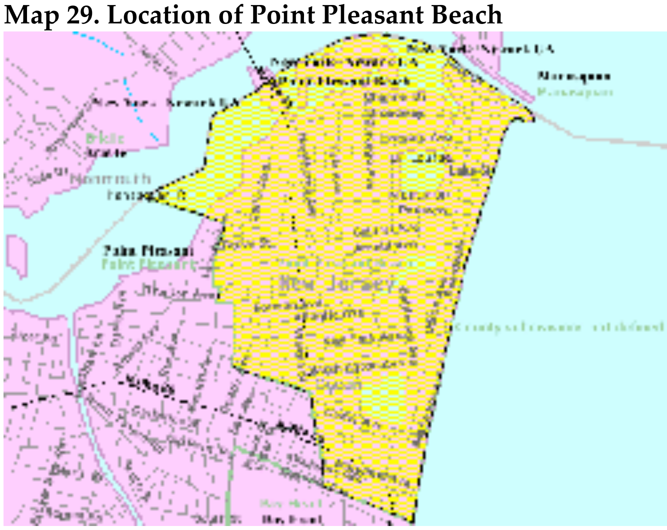
Because of the close relation between Point Pleasant and Point Pleasant Beach with regards to the commercial and recreational fishing industries, they are being considered here as a single community. The community of Point Pleasant, New

Jersey (40.08°N, 74.07°W) encompasses the adjacent boroughs of Point Pleasant and Point Pleasant Beach, and is located in the Ocean County. It is 16 miles from Toms River, NJ, 41.6 miles from Trenton, NJ, and 66.8 miles from New York, NY.

Map 28: Location of Point Pleasant.



Map 29. Location of Point Pleasant Beach



Historical/Background information

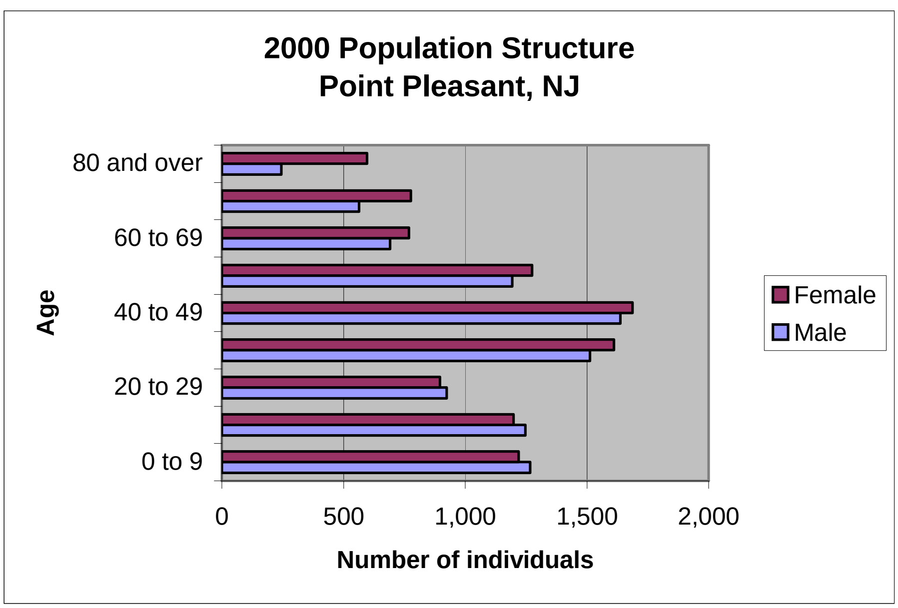
The first community in the Point Pleasant area was called Lovelandtown, and was made up of settlers who fished, clammed, hunted, and otherwise subsisted from bay environment. The first of the Lovelands probably arrived in the 1810s, and were proficient in boat building, fishing, decoy carving, guiding and gunning.[774] Over the years, Point Pleasant has transitioned from an existence as a summer resort town to becoming a family community of about 19,000 year-round residents.[775] Point Pleasant Beach, NJ, located 1.5 miles from Point Pleasant, is known as a destination for recreational fishermen. Some of the most popular areas to fish are the Manasquan Inlet Wall, which produces fish year round as it connects the Atlantic to the Manasquan River, the Manasquan River, and the "Canal" connecting the Manasquan River to the upper Barnegat Bay.[776] Point Pleasant supports a large recreational fishing fleet,[777] and a small commercial fleet targeting fluke, squid, silver and red hake, and scallops (mostly in local waters) and surf clams. Though the surf clam fishery was pioneered here and surf clams continue to be landed, there are no longer any processing plants in Point Pleasant.[778]

Demographic Profile
<u>Point Pleasant</u>

According to Census 2000 data, Point Pleasant had a total population of 19,306, up 6.2% from the reported population in 1990. Of this total in 2000, 50.9% were female and 49.1% were male. The median age was 39.4 years and 73.5% of the population was 21 years or older while 17.2% were 62 or older.

Point Pleasant's age structure showed a preponderance of the 30 to 49 years age group. The age group of 20-29 was smaller compared to the other age groups, showing that apparently young people are leaving the community after high school.

Figure 108: Point Pleasant's population structure by sex in 2000



The majority of the population of Point Pleasant was white (97.8%) with 0.3% of residents Black or African American, 0.1% Native American, 0.5% Asian, and 0% Pacific Islander or Hawaiian. Only 2.4% of the total population was Hispanic/Latino.

Residents linked their heritage to a number of ancestries including: Irish (32.7%), Italian (25.2%), German (21.5%), English (10%), and Polish (10%). With regard to region of birth, 79.7% were born in New Jersey, 16.5% were born in a different state and 3.1% were born outside of the U.S. (including 1.1% who were not United States citizens).

Figure 109: Point Pleasant's Racial Structure in 2000

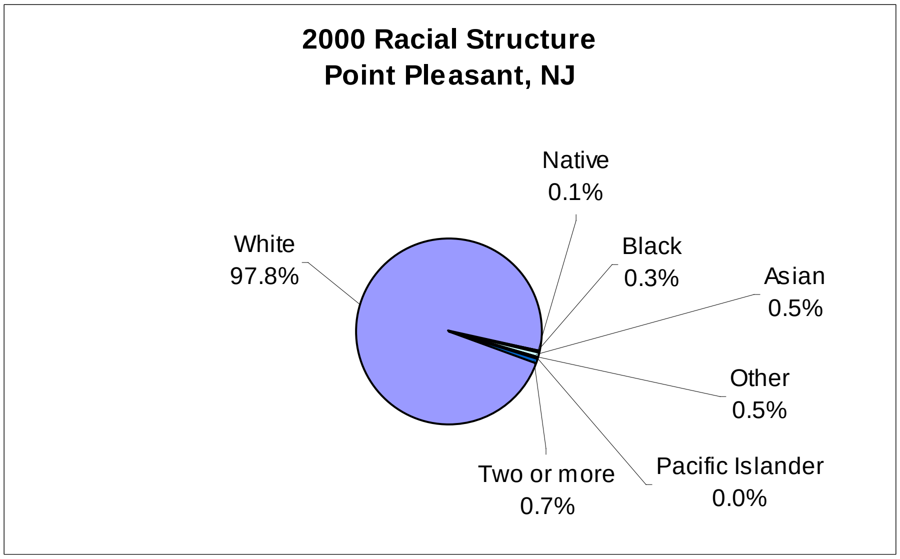
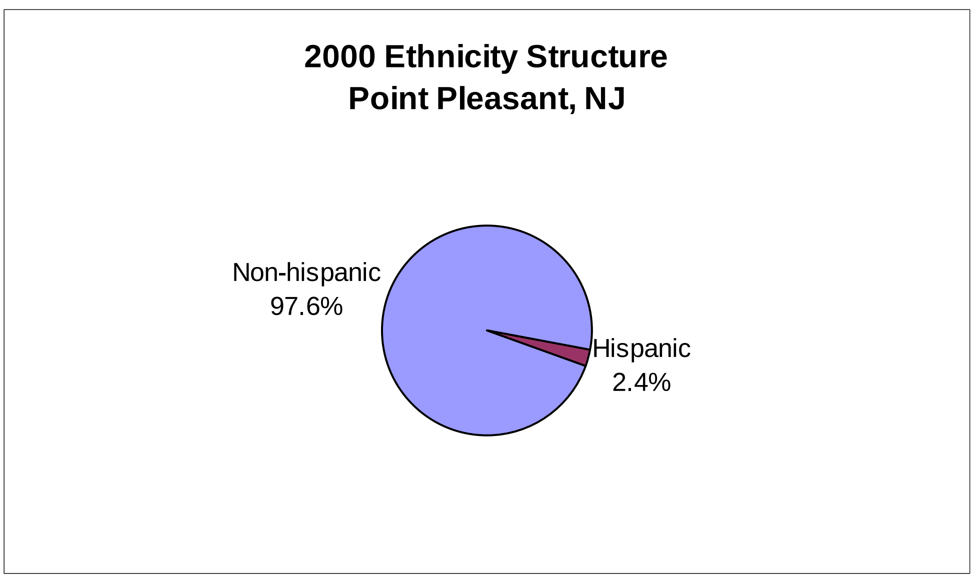


Figure 110: Point Pleasant's Ethnic Structure in 2000



For 94.5% of the population 5 years old and higher in 2000 only English was spoken in the home, leaving 5.5% in homes where a language other than English was spoken, including 0.9% of the population who spoke English less than 'very well'.

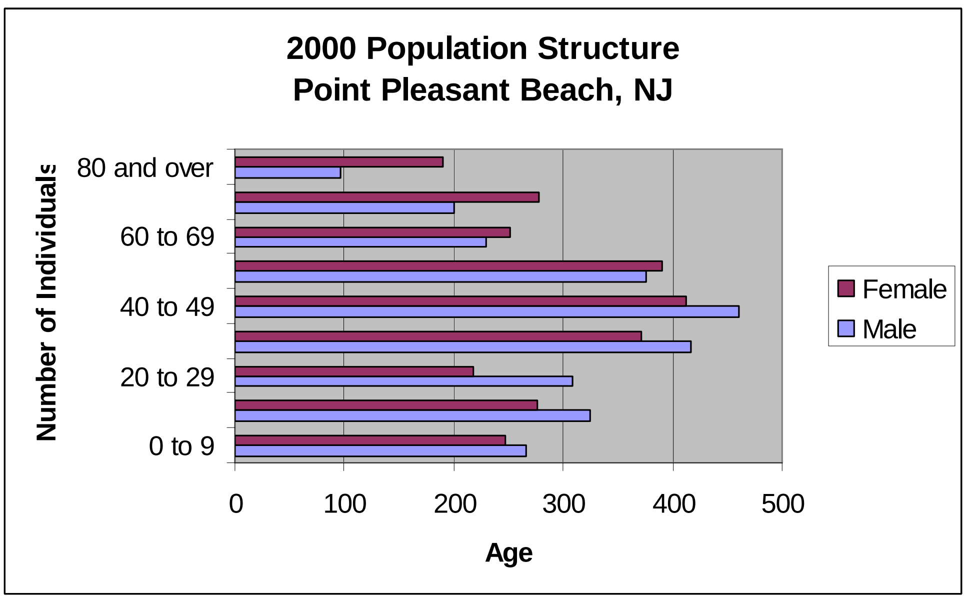
Of the population 25 years and over, 88.5% were high school graduates or higher and 27.8% had a bachelor's degree or higher. Again of the population 25 years and over, 2.6% did not reach ninth grade, 8.8% attended some high school but did not graduate, 34.7% completed high school, 20.2% had some college with no degree, 5.8% received their associate degree, 20.1% earned their bachelor's degree, and 7.7% received either their graduate or professional degree.

Point Pleasant Beach

According to Census 2000 data, Point Pleasant Beach has a total population of 5,314, up 4.0% from 1990.[779] Of this total in 2000, 49.6% were female and 50.4% were male. The median age was 42.6 years and 78.1% of the population was 21 years or older while 21.6% were 62 or older.

Point Pleasant Beach's age structure was similar to that of Point Pleasant in that it showed a preponderance of those in the 30 to 59 year age group, and again like Point Pleasant the age group of 20-29 was small compared to the other age groups, showing that apparently young people are leaving the community after high school. The median age, however, was three years older, and a higher percentage of the population was over 62, indicating that Point Pleasant Beach may be more of a retirement community.

Figure 111: Point Pleasant Beach's population structure by sex in 2000



Like Point Pleasant, the majority of the population of Point Pleasant Beach in 2000 was white (95.9%) with 0.5% of residents Black or African American, 0.3% Native American, 1.0% Asian, and 0% Pacific Islander or Hawaiian. Only 4.4% of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (28.5%), Italian (22.2%), German (19.5%), English (13.8%), and Polish (8.4%). With regard to region of birth, 68.6% were born in New Jersey, 24.7% were born in a different state and 5.8% were born outside of the U.S. (including 3.4% who were not United States citizens).

Figure 112: Point Pleasant's Racial Structure in 2000

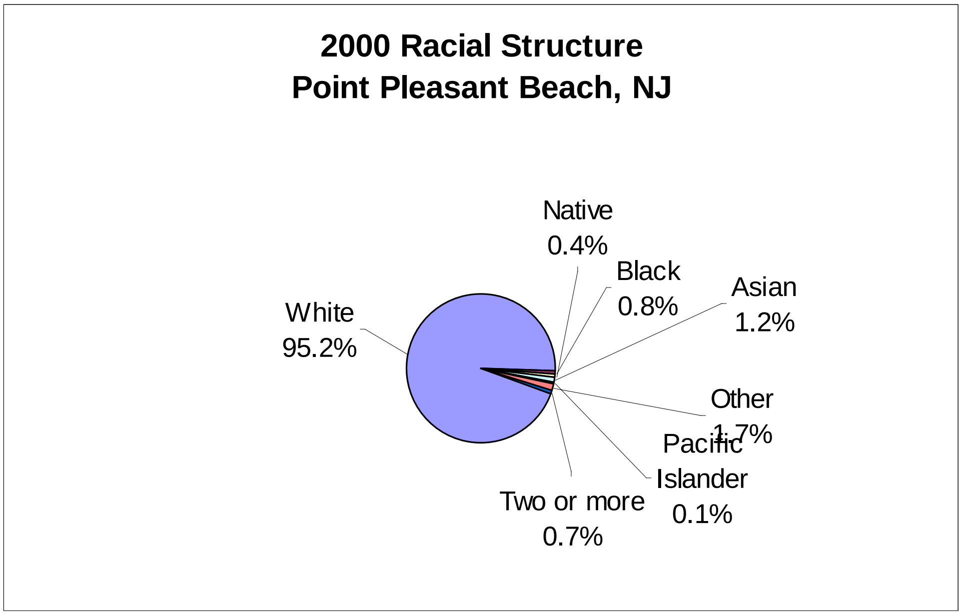
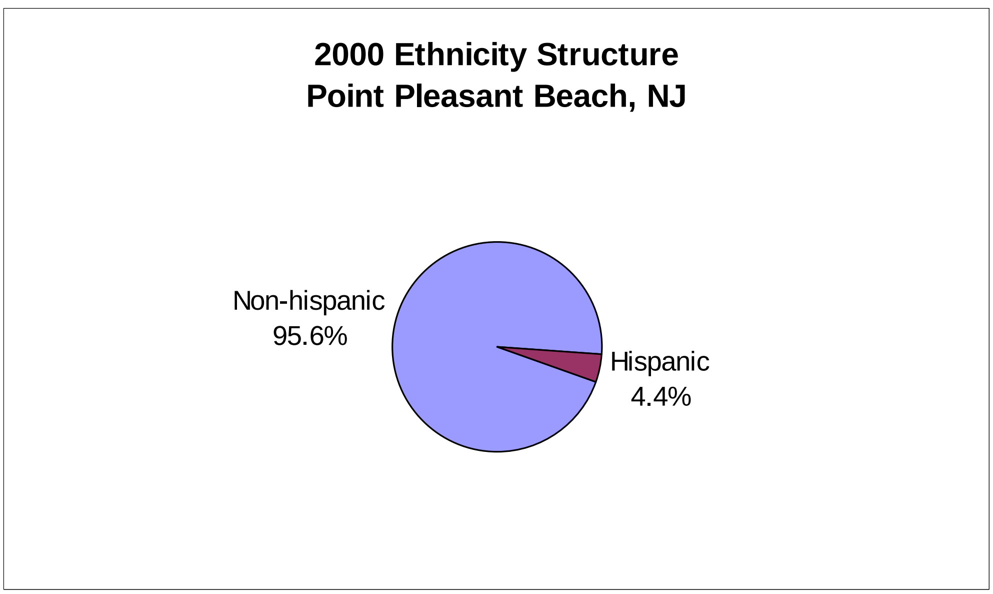


Figure 113: Point Pleasant's Ethnic Structure in 2000



For 90.5% of the population 5 years old and higher in 2000 only English was spoken in the home, leaving 9.5% in homes where a language other than English was spoken, including 3.4% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 87.1% were high school graduates or higher and 34.1% had a bachelor's degree or higher. Again of the population 25 years and over, 3.8% did not reach ninth grade, 9.1% attended some high school but did not graduate, 24.3% completed high school, 21.3% had some college with no degree, 7.5% received

their associate degree, 22.5% earned their bachelor's degree, and 11.6% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Ocean County was Catholic with 33 congregations and 212,482 adherents. Other prominent congregations in the county were Jewish (35 with 11,500 adherents), and The United Methodist Church (28 with 9,534 adherents). The total number of adherents to any religion was up 21.9% from 1990.

Issues/Processes

In 2005 a Virginia company was pushing to open the waters off New Jersey for pursuing menhaden with seine nets, an idea to which recreational fishermen are strongly opposed. Menhaden are a favorite bait fish for striped bass fishermen, and menhaden are also an important food source for striped bass.[780]

There were also been discussions in 2004 about further limiting the catch of certain recreationally targeted species, including striped bass[781] and winter flounder, greatly concerning those involved in the recreational fishing business, whether as party boat captains or bait sellers. The Recreational Fishing Alliance has played a large role in lobbying the Atlantic States Marine Fisheries Commission and the State to minimize restrictions for the economic health of the recreational fishery.[782]

Cultural attributes

Festival of the Sea is an event held every September since 1975, where area restaurants present local seafood dishes.[783] The Greater Point Pleasant Charter Boat Association holds the yearly two-day Mako Mania, considered by many to be the premier shark-fishing tournament in New Jersey.[784]

8.3.2 Infrastructure

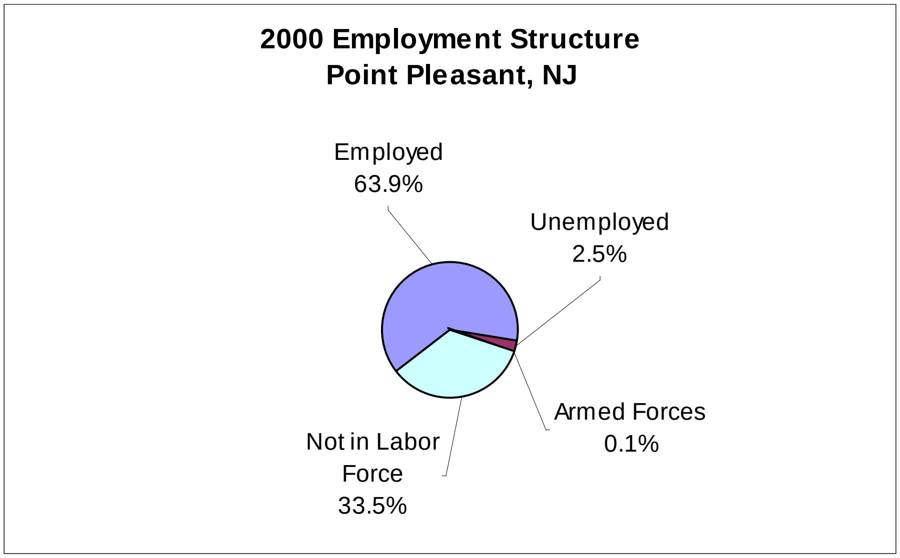
Current Economy

The majority of the docks, bait and tackle shops, and other infrastructure for the commercial fishing industry are located in Point Pleasant Beach. However, because real estate is likely to be much more expensive within the borough of Point Pleasant Beach, the majority of fishermen are likely to live in the borough of Point Pleasant. Point Pleasant, located along the Manasquan Inlet, is also in itself an important destination for recreational fishing, with numerous boats docked in Point Pleasant along the river.

Point Pleasant

According to the U.S. Census 2000, 66.5% (10,113 individuals) of the total population 16 years of age and over were in the labor force, of which 2.5% were unemployed and 0.1% were in the Armed Forces.

Figure 114: Point Pleasant's employment structure in 2000 (U.S. Census 2000)



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 31 positions or 0.3% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 619 positions or 6.4% of jobs. Educational health and social services (23.4%), retail trade (12.4%), construction (10.9%), professional, scientific, management, administrative and waste management services (9.3%), arts, entertainment, recreation, accommodation and food services (8.2%), and finance, insurance, real estate and rental and leasing (7%) were the primary industries.

Median household income in Point Pleasant was $55,987 (up 27.1% from 1990) and median per capita income was $25,715. For full-time year round workers, men made approximately 54.5% more per year than women.

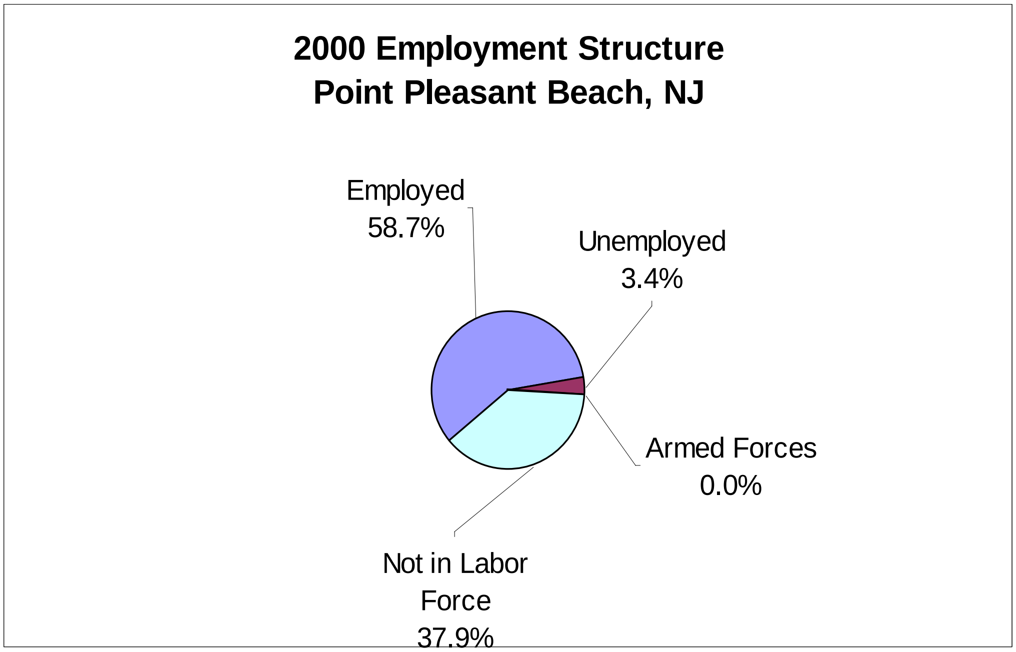
The average family in Point Pleasant consisted of 3.06 persons. With respect to poverty, 2% of families (up from 1.6% in 1990) and 3.2% of individuals earned below the official US Government poverty line, while 15.9% of families in 2000 earned less than $35,000 per year.

In 2000, Point Pleasant had a total of 8,350 housing units of which 90.5% were occupied and 83.1% were detached one unit homes. Only 8% of these homes were built before 1940. Mobile homes/vans/boats accounted for 0% of the total housing units; 92.2% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $160,100. Of vacant housing units, 63.4% were used for seasonal, recreational, or occasional use. Of occupied units 20.2% were renter occupied.

Point Pleasant Beach

According to the U.S. Census 2000, 58.7% (2,617 individuals) of the total population 16 years of age and over were in the labor force, of which 3.1% were unemployed and 0.0% were in the Armed Forces.

Figure 115: Point Pleasant Beach's employment structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 65 positions or 2.6% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 104 positions or 4.4% of jobs. Educational health and social services (19.2%), arts, entertainment, recreation, accommodation and food services (14.6%), retail trade (11.8%), public administration (10.2%), professional, scientific, management, administrative and waste management services (9.4%), and finance, insurance, real estate and rental and leasing (7.2%) were the primary industries.

Median household income in Point Pleasant Beach was $51,105 (up 48.9% from $34,799 in 1990) and median per capita income was $27,853. For full-time year round workers, men made approximately 8.0% more per year than women (significantly different than in Point Pleasant).

The average family in Point Pleasant Beach consisted of 2.96 persons. With respect to poverty, 5% of families (up from 1.6% in 1990) and 6.1% of individuals earned below the official US Government poverty line, while 18.3% of families in 2000 earned less than $35,000 per year.

In 2000, Point Pleasant Beach had a total of 3,558 housing units, of which 65.1% were occupied and 68.5% were detached one unit homes. A total of 28.4% of these homes were built before 1940. Mobile homes/vans/boats accounted for 0% of the total housing units; 83.9% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $223,600. Of vacant housing units, 76.2% were used for seasonal, recreational, or occasional use. Of occupied units 37.1% were renter occupied.

Much of the economy of Point Pleasant and Point Pleasant Beach is based on tourism, and a substantial segment of the tourist population travel to this area to fish. Even during the winter, Point Pleasant will sometimes maintain some tourism during years when fish are more plentiful during the winter months.[785] The largest employers in Point Pleasant Beach are mostly related to the tourist industry: Jenkinson's Beach and Boardwalk (with a beach, amusement rides, aquarium, night club, and restaurants), Meridian Health Center, Food Town, Chef's International (restaurant chain), and motels.[786] The most significant sources of employment in Point Pleasant, by contrast, are banks and car dealerships.[787]

Governmental

The City of Point Pleasant operates under the Council/Manager form of government. There are six members of Council, in addition to the Mayor. The Mayor has a four-year term, and the Council has staggered three-year terms.[788]

<u>Fishery involvement in government</u>

No information has been found from secondary sources at this time on fishery involvement in government.

Institutional

<u>Fishing associations</u>

The Fishermen's Dock Cooperative on Channel Drive in Point Pleasant Beach is one of two active fishing cooperatives in New Jersey. Incorporated as a cooperative in the early 1950s, the "Co-op" is an integral part of the waterfront community of Point Pleasant Beach. The Co-op markets its members' catch, and offers them fuel, packing, and ice at a discounted rate. Becoming a member of the Co-op is difficult; it requires a vacancy and proof of being an able fishermen, as well as the purchase of a share in the Co-op.[789] Many existing members of the Co-op are the sons of the original founders, and some are third or fourth generation fishermen.[790]

Garden State Seafood Association in Trenton is a statewide organization of commercial fishermen and fishing companies, related businesses and individuals working in common cause to promote the interests of the commercial fishing industry and seafood consumers in New Jersey.[791]

Fishery assistance centers

No information from secondary sources has been obtained at this time on fishery assistance centers.

Other fishing related institutions

The Greater Point Pleasant Charter Boat Association in Township was formed in 1981. Its goals are "A) to enhance the recreational fishing industry on the Manasquan River, B) to aid in the improvement of the coastal fishery and collectively voice concerns on marine conservation and environmental issues".[792]

The Manasquan River Watershed Association is a non-profit organization focused on protecting and restoring the Manasquan River through public education, restoration, and regional planning initiatives.[793]

Physical

Point Pleasant is within easy reach of Newark Airport and Port Newark/Elizabeth and only a bridge crossing away from both New York and Philadelphia.[794] Because of its large recreational fishing component, there are many bait and tackle stores in town.[795, 796]

8.3.3 Involvement in Northeast Fisheries

Commercial

The fleet of the Fishermen's Dock Co-op is comprised mostly of smaller draggers, up to about 80 feet in length. They fish mostly in the New York Bight, in mixed trawl fisheries. "They primarily target fluke, silver hake and squid but in the past have also had significant landings of winter flounder, bluefish, monkfish and scallop. While most of the Co-op member's harvest is sold to wholesale markets in the Mid-Atlantic States and Southern New England, a significant amount makes its way directly to consumers via the seafood market and restaurant adjacent to the dock."[797] Members of the Co-op recently got together to raise $1 million for necessary repairs to their dock.[798]

The development of the shellfishery here has been very important to maintaining a commercial fishing industry in Point Pleasant. Point Pleasant Beach was listed as the eighth largest commercial fishing port on the East Coast in 2003. The top three landed species by value in Point Pleasant for 2003 were: ocean quahog ($7,929,464), surf clam ($4,826,702), and sea scallop ($4,327,226). The values of the sea scallop fishery and the combined ocean quahog and surf clam fisheries were much higher in 2003 than the 8-year average. Other fisheries have declined in both the commercial and recreational sectors resulting from both a decrease in catches and an increase in regulation, and facilities previously used for processing finfish are now used for offloading and trucking quahogs and surf clams. The ocean quahogs and scallops as well as most of the surf clams are trucked away elsewhere for shucking, as Point Pleasant no longer has a processing plant here with the exception of a small facility where some surf clams are shucked by hand. Otter trawls and gillnetting continue to be important for this fleet as well, and other important species include monkfish, *Loligo* squid, and summer flounder.[799] Despite declining catches in some areas, the overall value of this fishery increased for both home-ported vessels and the value of landings brought into Point Pleasant from 1997-2003.

Landings by Species

Table 61: Dollar value by Federally Managed Groups of landings in Point Pleasant

	Average from 1997-2004	2003 only
Surf Clams, Ocean Quahogs	8,344,537	12,756,166
Scallop	2,599,891	4,327,226
Monkfish	1,648,313	1,299,920
Summer Flounder, Scup, Black Sea Bass	1,374,423	2,381,773
Lobster	678,319	414,007
Squid, Mackerel, Butterfish	562,825	289,133
Largemesh goundfish	305,682	423,301
Smallmesh groundfish	290,207	47,867
Dogfish	166,111	0
Bluefish	93,333	75,439
Skate	35,779	40,014
Tilefish	271	165
Other	776,393	794,550

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Vessels by Year

Table 62: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	59	18	5,833,943	16,905,177
1998	53	15	7,794,779	16,712,151
1999	56	16	9,938,174	17,862,091
2000	63	18	9,082,901	17,769,138
2001	65	19	7,493,107	18,924,389

2002	65	20	8,055,053	19,655,021
2003	58	22	10,061,787	22,849,561

Recreational

Point Pleasant is the most important community in New Jersey for recreational fishing. Fishermen travel from all over the state and beyond to fish from the numerous party and charter boats, from their own private recreational boats, or to participate in surf-fishing from several key spots. The New Jersey Department of Environmental Protection, Division of Fish and Wildlife, which licenses party and charter boats, lists 29 for Point Pleasant and Point Pleasant Beach,[800] but in some cases fishermen may own a charter license but rarely if ever use their boat for charter trips.[801] There are at least 18 charter boats listed as members of the Greater Point Pleasant Charter Boat Association.[802] Between 2001- 2005, there were 40 charter and party vessels making 8,032 total trips registered in NMFS logbook data by charter and party vessels in Point Pleasant carrying a total of 161,601 anglers.

Subsistence

Some owners of charter and party boats claim that before the bag limits for recreational fishing were increased, many of their clientele were coming fishing primarily as a means of consumption rather than sport, but that the clientele has shifted to represent more tourists fishing for the fun of it.[803]

Future

No information has been obtained at this time from secondary sources on future plans or people's perception of the future in Point Pleasant.

8.4 BELFORD-MIDDLETON, NJ

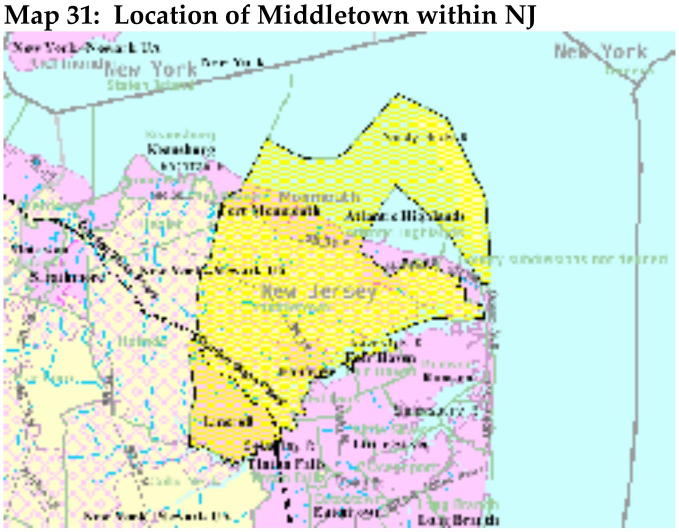
8.4.1 People and Places

Regional orientation

The community of Belford, New Jersey (40.42° N, 74.09°W) is located on the Bayshore in the township of Middletown, in Monmouth County. Belford lies along Sandy Hook Bay (part of the Raritan Bay complex), and occupies 1.3 square miles of land.[804] Belford is one of about a dozen villages within the township of Middletown and is governed by Middletown.[805]

Map 30: Location of Belford within NJ

Map 31: Location of Middletown within NJ



Historical/Background information

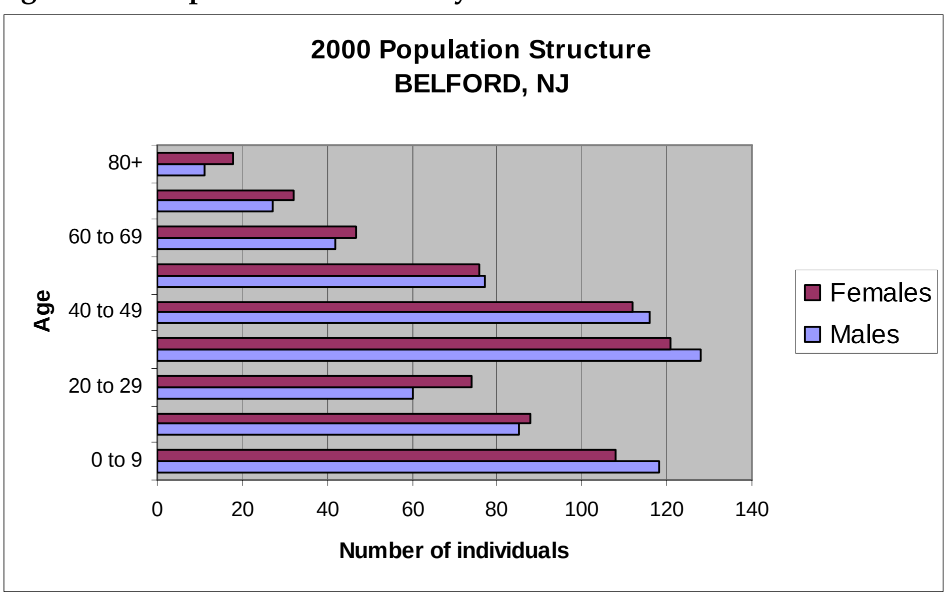
Fishing has been a long tradition in this area; the Lenni Lenape Indians fished in the bay here before white settlers arrived and the Dutch were fishing here in the 1600s.[806] Belford is part of the township of Middletown, which was first established as a township in 1664.[807] Middletown has 12 distinct villages, including North Monmouth, Port Monmouth, Belford, and Leonardo.[808] The area known today as Belford, along with what is now Port Monmouth, was originally known as Shoal Harbor. Shoal Harbor was relatively isolated until the mid-1800s when the construction of a road here as well as a nearby railroad opened this area up allowing farmers and fishermen to sell their wares in New York City and other areas.[809] Belford was officially established in 1891 when a rail station was built here, separating from Port Monmouth.[810] A menhaden processing plant was built in Belford in the late 1800s, which operated until 1982[811]; this was once the town's largest employer.[812] The presence and stench of the menhaden plant helped maintain Belford as a relatively unchanged fishing port while the rest of the shore around it was subject to intense development and tourism. Belford has notoriously been home to pirates, blockaders, rum runners, and even through the 1980s, fish poachers.[813] There is a long tradition among some Belford fishermen of not obeying fisheries regulations.[814] Some consider Belford to be the longest continuously operating fishing village on the East Coast.[815]

Demographics

Belford CDP

According to Census 2000 data, Belford had a total population of 1,340; 1990 population data was unavailable for Belford for comparison. Of this total in 2000, 50.4% were female and 49.6% were male. The median age was 35.8 years and 69.6% of the population was 21 years or older while 11.8% were 62 or older.
The population structure for Belford indicates that this is a community of young families. The largest percentages of residents were between 30-39 and 40-49 years of age. There were also a large number of children between the ages of 0-9, and a significant decline in the number of residents over the age of 60. Like many fishing communities, Belford's population showed a dip in the number of residents between the ages of 20-29 and even in the 10-19 age bracket, as young people left to go to school or in search of jobs. This is more prevalent for males than for females for the 20-29 age bracket.

Figure 116: Population structure by sex in 2000



The majority of the population of Belford in 2000 was white (97.2%), with 0.3% of residents Black or African American, 0.4% Native American, 0.7% Asian, and 0.1% of residents listed as Pacific Islander or Hawaiian. Only 4.7% of the total population was

Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (44.0%), Italian (38.2%) German (23.6%), and Polish (8.6%). With regard to region of birth, 63.2% were born in New Jersey, 32.3% were born in a different state and 2.7% were born outside of the U.S. (including 0.4% who were not United States citizens).

Figure 117: Racial Structure in 2000

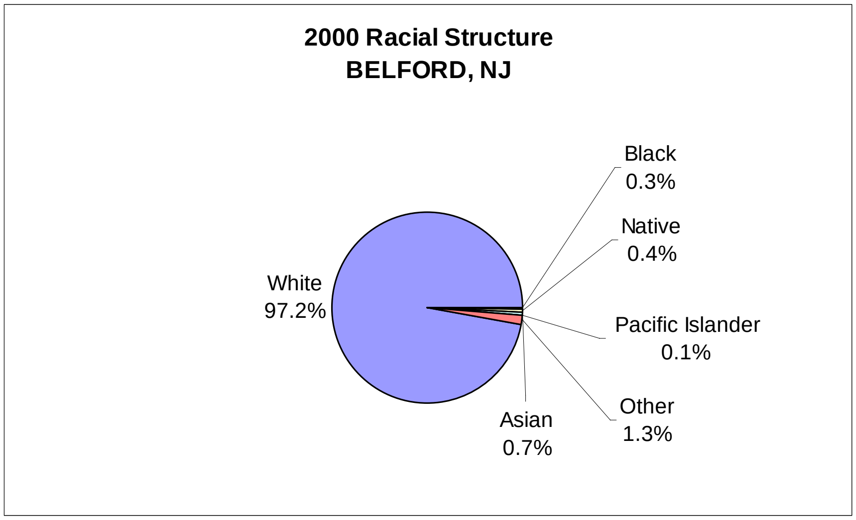
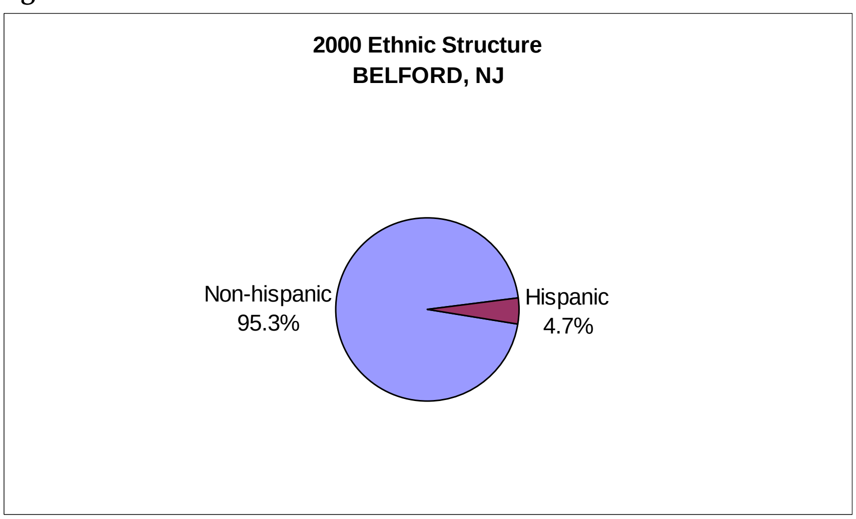


Figure 118: Ethnic Structure in 2000



For 90.0% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 10.0% in homes where a language other than English was spoken, and including 3.0% of the population who spoke English less than 'very well'.

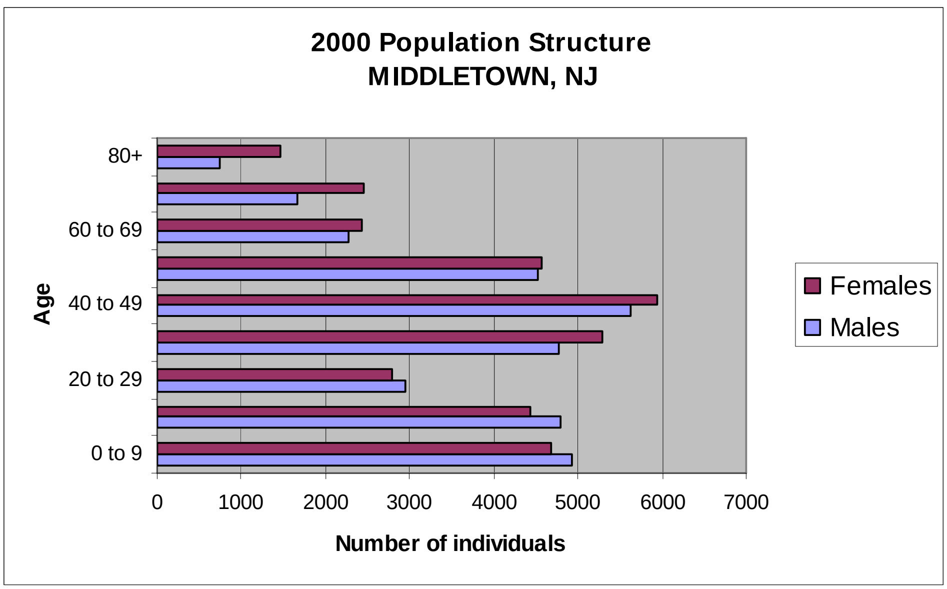
Of the population 25 years and over, 89.7% were high school graduates or higher and 16.8% had a bachelor's degree or higher. Again of the population 25 years and over, 1.0% did not reach ninth grade, 9.3% attended some high school but did not graduate, 41.6% completed high school, 24.3% had some college with no degree, 7.0% received their associate degree, 13.3% earned their bachelor's degree, and 3.4% received either their graduate or professional degree.

Middletown

According to Census 2000 data, Middletown township had a total population of 66,327, down 2.7% from 1990. Of this total in 2000, 51.4% were female and 48.6% were male. The median age was 38.8 years and 70.8% of the population was 21 years or older while 15.0% were 62 or older.

The population structure for Middletown indicates that this is a community of young families. The largest percentages of residents are between 40-49 years and 30-39 years of age. There are also a large number of children between the ages of 0-19, and a significant decline in the number of residents over the age of 60. Like many communities, Middletown's population has a dip in the number of residents between the ages of 20-29, as young people leave to go to school or in search of jobs.

Figure 119: Population structure by sex in 2000



The majority of the population of Middletown in 2000 was white (94.6%), with 1.4% of residents Black or African American, 0.2% Native American, 2.9% Asian, and 0.1% of residents listed as Pacific Islander or Hawaiian. Only 3.4% of the total population wass Hispanic/Latino. Residents linked their heritage to a number of ancestries including: Irish (32.9%), Italian (28.9%), German (17.4%), English (8.8%), and Polish (8.7%). With regard to region of birth, 58.7% were born in New Jersey, 34.1% were born in a different state and 6.4% were born outside of the U.S. (including 2.5% who were not United States citizens).

Figure 120: Racial Structure in 2000

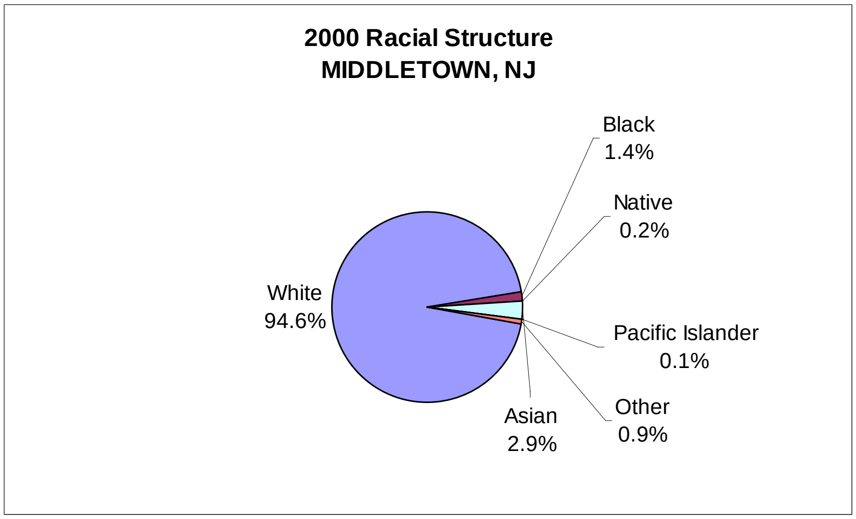
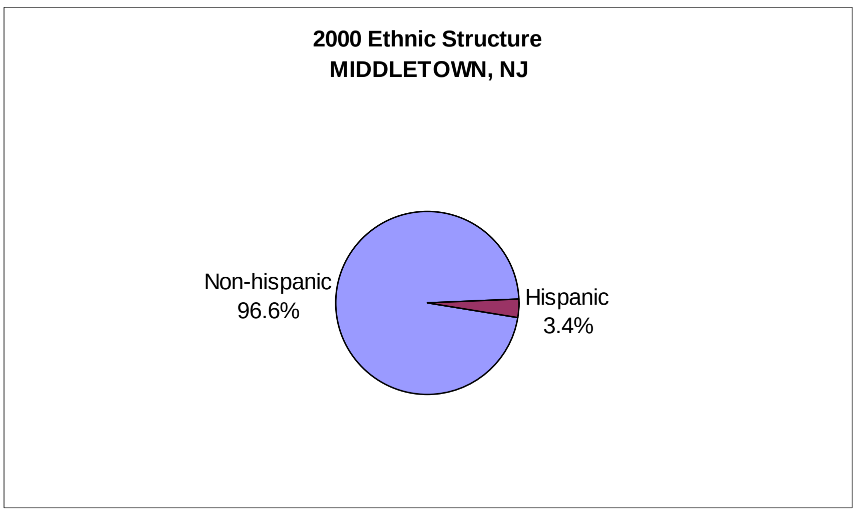


Figure 121: Ethnic Structure in 2000



For 91.1% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 8.9% in homes where a language other than English was spoken, and including 2.3% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 90.7% were high school graduates or higher and 35.0% had a bachelor's degree or higher. Again of the population 25 years and over, 2.7% did not reach ninth grade, 6.5% attended some high school but did not graduate, 29.2% completed high school, 19.7% had some college with no degree, 6.9% received their associate degree, 22.4% earned their bachelor's degree, and 12.6% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Monmouth County was Catholic with 50 congregations and 289,183 adherents. Other prominent congregations in the county were Jewish (42 with 65,000 adherents), United Methodist 47 with 12,992 adherents), and Muslim (5 with 9,455 adherents). The total number of adherents to any religion increased 38.9% from 1990 to 2000.

Issues/Processes

The promised clam depuration plant and renovation of the cooperative and other fishing infrastructure in Belford, which may be of great benefit to the fishing community here, have been continuously postponed, and fishermen are concerned that condominiums will be built on the property instead. The project was being headed by the Bayshore Economic Development Corporation, which later became surrounded with controversy and had some of its state funding cut off.[816] As Belford becomes more accessible to commuters to New York City and elsewhere, and as housing is increasingly scarce around the city, many people are moving to Belford and forcing up the price of homes. The resulting increase in property taxes may force some residents who have lived in Belford their entire lives to relocate.[817] Belford represents some of the last untouched waterfront real estate in New Jersey within commuting distance to New Jersey, and development pressures here are increasing.[818] There is frequently conflict between menhaden purse seine vessels from Belford and recreational fishermen, who criticize the vessels for catching large amounts of oysters and sport fish species along with the menhaden. For this and other reasons, there is frequently animosity between recreational and commercial fishermen. [819]

Cultural attributes

The site of the Belford Fisherman's Co-op has an interpretive exhibit about the commercial fishing industry here.[820] Monmouth County wishes to promote the co-op as a regional tourist attraction.[821] The Leonardo Party and Pleasure Boatman's Association hosts fishing tournaments out of the Leonardo State Marina.[822]

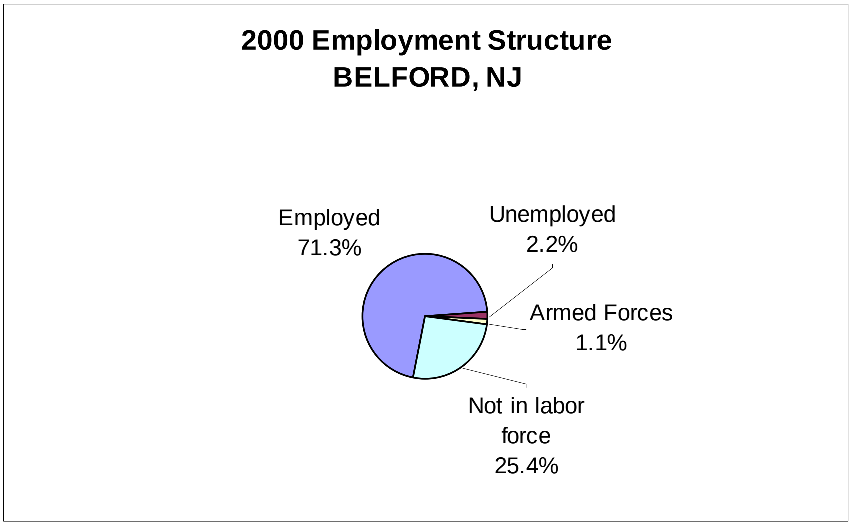
8.4.2 Infrastructure

Current Economy

Belford CDP

According to the U.S. Census 2000, 76.4% (799 individuals) of the total population 16 years of age and over were in the labor force, of which 2.2% were unemployed and 1.1% were in the Armed Forces.

Figure 122: Employment Structure in 2000



According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 17 positions or 2.3% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 46 positions or 6.2 % of jobs. Construction (17.5%), educational, health, and social services (16.5%), professional, scientific, management, administrative, and waste management services (12.8%), and manufacturing (8.9%) were the primary industries.

Median household income in Belford in 2000 was $66,964 (1990 population data was unavailable for Belford) and per capita income was $25,412. For full-time year round workers, men made approximately 47.9% more per year than women.

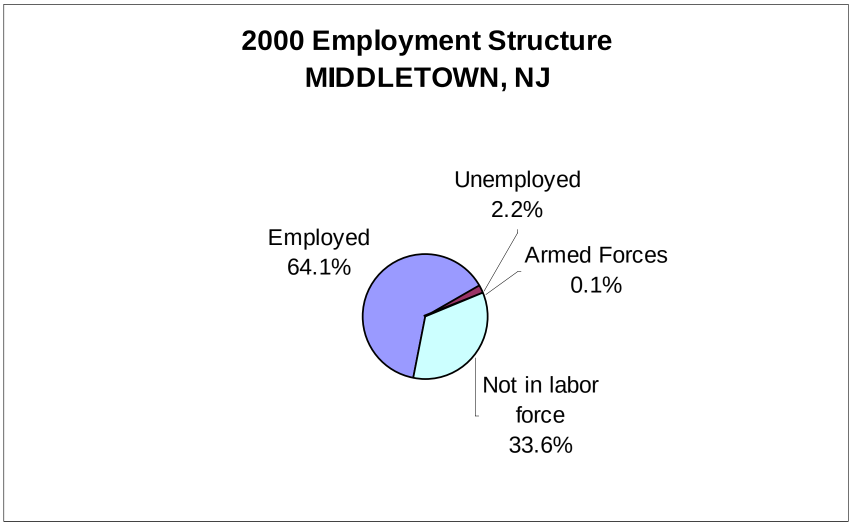
The average family in Belford consisted of 3.29 persons. With respect to poverty, 1.3% of families (1990 population data was unavailable for Belford) and 3.2% of individuals earned below the official US Government poverty line, while 14.4% of families in 2000 earned less than $35,000 per year.

In 2000, Belford had a total of 548 housing units, of which 95.2% were occupied and 94.2% were detached one unit homes. More than one-third (35.9%) of these homes were built before 1940. No mobile homes, boats, RVs, vans, etc. were found for Belford; 96.4% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $146,000. Of vacant housing units, 4.5% were used for seasonal, recreational, or occasional use, while of occupied units 13.5% were renter occupied.

Middletown

According to the U.S. Census 2000, 66.4% (33,789 individuals) of the total population 16 years of age and over were in the labor force, of which 2.2% were unemployed and 0.1% were in the Armed Forces.

Figure 123: Employment Structure in 2000



According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 95 positions or 0.3% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 1,587 positions or 4.9 % of jobs. Educational, health, and social services (18.6%), finance, insurance, real estate, and rental and leasing (13.4%), professional, scientific, management, administrative, and waste management services (12.6%), and retail (12.0%) were the primary industries.

Median household income in Middletown in 2000 was $75,566 (up 38.6% from $54,503 in 1990[823]) and per capita income was $34,196. For full-time year round workers, men made approximately 67.7% more per year than women.

The average family in Middletown consisted of 3.27 persons. With respect to poverty, 1.9% of families (similar to 1.8% in 1990[824]) and 3.1% of individuals earned below the official US Government poverty line, while 11.3% of families in 2000 earned less than $35,000 per year.

In 2000, Middletown had a total of 23,841 housing units, of which 97.5% were occupied and 80.6% were detached one unit homes. Just over ten percent (12.1%) of these homes were built before 1940. Mobile homes, boats, RVs, vans, etc. accounted for 0.1% of housing; 80.0% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $210,700. Of vacant housing units, 12.3% were used for seasonal, recreational, or occasional use, while of occupied units 13.6% were renter occupied.

The largest employers in the township of Middletown are the following: AT&T (3,300+ employees[825]), Food Circus Supermarkets, Inc. (1,263 employees), Brookdale Community

College (737 employees), and T&M Associates (200 employees). There are many other large employers throughout Monmouth County where Middletown residents are likely to be employed.[826] Additionally, many of Middletown's residents commute to work in New York City.[827]

Governmental

Middletown is governed by a five-member township committee, which includes the mayor, who is designated for one year by the other members. Each committee member serves a three-year term. Belford is one of about a dozen villages within the township of Middletown.[828]

Fisheries involvement in government

In 2006 the Town of Middletown was awarded a $75,000 Smart Future planning grant from the state to study ways to improve the economic vitality of the fishing industry in Belford.[829]

Institutional

Fishing associations

"Belford is believed to have the oldest continually operating fishing cooperative on the east coast. It was founded in 1953… The Belford Seafood Cooperative handles members' catches, purchases fish from non-members, arranges for the sale and transportation of the fish, and leases a lot of the docks to the fishermen." [830]

Fishing assistance centers

No information has been obtained through secondary data sources at this time on fishing assistance centers for Belford.

Other fishing related institutions

The Leonardo Party and Pleasure Boatman's Association hosts fishing tournaments.[831] The NY/NJ Baykeeper is working to protect and preserve the Hudson/Raritan Estuary for the benefit of both natural and human communities.[832] The organization worked unsuccessfully in conjunction with the Belford fishermen in an attempt to prevent the construction of the New York City ferry dock in Belford.

Physical

Belford is located within the shelter of Sandy Hook.[833] The Belford Seafood Cooperative "includes the Pirate's Cove Restaurant and retail fish establishments, as well as a net house, the dock, and the boats. There is also a wholesale and retail lobster facility nearby called Shoal Harbor Lobster. The co-op is on Compton's Creek, which runs directly into Raritan Bay. A relatively new wastewater facility and a brand-new ferry terminal share the creek with the fishermen." When the New York City ferry was put into place in Compton Creek, the creek was widened and more bulkheads were put in, providing more docking space for fishing vessels.[834] The town of Middletown has at least three marinas and a boat ramp. Bayshore Waterfront Park has a fishing pier and a marina.[835] The Leonardo State Marina, located in the village of Leonardo, has 179 berths, a bait and tackle shop, fuel, and a boat ramp. There are both charter and party boats found here.[836]

The township of Middletown has a NJ Transit rail station and several NJ transit bus stops. Route 36 runs through Belford, and the Garden State Parkway and Route 35 run through Middletown.[837] Belford is about 30 miles from Point Pleasant, 35 miles from Newark, and about 44 miles from New York City. The nearest airport is Newark Liberty International Airport. In 2002 ferry service between Belford and Pier 11 in Manhattan began operation. There are 500 parking spaces available at the Belford Ferry terminal. The commute takes about 40 minutes.[838]

8.4.3 <u>Involvement in Northeast Fisheries</u>

Commercial

Belford is listed as one of the six major commercial fishing ports in the state of New Jersey.[839] Belford has a tradition of fishing for menhaden that dates back to the 1800s, when a processing plant was constructed here. Although the plant is no longer in existence, today menhaden are still pursued from Belford with trawlers fitted with purse seines.[840] Menhaden have experienced a resurgence recently (2006), primarily for use as bait.[841] The commercial fishing activity is based out of Compton Creek. Commercial catches all go through the Belford Seafood Cooperative, which sells most of its product to Fulton Fish Market and to other markets along the East Coast. There are about 20-30 vessels associated with the Co-op, including about 14-15 draggers, about 12 lobster boats, and a number of crabbing boats. There are about 40 vessels in total located in Belford. Much of the fishing here is done less than a mile from shore; this is primarily a baymen's port. Shoal Harbor Lobster, also located in Belford, is an independent wholesaler; the lobsters sold here come from many different places.[842] They provide all lobsters sold in A&P Supermarkets in New Jersey and Long Island.[843] Shoal Harbor sells some lobsters from local vessels; they used to have their own boats but they sold them. There are 4 employees at this business.[844]

The data reaffirm that most fishing in Middletown takes place from Belford itself. The number of vessels listed for Belford is relatively consistent, with a high of 36 in 2004. The level of landings and the value of home port fishing, while somewhat variable, displayed a relatively steady trend, with 2005 being the most valuable year in both categories. In 2005 landings in Belford brought in over $3.5 million. For each year, the level of home port fishing is just slightly less than the level of landings for Belford, which likely indicates that almost every vessel landing its catch in Belford is also home ported here. In 2003 the most valuable species landed in Belford was summer flounder (worth $1,165,436), followed by winter flounder ($259,551) – listed below within the large mesh groundfish category, and scup ($161,271). Overall, the value of the summer flounder, scup, and black sea bass was higher in 2003 than the 1997-2006 average values, but most other landings categories were less than the average values in 2003. In particular, lobster landings seem to have experienced a large decline in 2003.

Middletown had a very small level of landings in 2003 ($1,873), all of which was summer flounder. Most years saw few if any landings listed for Middletown; 2005 however had more than $10,000 in landings here. In only one year, 2001, were there any landings attributed to home ported vessels in Middletown, in no year from 1997-2005 were there more than three vessels home ported here. There are, however, from 5-11 vessels with owners living in Middletown, with the high of 11 in 2005. This indicates that many of the vessels fishing out of Middletown have owners living elsewhere within the township.

Landings by Species

Table 63. Dollar value of Federally Managed Groups of landing in Belford

BELFORD	Average from 1997-2006	2003 only
Sumer flounder, Scup, Black Sea Bass	949,161	1,348,597
Lobster	342,225	8,176
Largemesh groundfish	240,329	278,728
Squid, Mackerel, Butterfish	176,819	99,987
Smallmesh groundfsh	117,915	57,317
Surf Clams, Ocean Quahogs	68,532	88,295
Bluefish	53,582	66,834
Monkfish	32,255	18,411
Dogfish	24,571	0
Skate	13,948	8,203
Scallop	5,922	0
Herring	459	138
Tilefish	128	225
Other	428,601	224,161

.

Table 64. Dollar value of Federally Managed Groups of landing in Middletown

MIDDLETOWN	Average from 1997-2006	2003 only
Summer flounder, Scup, Black Sea Bass	1,828	1,873
Other	130	0

Tilefish	86	0

Vessels by Year

Table 65: All columns represent vessel permits or landings value combined between 1997-2005 for Belford

BELFORD Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	36	15	3,052,183	2,471,414
1998	31	14	2,834,484	2,895,386
1999	31	14	3,005,290	3,001,243
2000	35	15	2,506,481	2,576,257
2001	33	15	2,284,268	2,389,588
2002	33	14	1,830,612	2,389,009
2003	35	18	2,069,945	2,199,072
2004	36	19	2,713,595	2,829,252
2005	33	16	3,341,873	3,525,737

Table 66: All columns represent vessel permits or landings value combined between 1997-2005 for Middletown

MIDDLETOWN Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)*	Level of fishing landed port ($)
1997	0	5		0
1998	0	6		0
1999	0	5		0
2000	1	6		2,140
2001	3	6		759
2002	2	7		1,216
2003	2	10		1,873
2004	3	11		3,291
2005	3	11		10,305

* Only 2001 shows any landings for vessels with a home port of Middletown. Data cannot be shown for reasons of confidentiality.

Recreational

Recreational fishing is important to the Bayshore region; there are a number of bait and tackle shops and marinas located here. However, there is little recreational fishing in Belford itself.[845] Port Monmouth has a fishing pier and marina at Bayshore Waterfront Park.[846] Leonardo State Marina has a bait and tackle shop as well as both charter and party boats which leave from here.[847] The Leonardo Party and Pleasure Boatman's Association hosts fishing tournaments out of the Leonardo State Marina.[848]

Subsistence
No information about subsistence fishing has been obtained through secondary sources at this time.

Future

The Middletown Master Plan recognizes the importance of Belford as a fishing community and expresses a determination to maintain this character. There is a proposed fishing center for Belford called the Bayshore Technology Center, which would include a research and development facility, a fish farming center, and a clam depuration plant. The goals of the technology center would be to create jobs, promote growth in the Bayshore's commercial fishing industry, and secure the future of the Cooperative.[849] There are also plans in the works to refurbish the cooperative itself.[850] These plans have recently been stalled, but the town has just received a grant from the state to begin working on this project itself.[851] The township and county have been making major infrastructure improvements in and around Belford to roads, bridges, etc. in an effort to revitalize the community and to draw people from elsewhere.[852]

The community of Belford, despite its proximity to many large urban centers, had been relatively isolated and underdeveloped. However, recently ferry service began between Belford and New York City, and a large upscale condominium development was built, bringing an influx of people to the community. Fishermen anticipate the community will change a great deal. The town has expressed a desire to maintain fishing here, but commercial fishermen perceive this as referring to only recreational fishing activity. There is concern that the new residents won't like the sight and smell of the fisherman's co-op, and the resulting conflict will harm the fishing industry. Many fishermen believe the proposed construction of a clam depuration plant could boost the industry; currently all clams taken from the bay need to be purified to rid them of pollution, and the depuration plants in nearby communities don't have the capacity to take many clams from Belford.[853]

8.5 ATLANTIC CITY, NJ

8.5.1 People and Places

Regional orientation

Atlantic City (39.364°N, 74.423°W) is located in Atlantic County on Absecon Island, just off the coast of New Jersey. Other resort communities on the island include Ventnor, Margate, and Longport. The island ends at Absecon Inlet to the north and Great Egg Harbor Inlet to the south.[854] Atlantic City is 48 miles north from Cape May, NJ, 41.3 miles south from Barnegat, NJ, and 62.2 miles southeast from Philadelphia, PA.

Map 32: Location of Atlantic City

Historical/Background information

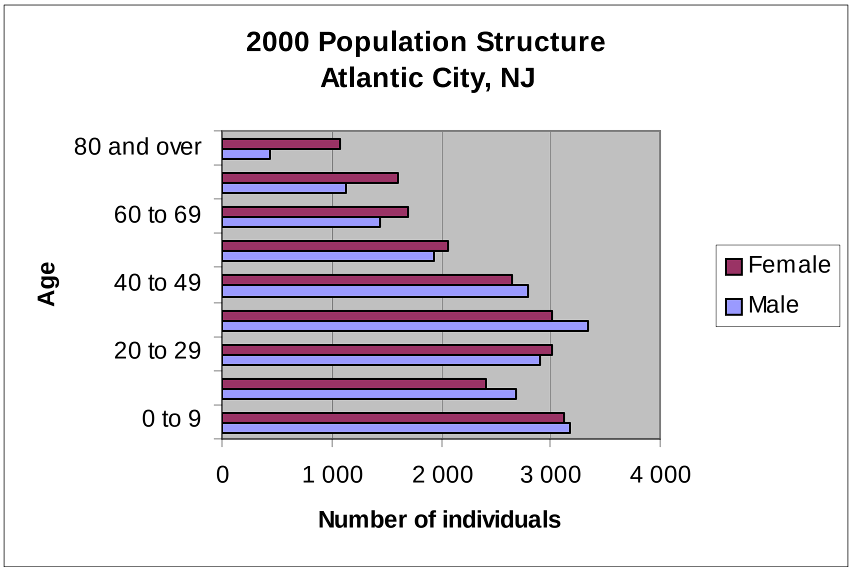
The Lenni-Lenape Indians were the original inhabitants of Absecon Island, though they used it only as a summer campground. While the island was visited often by European settlers and hunters it was not until the late 1700s that the first home was built here by the settlers. As late as 1850, there were only seven permanent dwellings on the island. That changed in 1854, with the completion and opening of the Camden-Atlantic City Railroad. Tourists began to arrive by train, while at the same time Atlantic City was developing into an active seaport. Shortly afterwards, in 1870, the first road into Atlantic City was completed. The resort town of Atlantic City, New Jersey was formally opened with great fanfare on June, 16 1880. The town grew quickly in size and in popularity; prominent doctors and businessmen from Philadelphia and New York built their summer homes here, and along the boardwalk, immense, elaborate hotels and amusement piers began popping up. By 1900, there were over 27,000 residents in Atlantic City, up from 250 just 45 years before. Atlantic City became known for its entertainment, from numerous games and amusements to vaudeville and Hollywood entertainers. [855] In 1921, Atlantic City became the home of the first Miss America pageant, and in 1935, the classic Parker Brothers game Monopoly, set in Atlantic City, was invented.[856] In 1976, the Casino Gambling Referendum was passed[857], and the city quickly became best known for its casinos. Today there are twelve casinos in Atlantic City, many open 24 hours a day, attracting tourists from all over.[858]

Demographic Profile

According to Census 2000 data, Atlantic City had a total population of 40,517, up 6.7% from 1990. Of this total in 2000, 51% were female and 49% were male. The median age was 34.7 years and 70.5% of the population was 21 years or older while 16.5% are 62 or older.

Atlantic City's age structure showed the largest population categories to be children and young people, with the largest groups being 30-39 and 0-9. This seems to imply lots of young families.

Figure 124: Atlantic City's population structure by sex in 2000



The majority of the population of Atlantic City in 2000 was Black or African American (44.2%), with 26.7% white, 0.5% Native American, 10.4% Asian, and 0.1% Pacific Islander or Hawaiian. Of the total population, 24.9% were Hispanic/Latino. Residents linked their heritage to a number of ancestries, with the largest groups being Italian (4.9%) and Irish (4.1%). With regard to region of birth, 45.8% were born in New Jersey, 24.3% were born in a different state and 24.7% were born outside of the U.S. (including 16.2% who were not United States citizens).

Figure 125: Atlantic City's Racial Structure in 2000

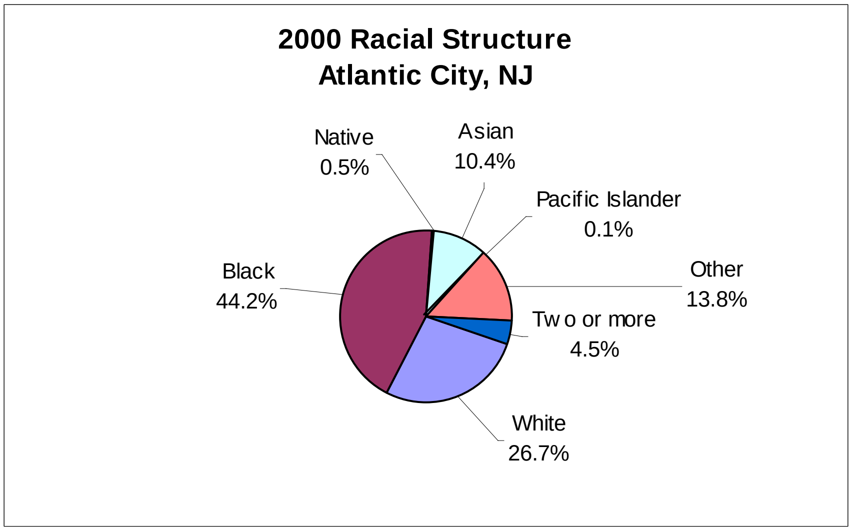
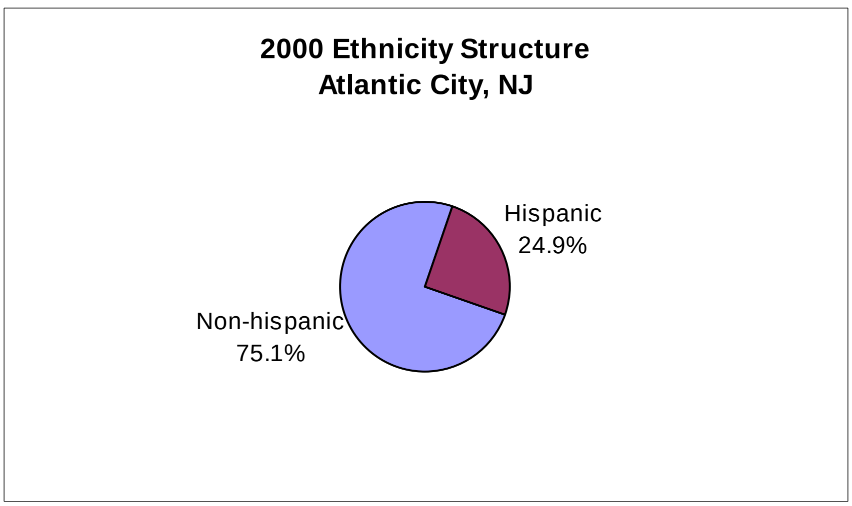


Figure 126: Atlantic City's Ethnic Structure in 2000



For 61.6% of the population 5 years old and higher in 2000 only English was spoken in the home, leaving 38.4% in homes where a language other than English was spoken, including 21.8% of the population who spoke English less than 'very well' according to the 2000 Census.

Of the population 25 years and over, 61.8% were high school graduates or higher and 10.4% had a bachelor's degree or higher. Again of the population 25 years and over, 11.9% did not reach ninth grade, 26.3% attended some high school but did not graduate, 30.7% completed high school, 16.7% had some college with no degree, 4.0% received their associate degree, 7.2% earned their bachelor's degree, and 3.2% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Atlantic County was Catholic with 23 congregations and 62,940 adherents. Other prominent congregations in the county were Jewish (12 with 14,600 adherents), and Assemblies of God (10 with 1,409 adherents). The total number of adherents to any religion was down 5.2% from 1990.

Issues/processes

The New Jersey Fresh Seafood Festival, traditionally held every year in Atlantic City, will no longer take place after 2006 because the city no longer has room for the festival and has lost interest in supporting festivals.[859]

Cultural attributes

The Fleet New Jersey Fresh Seafood Festival is held annually the second weekend in June at Atlantic City. One of the Festival's major goals is to educate people about the ocean environment through live exhibits and interactive, hands-on demonstrations. The proceeds of the festival are donated to a number of charitable organizations, including marine science education programs and fishing industry research and development.[860] However, as noted above, 2006 is likely to be the last year in which the festival is held. The Atlantic City Aquarium at Gardner's Basin is accessible by land or by sea, and offers a chance to educate visitors about the sea.[861]

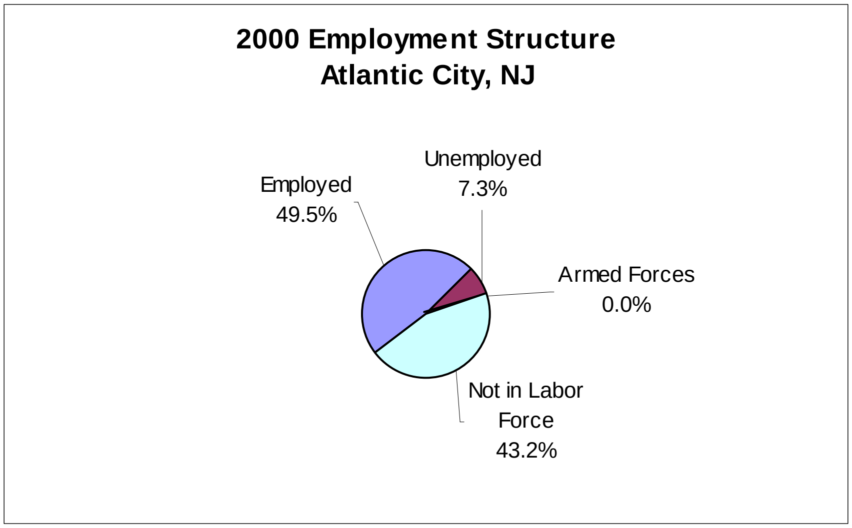
8.5.2 Infrastructure

Current Economy

Atlantic City's numerous casinos are a significant source of employment for the people of the city, providing more than 40,000 jobs in 2002. Conventions are another important source of income for the area's hotels, especially in off seasons. Beyond these, health care is also important to the region as a whole as are the FAA's William J. Hughes Technical Center, several fine china, glass and plastics companies, and boatyards which construct many types of vessels, including luxury yachts.[862]

According to the U.S. Census 2000, 56.8% (31,117 individuals) of the total population 16 years of age and over were in the labor force, of which 7.3% were unemployed and 0% were in the Armed Forces.

Figure 127: Atlantic City's employment structure in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 29 positions or 0.2% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 492 positions or 3.2% of jobs. Arts, entertainment, recreation, accommodation and food services (52.6%), educational health and social services (11.4%), retail trade (6.8%), professional, scientific, management, administrative and waste management services (4.6%), and public administration (4.5%) were the primary industries.

Median household income in Atlantic City was $26,969 (up 32.8% from 1990) and median per capita income was $15,402. For full-time year round workers, men made approximately 6.7% more per year than women.

The average family in Atlantic City in 2000 consisted of 3.26 persons. With respect to poverty, 19.1% of families (down from 1.5% in 1990) and 23.6% of individuals earned below the official US Government poverty line, while 54.8% of families earned less than $35,000 per year.

In 2000, Atlantic City had a total of 20,219 housing units of which 78.4% were occupied and 15.4% were detached one unit homes. Approximately one-quarter (26.4%) of these homes were built before 1940. There were a number of mobile homes/vans/boats in this area, accounting for 0.3% of the total housing units; 74.4% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $87,500. Of vacant housing units, 9.6% were used for seasonal, recreational, or occasional use while of occupied units 71.1% were renter occupied.

Governmental

The city of Atlantic City operates under the Council/Manager form of government. There is a nine-member City Council and a Mayor.[863]

Fishery involvement in government

There are no fishing or maritime boards or commissions which can be found through secondary sources.

Institutional

Fishing associations

There are no Atlantic City based fishing associations which could be found through secondary sources. However, Garden State Seafood Association in Trenton is a statewide organization of commercial fishermen and fishing companies, related businesses and individuals working in common cause to promote the interests of the commercial fishing industry and seafood consumers in New Jersey.[864]

Fishery assistance centers

No information has been obtained at this time through secondary sources on fishery assistance centers.

Other fishing related institutions

The Atlantic City Historical Waterfront Foundation provided much of the funding for the city's aquarium.

Physical

There are several ways to access Atlantic City and to travel within the city. The Atlantic City Jitney buses run 24 hours a day, every day in Atlantic City. Nine miles northwest of Atlantic City, the Atlantic City International Airport offers non-stop or connector flights to over 100 destinations on Delta and Spirit Airlines. The Atlantic City Rail Line runs twenty-nine trains per day between Philadelphia and the Atlantic City Rail Terminal with local stops.[865]

Atlantic City has also numerous marinas. The Senator Frank S. Farley State Marina is a full service marina which can house 640 boats and provides water, electricity, ice, restaurant, charter boats, and gas and diesel fuel.[866] Situated on Clam Creek, the marina is a short distance from the Atlantic Ocean via Absecon Inlet, or the Intracoastal Waterway. The Atlantic City Aquarium operates a marina in the city's historic Gardner's Basin, where they also have a restaurant selling seafood from the boats that dock there.[867] In addition, there are multiple private marinas.[868]

8.5.3 Involvement in Northeast Fisheries

Commercial

Atlantic City's commercial fishing fleet is based in the Marina section of the city, in the shadow of the casinos. The fishery almost exclusively targets surf clams and ocean quahogs. This fishery is conducted by larger vessels, 70 to 150 feet in length, equipped with hydraulic dredges. Atlantic City's fishery provides much of the world's supply of minced clams and clam strips. There are no processing facilities in Atlantic City, so the clams must be trucked elsewhere.[869] In addition to the large commercial clam industry, numerous small-scale fishing operations in Atlantic City fish for clams on the bay side using rakes and tongs or fishing by hand. There are also some clam aquaculture facilities here.[870]

In 2003, the value of the surf clam landings was $19,934,614, far greater than the ocean quahog landings, valued at $761,816. The third most important species was black sea bass ($59,355). The value of landed catch in Atlantic City seems to have been relatively constant in the years cited, whereas the catch value for vessels with their home port in Atlantic City has increased slightly in the last 7 years. The number of vessels home ported in Atlantic City seems to have remained relatively constant; it is also interesting to note that most vessel owners do not live in Atlantic City.

Landings by Species

Table 67: Dollar value by Federally Managed Groups of landings

	Average from 1997-2004	2003 only
Surf clams, Ocean quahogs	19,104,260	20,696,430
Summer flounder, Scup, Black Sea Bass	33,369	59,356
Lobster	6,152	1,876
Scallop	1,280	22
Bluefish	340	0
Monkfish	336	0
Smallmesh groundfish	79	0
Squid, Mackerel, Butterfish	4	0
Other	26,126	2,793

Landings by Vessels

Table 68: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)

1997	24	3	17,882,496	20,796,672
1998	28	1	18,260,756	17,828,564
1999	26	2	19,966,741	20,002,005
2000	31	2	25,632,408	26,079,708
2001	28	1	27,711,967	25,160,380
2002	27	1	29,179,530	22,429,230
2003	26	2	28,907,729	20,760,477

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Recreational

There are a number of businesses operating recreational fishing charter and party boats in Atlantic City, fishing year round for a large variety of species including flounder, seabass, cod, striped bass, weakfish, bluefish, tuna, shark, and mahi mahi, among others.[871] Charter vessels from the Gardner's Basin area offer both deep sea and bay fishing.[872]

Subsistence

No information on subsistence fishing in Atlantic City has been found at this time through secondary sources.

Future

The Casino Reinvestment Development Authority has invested $225 million in the construction of new residential housing to revitalize the image of Atlantic City. This goal of this project is to restore the vitality of the city's architecturally and culturally diverse neighborhoods and to re-establish thriving residential communities. The CRDA has funded and completed construction on a total of 1,897 housing units since its inception in 1984, increasing Atlantic City's housing stock by 12%.[873] The Inlet section of Atlantic City, where some of the commercial fishing fleet is based and which has been largely underdeveloped, is now being built up with condominiums and homes, forcing out the annual seafood festival held here.[874] Gardner's Basin, home to many of the clam docks, is also home to numerous townhouses and is zoned "marine commercial".[875]

9.0 MARYLAND

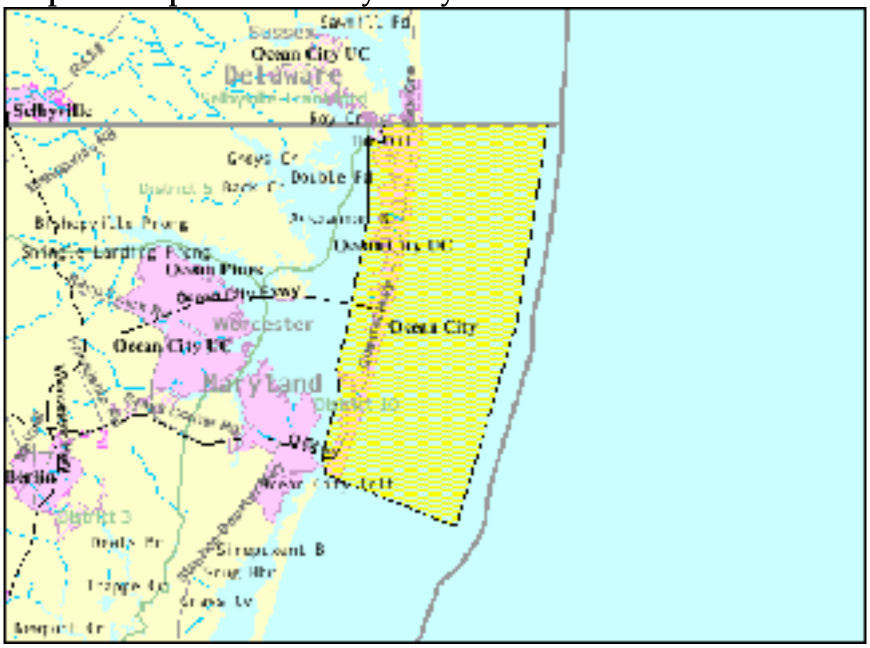
9.1 OCEAN CITY, MD

9.1.1 <u>People and Places</u>

Regional orientation

Ocean City, Maryland (38.33º N, 75.09º W) is a town located in Worcester County, in the Eastern Pines metro area. It is bordered to the east by the Atlantic Ocean and to the west by the Assawoman Bay. The town has a total area of 36.4 mi^2, 4.6 mi^2 of that is land and 31.8 mi^2 is water. West Ocean City is across the bay from the southern portion of Ocean City.

Map 33: Map of Ocean City Maryland from U.S. Census



Historical/Background Information

The first European came to Ocean City in 1524 from France, but the town wasn't truly settled until the late 17th century with an influx of Virginians from the Eastern Shore. The area of land belonging today to Worcester county Maryland changed many times over the years, belonging at times to Delaware and Somerset County, Maryland. In 1869, a man named Isaac Coffin came to Ocean City and built a cottage to house guests who wanted to go to the beach or to fish. People quickly came and the area soon became a popular summer resort, eventually adding dancing and billiards. In 1933 a storm formed the Ocean City Inlet and engineers decided to make this act of nature permanent. This decision helped to establish Ocean City as an important fishing port, offering easy access to both the bay and the Atlantic Ocean.[876] West Ocean City, while on the other side of the bay and not part of the town, is generally not considered by locals to be a distinct entity from Ocean City.[877]

Demographics

Though considered by local people to be one community, Ocean City and West Ocean City are separate places for purposes of the Census. Data for both locations are provided here.

Ocean City

According to the Census 2000 data, Ocean City town had a population of 7,173, up from a reported population of 5,074 in 1990. Of this total in 2000, 51.3% were males and 48.7% were females. The median age was 47.2 years and 86.5% of the population was 21 years or older while 30.0% of the population was 62 or older.

The population structure for Ocean City showed an older population, with the largest percentage of residents between the ages 60-69, and significant numbers of residents in the 50-59 and 70-79 age categories. This indicates that many people may retire to Ocean City. There were also, however, a significant number of residents between the ages of 20-49 as well. Ocean City had surprisingly few children in the 0-9 and 10-19 age categories.

Figure 128: Age Structure of Ocean City in 2000

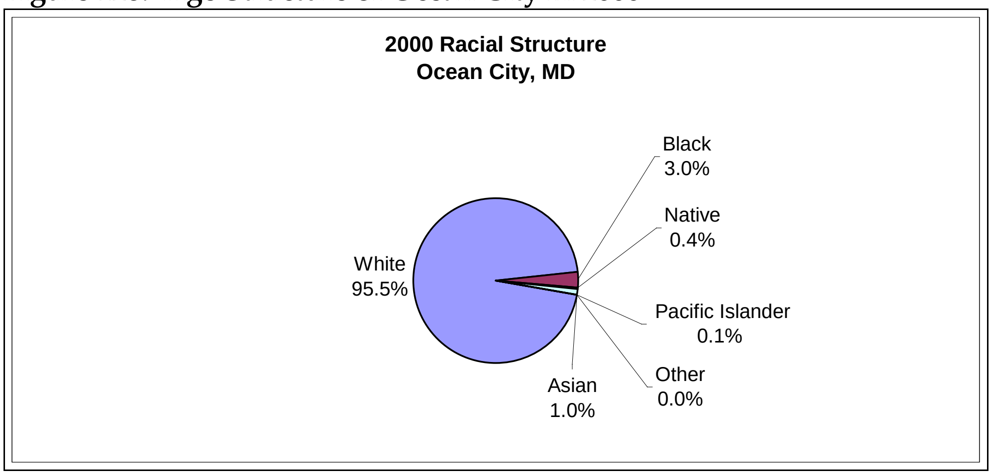
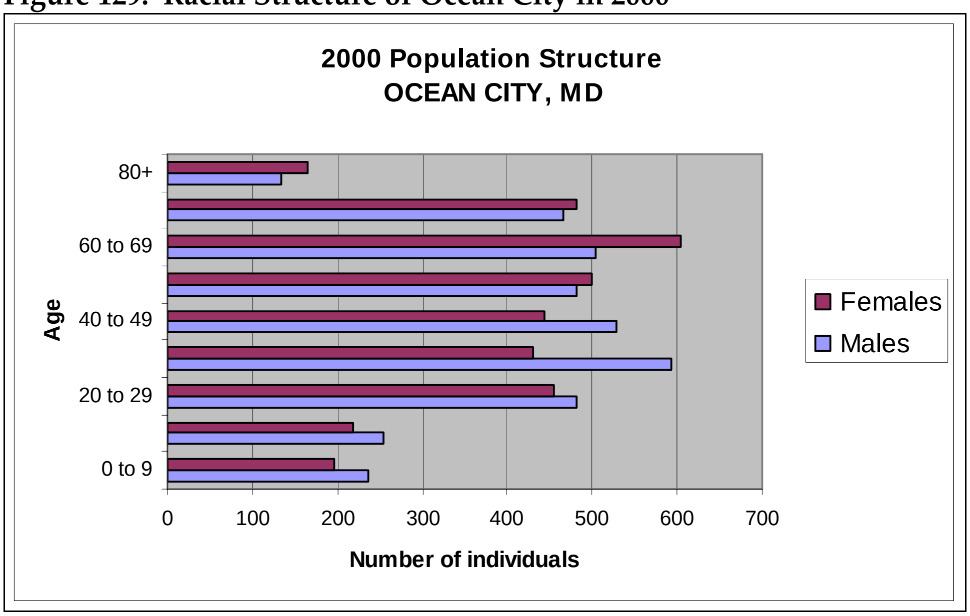
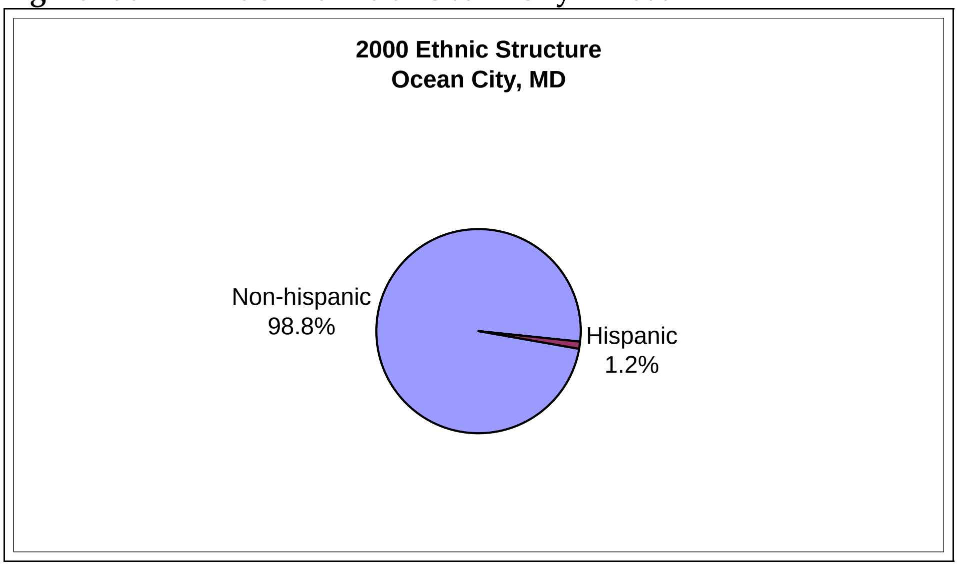


Figure 129: Racial Structure of Ocean City in 2000



The majority of the population of Ocean City in 2000 was white (95.5%) with 3.0% Black or African America, 0.4% Native American, 1.0% Asian and 0.1% Native Hawaiian or Other Pacific Islander. Of the total population, 1.2% identified themselves as Hispanic/Latino. Residents linked their heritage to a number of ancestries including: German (25.6%), Irish (21.0%), English (16.0%), and Italian (8.7%). With regard to region of birth, 51.5% were born in Maryland, 43.7% were born in a different state and 4.5% were born outside of the U.S. (including 3.0% who were not United States citizens).

Figure 130: Ethnic Structure of Ocean City in 2000



For 93.0% of the population in 2000, only English was spoken in the home, leaving 7.0% in homes where a language other than English was spoken, including 2.9% of the population who spoke English less than 'very well' according to the 2000 Census.

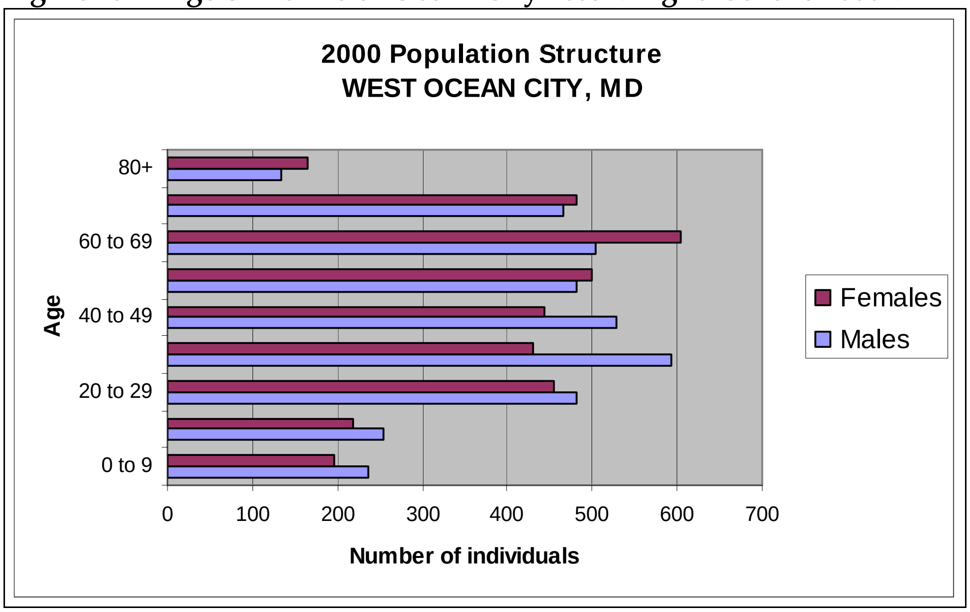
Of the population 25 years and over, 87.1% were high school graduates or higher and 28.0% had a bachelor's degree or higher. Again of the population 25 years and over, 2.6% did not reach ninth grade, 10.3% attended some high school but did not graduate, 31.7% completed high school, 22.7% had some college with no degree, 4.8% received their associate degree, 20.1% earned their bachelor's degree, and 7.9% received either their graduate or professional degree.

West Ocean City CDP

According to the Census 2000 data, West Ocean City CDP had a population of 3,311, up 65.5% from a reported population of 2,000 in 1990. Of this total in 2000, 49.3% were males and 50.7% were females. The median age was 43.5 years and 77.9% of the population was 21 years or older while 23.3% of the population was 62 or older.

The population structure for West Ocean City showed essentially two peaks; the first was between ages 30-39, and the second between 60-69. Interestingly, men between the ages of 30-39 far outnumbered women of the same age, and conversely women aged 60-69 far outnumbered their male counterparts. This patterns suggests two possible trends; one is that younger adults, and particularly males without children aged 20-39 are moving to West Ocean City, and the other is that many people are retiring here, judging by the large number of residents in the 60-69 and 70-79 age categories. There were not many children in West Ocean City, compared to what one might expect to see considering the number of residents here.

Figure 131: Age Structure of Ocean City according to Census 2000 data



The majority of the population of West Ocean City in 2000 was white (95.9%) with 2.0% of residents Black or African American, 0.8% Native American, 1.0% Asian, and 0.1% Pacific Islander or Hawaiian. Of the total population, only 1.4% identified themselves as Hispanic/Latino. Residents linked their heritage to a number of ancestries including: German (22.1%), English (19.0%), and Irish (16.7%). With regard to region of birth, 57.2% were born in Maryland, 38.2% were born in a different state and 4.4% were born outside of the U.S. (including 2.2% who were not United States citizens).

Figure 132: Racial Structure of Ocean City in 2000

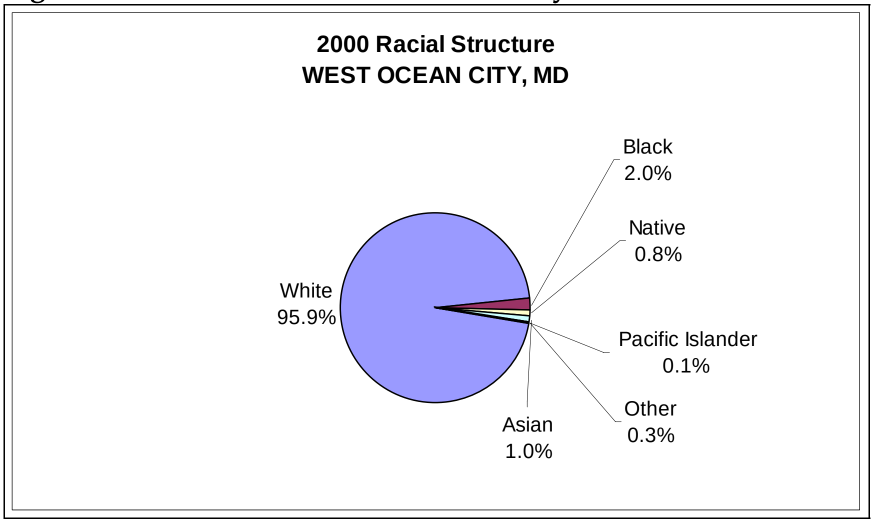
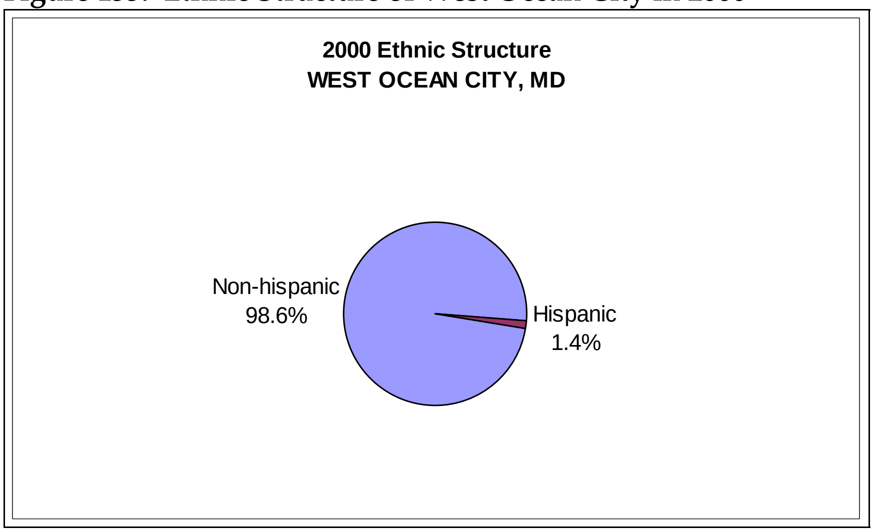


Figure 133: Ethnic Structure of West Ocean City in 2000



For 93.2% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 6.8% in homes where a language other than English was spoken, including 2.8% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 81.2% were high school graduates or higher and 20.7% had a bachelor's degree or higher. Again of the population 25 years and over, 3.6% did not reach ninth grade, 15.2% attended some high school but did not graduate, 31.5% completed high school, 21.1% had some college with no degree, 7.9% received their associate degree, 12.6% earned their bachelor's degree, and 8.1% received either their graduate or professional degree.

Although religious percentages are not available through U.S. Census data, according to the American Religion Data Archive in 2000 the religions with the highest number of congregations in Worcester County included Catholic (5 with 7,700 adherents), United

Methodist (39 with 7,628) and Southern Baptist Convention (8 with 3,009 adherents). The total number of adherents to any religion was up 59.6% from 1990.

Issues and Processes

Many people in Ocean City in 2004 were writing letters to the editor of a local paper regarding the very high prices and taxes for real estate. Because Ocean City is primarily a resort town, the real estate market is hot. The prices are making it hard for the locals to keep their homes and afford rent in the area.[878] As recently as 2006 the real estate market remained a problem for those seeking to by a first home, especially blue collar workers.[879] Many people are also concerned about aquaculture developing in the area. They are concerned that if it does develop, it will be run by the large poultry companies in the area, as has happened in areas further to the south.[880]

Dock space in West Ocean City, where the commercial fishing fleet is based, is limited; fortunately protective zoning by Worcester County means the docks are not immediately threatened. Some processing plants and a clam dock in the area recently closed as a result of a consolidation of surf clam and ocean quahog boats, particularly a decline in owner-operated boats, after the implementation of ITQs in this fishery.[881]

Cultural Attributes

Ocean City hosts many fishing tournaments each year. In 2006 they begin in June with the Mako Mania Shark Tournament. In July comes the Ocean City Tuna Tournament which features nightly weigh-ins as well as food, entertainment, crafts and fishing related games for children. In August, the town hosts the world's largest billfish tournament, the White Marlin Open, which offers cash prizes for white marlin, blue marlin, tuna, wahoo, dolphin and shark; nightly weigh-ins are a popular event. In 2006, $2.3 million was given away in prizes. Later in the month is the only local Ladies Only fishing tournament, Captain Steve Harman Poor Girl's Open Fishing Tournament. In September the Mid-Atlantic Bartenders Open Fishing Tournament is another popular event.[882] Other tournaments are held as well.[883]

Each year the Maryland Watermen's Association sponsors the East Coast Commercial Fishermen's and Aquaculture Trade Exposition in Ocean City, which features aquaculture and commercial fishing seminars, gear, equipment, and boats.[884] The Seasie Boat Show is held in February. May brings the Great American RV, Outdoor & Watersports Show and the Annual White Marlin Festival & Crab Soup Cookoff.[885] One of the fish docks in West Ocean City sponsored a "Mid-Atlantic Commercial Fishing Skills Contest", which included competitions in rope tying, net mending, rope splicing, survival suit-donning, and other fishing-related activities.[886]

9.1.2 Infrastructure

Current Economy

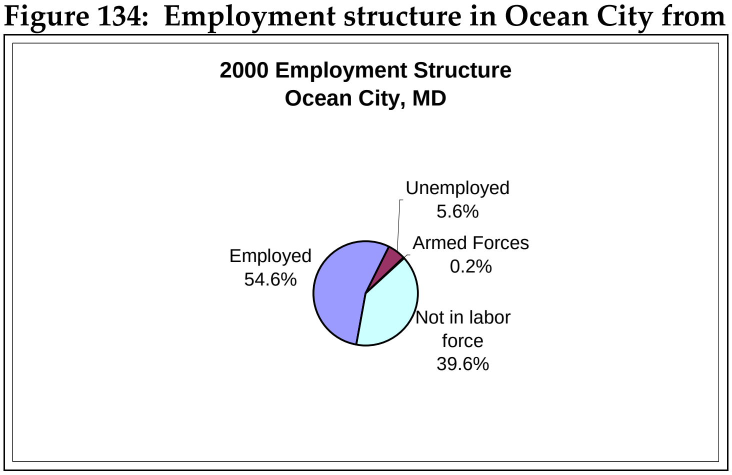
Many of the people in Ocean City work in restaurants and in the resorts that have made this area so popular with tourists. In fact, The six major employers in Ocean City are all in tourism and property management/development industries: Harrison Group (golf resort), Purnell Properties (hotel management), O.C. Seacrets, Inc. (night club), Trimpers Rides (amusement park), Dough Roller Restaurants, Bayshore Development and Clarion/Gateway Hotels.[887]

There are three packing houses in West Ocean City, which combined employ about sixteen people. There are probably at least 230 people employed on the charter and party boats in Ocean City, not including additional support staff or those that work at related businesses like bait and tackle shops. Recreational fishing is one of the more important aspects of Ocean City's tourist economy.[888] Some other major employers in Worcester County in 2006 include: Tyson Foods (poultry processing – 785 employees); Perdue Farms (poultry processing – 540 employees); Candy Kitchen Shoppes (candy – 250 employees); Bel-Art Products (plastic components, laboratory equipment – 104 employees); and Mid-Atlantic Foods/Sea Watch International in Pocomoke City (seafood processing – 74 people).[889]

Ocean City

According to the U.S. Census 2000, 60.4% (3,909 individuals) of the total population 16 years of age and over were in the labor force, of which 5.6% were unemployed and 0.2% were in the Armed Forces.

Figure 134: Employment structure in Ocean City from Census 2000 data



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for only 12 or 0.3% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 392 or 11.1% of jobs. Arts, entertainment, recreation, accommodation and food services (29.5%), retail trade (12.9%), finance, insurance, real estate, and rental and leasing (12.0%), and educational, health, and social services (11.1%) were the primary industries.

Median household income in Ocean City in 2000 was $35,772 (up from $25,959 in 1990) and median per capita income was $26,078. For full-time year round workers, men made approximately 4.2% more per year than women.

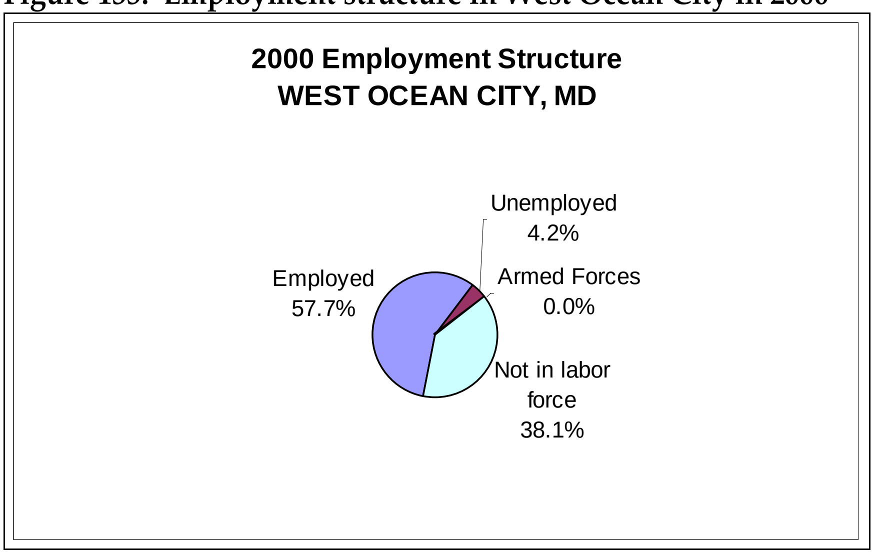
The average family in Ocean City consisted of 2.47 persons. With respect to poverty, 6.0% of families (down slightly from 6.4% in 1990) and 8.4% of individuals earned below the official US Government poverty line, and 37.7% of families in 2000 earned less than $35,000 per year.

In 2000, Ocean City had a total of 26,317 housing units of which 14.2% were occupied and 9.4% were detached one unit homes. Almost none of these homes were built before 1940. There are a few mobile homes, boats, RVs, vans, etc. in the area, accounting for 6.9% of the total housing units; 96.9% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $152,200. Of vacant housing units, 63.3% were used for seasonal, recreational, or occasional use. Of occupied units, 32.6% were renter occupied.

West Ocean City CDP

According to the U.S. Census 2000, 61.9% (1,724 individuals) of the total population 16 years of age and over were in the labor force, of which 4.2% were unemployed and none were in the Armed Forces.

Figure 135: Employment structure in West Ocean City in 2000



According to Census 2000 data, jobs with agriculture, forestry, fishing and hunting accounted for 15 or 0.9% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 145 or 9.0% of jobs. Arts, entertainment, recreation, accommodation and food services (24.1%), retail trade (15.8%), finance, insurance, real estate, and rental and leasing (11.6%), educational, health, and social services (10.7%), and construction (10.7%) were the primary industries.

Median household income in West Ocean City in 2000 was $42,279 (up 33.7% from $31,632 in 1990) and median per capita income was $28,132. For full-time year round workers, men made approximately 11.8% more per year than women.

The average family in West Ocean City consisted of 2.77 persons. With respect to poverty, 3.0% of families (down considerably from 9.3% in 1990) and 5.0% of individuals earned below the official US Government poverty line, and 27.1% of families in 2000 earned less than $35,000 per year.

In 2000, West Ocean City had a total of 2,075 housing units of which 68.7% were occupied and 77.0% were detached one unit homes. Less than 5% of these homes were built before 1940. Mobile homes accounted for 10.1% of the total housing units; 88.6% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $157,500. Of vacant housing units, 45.4% were used for seasonal, recreational, or occasional use. Of occupied units, 20.1% were renter occupied.

Governmental

Ocean City is run by a mayor and Town Council. The Town Council consists of a Council President, Council Secretary and five general Council Members.[890] West Ocean City is governed by Worcester County, which has a seven-member board of County Commissioners.[891]

Fishery Involvement in Government

Worcester County manages a commercial dock in West Ocean City. The Worcester County Commission has zoned the harbor area here as a commercial marine district, to protect commercial fishing operations from being pushed out by condominiums and other private development. The Worcester County comprehensive plan also recognizes commercial fishing as one of the County's economic assets (p. 31) and has a goal of preserving fisheries and their nurseries (p. 33) and has 5 goals specifically aimed at retaining commercial fishing and seafood processing in the County (p. 60).[892] Ocean City's comprehensive plan encourages water uses on the bay and marina construction.[893] It also recognizes the importance of water quality and commercial fishing to the town.[894]

Institutional

Fishing Associations

There is a statewide fishermen's organization called the Maryland Watermen's Association but few of the ocean fishermen belong to it because it emphasizes helping the Chesapeake Bay fishermen rather than the ocean fishermen. They focus on the Bay fishermen because there are more bay crabbers, clammers, and gill netters than there are ocean fishermen. The ocean fishermen are concerned that they are not prepared for what may happen and they lack representation.[895]

There are some sport fishing groups in Ocean City that work to promote sport fishing in the area. One is the Ocean City Marlin Club, which began in 1936. The club is primarily a social one, although they are becoming increasingly political. They also host several tournaments.[896] The OC Surf Anglers hosts surf fishing tournaments. The Ocean Pines Fishing Club is made up of members of Ocean Pines, a planned community in West Ocean City. The captains of the charter boats located at the Ocean City Fishing Center are all members of the Ocean City Charter Captain's Association.[897]

Fishery Assistance Centers

Information on fishery assistance centers in Ocean City is either unavailable through secondary data collection or does not exist.

Other Fishing Related Institutions

The Marine Trades Association of Maryland is involved in providing information for boaters and fishermen in the state of Maryland. They hold safety classes and have a wide variety of information for boaters in their website. They represent marine issues in front of the state legislature, participate on governmental boards and committees related to boating and fishing, they also provide information and host boat shows in the area.[898] The OC Reef Foundation is working to provide artificial reefs around Ocean City for the area's recreational fishermen.[899]

Physical

Ocean City is located about 30 minutes from the Salisbury-Wicomico County Regional Airport and has locally the Ocean City Municipal Airport for private flights.[900] It is accessible from Routes 589 and 611 from the west, and Route 528 from the north. Ocean City is located about 4.5 hours from New York City, about 3 hours from Washington D.C. and about 3 hours from Philadelphia, PA. A large park and ride facility has been established outside of Ocean City which allows visitors to park here and catch a bus into town.[901]

The commercial fishing industry in Ocean City is actually located in West Ocean City, an unincorporated segment of Worcester County just across the bay from Ocean City. The harbor here has a commercially-owned dock, a recreational fishing marina, and three commercial packing houses. Some private dock owners also lease space to the commercial vessels.[902] The Sunset Marina has a sheltered 18 acre deep water basin that can accommodate vessels up to 100′ in length. There are 20 charter boats located here, as well as a bait and tackle shop and marine supplies shop.[903]

The Maryland Fishing Center, also located in Ocean City, has 170 slips, free parking and security. It is home to the largest charter fleet in the town, comprised of 30 boats. It also has a bait shop, restaurant and repair service.[904] There are also three recreational marinas located in West Ocean City; 75% of the charter boats are found here, along with two of the largest ocean-going party boats.

There are also a number of places along the shore frequented by anglers, including three pay piers (the Ocean Pier, the Oceanic Pier, and the Shantytown Pier), the Route 50 Bridge, a number of public piers and bulkheads, and a public crabbing and fishing area on Isle of Wight. There are four public boat launches found in West Ocean City harbor. The Ocean City area also has a number of fish cleaning businesses.[905] The government of Ocean City owns the Bayside Boardwalk/ 9th St Fishing Pier and the Bering Road Boat Ramp.[906]

9.1.3 <u>Involvement in Northeast Fisheries</u>

Commercial

The commercial fishing industry in Ocean City is actually located in West Ocean City.[907] However, as evidenced from the landings data provided for both cities below, the landings are declared for Ocean City and most vessels are listed as having their home port in Ocean City. The most valuable species in Ocean City in 2003 was the ocean quahog, worth $2,619,544 in landings, followed by the surf clam, which brought in $2,117,792, and black sea bass, with a value of $551,090. Overall, the landings values for 2003 were higher than the 10-year average values for the surf clam and ocean quahog category, and for the summer flounder, scup, and black sea bass category, but were lower for scallops and “other” species.

The number of vessels listing Ocean City as their home port was highly variable from 1997 to 2005, going from a low of 19 in 1999 to a high of 40 in 2005. There are far more boats listing Ocean City as their home port than there are vessels with owners residing in Ocean City, indicating that many people from outside Ocean City dock their boats there.

Overall, the value of landings to home ported vessels showed a consistent increase for the years provided here. In particular, in 2004 the landings in Ocean City increased from over $6.6 million in the previous year to over $46.6 million. In 2005, landings declined to $10.4 million; in the same year the number of home ported vessels increased from 28 to 40. The level of home port fishing for Ocean City vessels is about 5-6 million dollars less in most years than the level of landings for Ocean City, pointing to the fact that many people from outside Ocean City are dropping off their catches in the town. Ocean City is a popular place for fishermen in the area to unload their catches because it is the only major ocean port between Cape May, NJ and Hampton Roads, VA. Even the people who are considered to be locals do not live in Ocean City itself but live about 30 minutes away on the land side of the harbor.[908] Some of the fishermen who land their catch here are from Delaware, as there are no packing facilities in Delaware.[909]

In 2003 West Ocean City was home to five surf clam and ocean quahog boats, at least seven draggers, and at least fifteen small boats that engaged in potting, gillnetting, dredging, and/or handlining. Conching is a common practice among the smaller vessels. Twenty years ago, there were 30 surf clam and ocean quahog boats docked here, but consolidation resulting from the use of ITQs drastically reduced this number. Most of these are small, owner-operated vessels with the exception of four surf clam and ocean quahog boats owned by J.H. Miles Co., a clam harvesting and processing operation based in Norfolk, VA. There are three fish and shellfish packing facilities here, one of which is a satellite operation of J.H. Miles. Two of these fish houses opened recently; another has existed there since 1957. The older packing house mostly buys from local boats, and has two draggers that land here. Some of the seafood here is sold at their retail market or to local restaurants, but most is sold to buyers in Hampton, VA, Philadelphia, or New York City.[910]

Landings by Species

Table 69: Dollar value of Federally Managed Groups of landing in Ocean City

	Average from 1997-2006	2003 only
Other	4,721,080	488,672
Surf Clams, Ocean Quahogs	4,093,333	4,737,336
Summer Flounder, Scup, Black Sea Bass	854,432	992,494
Scallop	815,353	213,621
Monkfish	228,278	121,496
Dogfish	156,482	13
Lobster	89,091	60,155
Squid, Mackerel, Butterfish	49,892	5,136
Bluefish	8,928	5,136
Skate	7,049	1,161
Largemesh groundfish	2,106	327
Smallmesh groundfish	593	184
Tilefish	309	0
Herring	308	198
Redcrab	65	0

Vessels By Year

Table 70: All columns represent vessel permits or landings value combined between 1997-2005 for Ocean City

Ocean City Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	28	18	1,501,729	7,184,451
1998	19	16	1,471,368	6,356,802
1999	17	14	1,353,935	6,145,998
2000	20	10	1,408,715	6,595,554
2001	25	9	2,334,293	8,632,994
2002	23	7	2,602,657	8,129,245
2003	27	9	2,686,486	6,625,929
2004	27	8	2,623,788	46,613,502
2005	40	12	3,664,672	10,399,346

Table 71: All columns represent vessel permits or landings value combined between 1997-2005 for West Ocean City

West Ocean City Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	0	0	0	0
1998	2	0	135,792	0
1999	2	0	174,495	0
2000	2	0	148,647	0
2001	1	0	36,122	0
2002	1	0	68,792	0
2003	1	0	98,251	0
2004	1	0	88,929	0
2005	1	0	148,025	0

Recreational

Ocean City is famous for its recreational fishing and hosts many fishing tournaments every year. The most popular species to fish are bigeye and yellowfin tuna, mako and dolphin, white marlin, blue marlin and sailfish.[911] Ocean City is known as the "White Marlin Capital of the World".[912] There are also many sport fishing associations such as the Ocean City Marlin Club and the Maryland Saltwater Sport fishing Association.[913] Ocean City has at least five large ocean-going party boats and around six party boats that fish in the bay.

There are an estimated 100 charter boats in Ocean City's six major marinas. Tuna fishing is especially popular here; marlin tends to be a more elite fishery targeted by more expensive and exclusive charter boats. Ocean City is also popular with recreational anglers who fish from their own boats, from rental boats, or from shore; many of these are targeting summer flounder. There are numerous jetties, pay piers, and bridges from which anglers may fish, in addition to surf fishing from the beach. Crabbing and clamming are also important recreational activities. According to NMFS VTR data, between 2001-2005 there were a total of 31 charter and party boats which logged trips in Ocean City, carrying a total of 83,505 anglers on 3,137 different trips.

Subsistence

Fishing for something to take home for dinner is less common in Ocean City now than it once was, and catch-and-release fishing is increasingly popular. Some theorize this may be in part because of the rising cost of vacationing in Ocean City, bringing in tourists of a higher socioeconomic status who do not using fishing for subsistence.[914]

Future

The Ocean City Development Corporation has many plans for the Downtown area of Ocean City. Current plans include more parking and mass transportation such as busses to help bring people to the downtown area. They are also planning on building a new wraparound boardwalk and a free open public park. New zoning will help to bring in more businesses and improvement of the roadways and signs will make getting around much easier.[915]

People who live in the Ocean City area are worried about being priced out because the area is very focused on its recreation and its image as a resort town. The cost of living has been going up and is making it hard for people who have lived there their whole lives to continue living there. Housing and services in the town are getting to be very expensive for the average person living in the town.[916] Fishermen in the area are also concerned about rezoning in the harbor. One major concern is that the docks will become non-conforming meaning that replacement or fixing of the structures will be impeded. The fishermen are interpreting this rezoning to mean that people in the area are trying to force out the fishermen; much of the rezoning has been because of new condominiums being built in the area.[917] Despite protective zoning measures, gentrification of the waterfront is a concern. Commercial fishing here does, however, serve as a tourist attraction and is important to the community in that respect.[918]

10.0 VIRGINIA

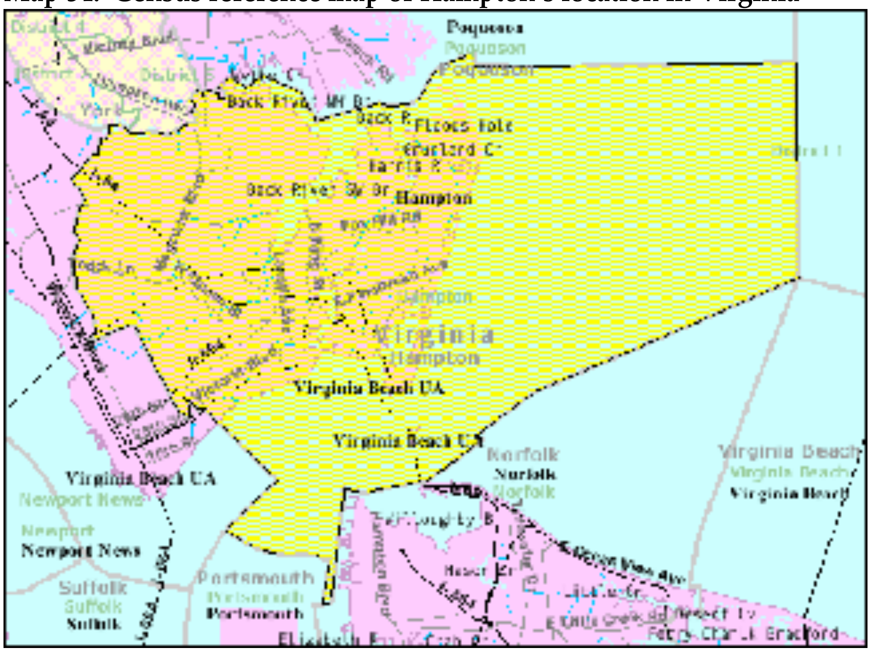
10.1 HAMPTON, VA

10.1.1 <u>People and Places</u>

Regional Orientation

Hampton, Virginia (37.03° N, 76.35° W) is situated in Hampton County on the southern shores of the state on the James River.[919] Hampton is located approximately 30 miles from Virginia Beach, 30 miles from historic Williamsburg, 17 miles from Norfolk and 7 miles from Newport News. Newport News is part of the Hampton Roads area, which includes Newport News, Hampton, and Virginia Beach, as well as a number of other cities and towns whose inclusion varies by source.[920]

Map 34: Census reference map of Hampton's location in Virginia



Historical/Background Information

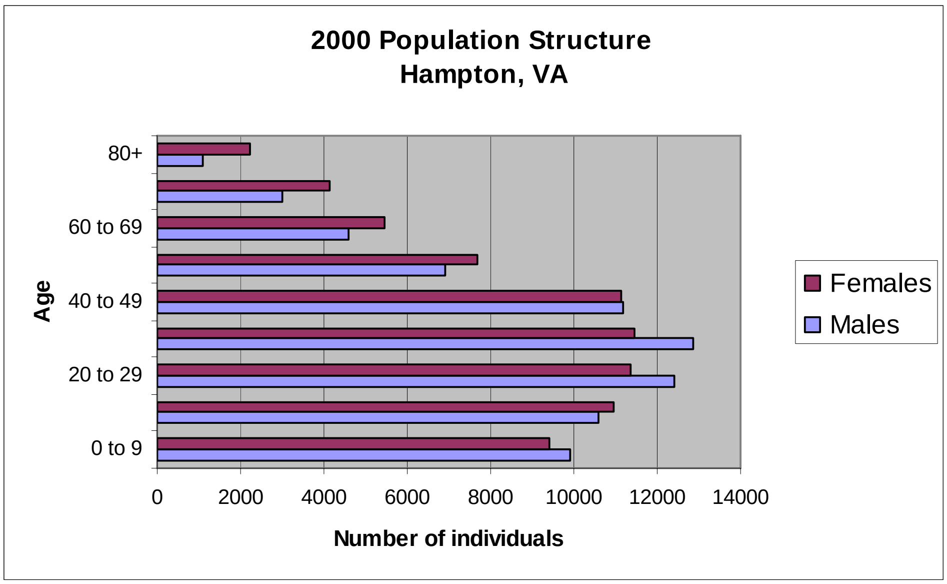
Hampton is an independent city, in the Virginia Beach-Norfolk metro area.[921] The community was named for the Southampton (Hampton) River, which was named for the Earl of Southampton. Hampton and the surrounding area is the oldest continuous English-speaking settlement in America.[922] Englishmen were sent by the Virginia Company in 1607 to settle the area and the first Africans arrived in 1619.[923] The wealth of the colonies around Hampton's waterfront made the city an inviting target for pirates in the 17th century, the most notorious being Blackbeard.[924] Hampton is also known for having the first battle between two ironclad ships in 1862, when Confederate forces from the *Merrimack* (aka *Virginia*) attacked the *Monitor*.[925] In the eighteenth century, Hampton became a thriving port, with tobacco as a chief export and medium of exchange. In the late 1800's, Union General Benjamin Butler first applied the term "contraband" to three runaway slaves, establishing an avenue to freedom for African Americans throughout the South.[926]

Demographics

According to the Census 2000 data, the city had a population of 146,437, up from the reported population of 133,793 in 1990. Of this 2000 total, 49.6 % were males and 50.4 % were females. The median age was 34.0 years and 70.1% of the population was 21 years or older while 12.5 % of the population was 62 or older.

Hampton's population structure showed a large population in both 0-19 and 20-49 age groups and a rapid drop off in the 50-59 age group, likely indicating large numbers of young families. The largest category was males in the 30-39 age bracket.

Figure 136: Population structure by sex in 2000



The majority of the population of Hampton in 2000 was white (77.0 %), with 12.6 % of residents Black or African American, 0.9 % Native American, 3.7 % Asian, and 0.1 % Pacific Islander or Hawaiian. Only 2.8 % of the total population was Hispanic/Latino. Residents linked their heritage to a number of ancestries including: German (9.0 %), English (7.8 %), United States or American (7.2 %), and Irish (7.1 %). With regard to region of birth, 46.9 % were born in Virginia, 46.8 % were born in a different state, and 2.4 % were born outside the U.S. (including 1.7 % who were not United States citizens).

Figure 137: Racial Structure in 2000

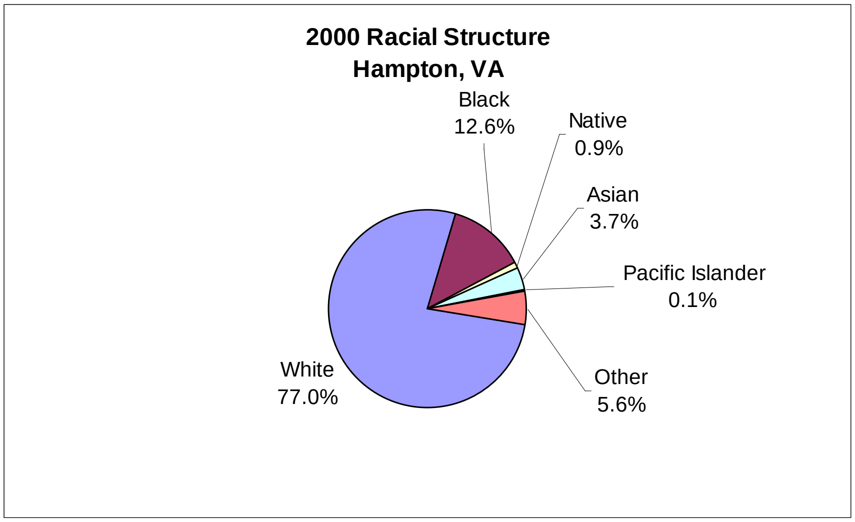
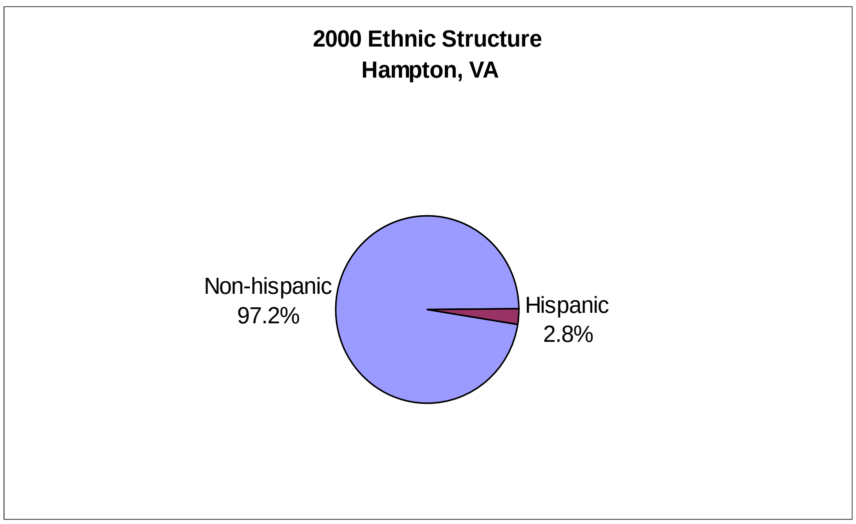


Figure 138: Ethnic Structure in 2000



For 93.3 % of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 6.7 % in homes where a language other than English was spoken, including 2.1 % of the population who spoke English less than 'very well'.

Of the population 25 years and over, 85.5 % were high school graduates or higher and 21.8 % had a bachelor's degree or higher. Again of the population 25 years and over, 4.1 % did not reach ninth grade, 10.4 % attended some high school but did not graduate, 28.0 % completed high school, 27.2 % had some college with no degree, 8.6 % received their associate degree, 13.5 % earned their bachelor's degree, and 8.3 % received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the Association of Religion Data Archives in 2000 the religion with the highest number of adherents in Hampton County was Southern Baptist Convention with 21 congregations and 16,666 adherents. Other prominent congregations in the county were United Methodist (12 with 7,019 adherents), Catholic (5 with 5,217 adherents), and Assemblies of God (5 with 3,263 adherents). The total number of adherent to any religion was up 9.2 % from 1990.

Issues/Processes

In August 2005, the coastal fisheries commission in VA approved capping the catch of menhaden in the Chesapeake Bay to about 230 million pounds. This mostly strongly affects Omega Protein Corp., the nation's largest menhaden processor, which has warehouse facilities in Norfolk. Menhaden fuels one of Virginia's largest commercial fishing industries and is considered an abundant resource coast-wide but biologists are concerned about the decline of young fish over the past 15 years.[927] Crew turnover on trawlers is also an emerging problem.[928]

Cultural Attributes

Hampton celebrates the fearsome and successful Caribbean pirate Edward Teach, a.k.a. Blackbeard, through The Hampton Blackbeard Festival every year in June. The event features Tall Ships, re-enactments of important battles and a Grand Pirate Ball.[929] Also featured is the annual Hooked on Hampton Fishing Tournament.[930]

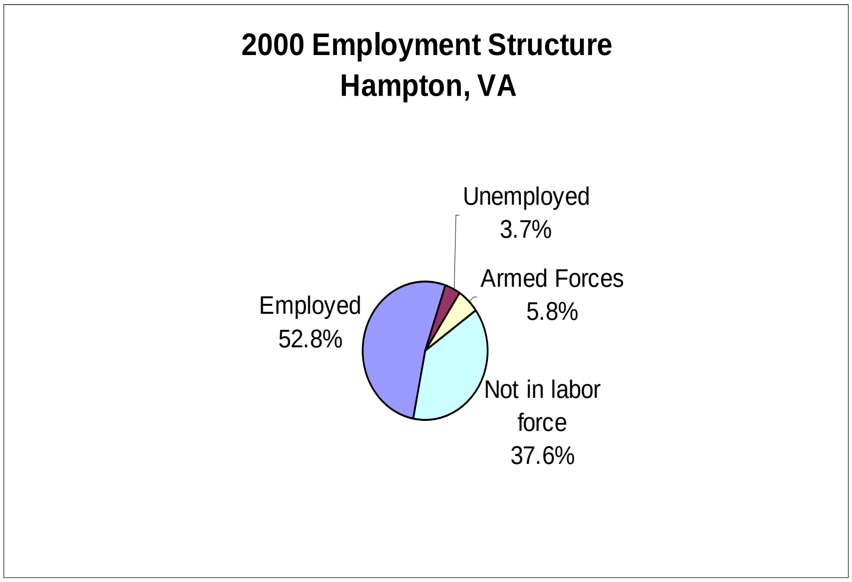
The Hampton History Museum on Old Hampton Lane, boasts a wide selection of permanent and changing exhibits highlighting Hampton's rich history. Of maritime interest is the Port Hampton exhibit, where visitors can walk through a simulated ship's hold with original and reproduction artifacts, including old hogshead barrels to illustrate the importance of tobacco in Hampton's trade and commerce past.[931]

The Downtown Hampton In-Water Boat Show is held at the Hampton Public Piers water front and showcases boats in and out of the water from many regional boat dealers.[932] The Seafest, a large marine trade show, is held every September.[933] Also in September, the town celebrates its waterfront heritage with art, entertainment and the regional seafood with the annual Hampton Bay Days festival.[934]

10.1.2 <u>Infrastructure</u>
Current Economy

Lucent Technologies, Gateway Computers, Canon, tourism, Langley Air Force Base and NASA are amongst the large employers, drawing the highly skilled labor.[935] According to the U.S. Census 2000, 62.4 % (71,790 individuals) of the total population 16 years of age and over were in the labor force, of which 3.7 % were unemployed and 5.8 % were in the Armed Forces.

Figure 139: Employment structure in 2000



According to the Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 208 positions or 0.3 % of all jobs. Self employed workers, a category where fishermen might be found, accounted for 2,237 positions or 3.7 % of jobs. Educational, health and social services (20.4 %), manufacturing (15.5 %) and retail trade (13.0 %) were the primary industries.

Median household income in Hampton was $39,532 (up 15.3 % from $34,291 in 1990) and per capita income was $19,774. For full-time year round workers, men made approximately 28.8 % more per year than women.

The average family in Hampton in 2000 consisted of 3.02 persons. With respect to poverty, 8.8 % of families (up from 2.5 % in 1990) and 11.3 % of individuals earned below the official US Government poverty line, while 46.5 % of families in 2000 earned less than $35,000 per year.

In 2000, Hampton had a total of 57,311 housing units, of which 94.0 % were occupied and 64.1 % were detached one unit homes. Less than ten percent (7.4 %) of these homes were built before 1940. There were a few mobile homes, boats and RV's in this area, accounting for 1.8 % of the total housing units; 93.5 % of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $91,100. Of vacant housing units, 8.3 % were used for seasonal, recreational, or occasional use, while of occupied units 41.4 % were renter occupied.

Governmental

The Hampton City Council is composed of seven members, including an elected Mayor, and a Vice Mayor, who is selected by the Council after each election. Council members are elected to four-year terms in staggered elections in even years. The Council also appoints the City Manager, who is the chief administrator and executive officer of Hampton.[936]

Fishery involvement in government

NOAA Fisheries, Fisheries Statistics Office, has three port agents based in Hampton. Port agents sample fish landings and provide a 'finger-on-the-pulse' of their respective fishing communities.[937] The Virginia Marine Resource Commission (VMRC) has its offices in nearby Newport News.

Institutions

Fishing Associations

At the federal commercial level, there are no apparent active fishery associations in the Hampton Roads area. At the State level, there are several local "Waterman's" Associations, formed generally to address specific regulations being considered by the VMRC. These associations focus primarily on Chesapeake Bay fisheries.[938] One such association (Working Waterman's Association) has its Vice President from Hampton.[939]

Fishery assistance centers

No information has been obtained at this time on fishery assistance centers in Hampton.

Other fishing related institutions

The Coastal Conservation Association (CCA) operates a state chapter out of Virginia Beach, VA with activities in Hampton. The CCA is a non-profit organization aiming to education the public about marine conservation, whose members are primarily saltwater anglers.[940]

Physical

Hampton is located south of Interstate Highway 64 along the Hampton River. Hampton is situated at the end of a peninsula, with access to both the Chesapeake Bay and the Atlantic Ocean.[941] Hampton is 3 miles from Langley Air Force Base, 11 miles from Newport News/Williamsburg International Airport and approximately 14 miles from Norfolk International Airport. There are Amtrak stations in both Newport News (7 miles) and Norfolk (14 miles). [942] The Hampton Roads Transit (HRT) provides public transportation service throughout the Hampton Roads area.[943]

Hampton's extensive waterfront offer access to multiple marinas[944] including the Salt Ponds Marina Resort which is one of the largest on the Chesapeake Bay, providing storage for boats up to 80 feet long and a complete range of marina services. The Intercoastal Waterway also flows through Hampton, accommodating various types of boat traffic.[945] Hampton Marine Services offers a wide range of parts and services for different vessel types and has been in business for over 20 years.[946] On the west side of the Hampton River near downtown is a large working wharf with numerous yachting centers.[947]

10.1.3 Involvement in Northeast Fisheries

Commercial

The top three species landed in Hampton in 2003 by value were sea scallops ($19,157,183), summer flounder or fluke ($1,693,342) and blue crab ($559,225). Blue crab falls under the 'other' category in Table 1, since it is a state managed species. Menhaden is one of Virginia's largest commercial fisheries, with 58 % of the total coast-wide harvest from 1996 to 2004 coming from the Chesapeake Bay. In 2004, commercial menhaden landings generated about $24 million for the Virginia economy and about 395 full time jobs.[948]
Sea-scalloping with dredges is the most important fishery by value, although a significant portion of scallops are caught out of Hampton using otter trawl vessels. The landings of scallops in 2003 was more than double the 1997-2004 scallop landings average and several other categories also increased.

The diversity of species landed in Hampton is high and other gear used include handlines, haul seines, pound nets, sink gillnets, pots, patent tong for hard clams, as well as the popular scallop dredge and otter trawls. There is also a small amount of pelagic longlining from Hampton, targeting various sharks and tuna. In 1999, two or three boats in Hampton had Vietnamese owners, captains and crew. Crab picking and oyster shucking, once important trades, are now supported by only one crab house.[949]

The number of vessels homeported and the number of vessels whose owner lives in Hampton has stayed relatively consistent from 1997 to 2003. However, the level of fishing landed port increased by over $6.5 million in one year, from 2002 to 2003.

Landings by Species

Table 72: Dollar value of Federally Managed Groups of landing in Hampton, VA

	Average from 1997-2004	2003 only
Scallop	8,255,820	19,157,183
Other	1,721,015	1,655,420
Summer Flounder, Scup, Black Sea Bass	1,394,526	2,030,356

Squid, Mackerel, Butterfish	158,510	60,450
Monkfish	111,974	52,543
Bluefish	23,843	16,790
Herring	6,418	0
Lobster	3,725	0
Skate	1,497	1,650
Dogfish	1,465	0
Smallmesh groundfish	848	46
Largemesh groundfish	449	836
Tilefish	5	0

Vessels by Year

Table 73: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	14	30	3,429,872	7,044,952
1998	11	30	2,611,907	8,218,162
1999	11	30	4,139,490	8,670,343
2000	11	31	4,926,825	10,945,011
2001	10	29	4,409,914	12,332,604
2002	11	35	4,547,615	16,421,022
2003	7	27	3,852,351	22,975,274

Recreational

In 2005, the economic impact generated by marine recreational fishing in Hampton was third highest in the state, next to Virginia Beach and Newport News. The total sales/economic activity for Hampton was $53,275,000, a cumulative income of $30,639,000, and recreational fishing employed 757 people. In 2004, 20 % more marine recreational licenses were sold than in 1994.[950]

Subsistence

No information has been obtained at this time through secondary sources on subsistence fishing.

Future

There is pressure by developers to use dock space for tourist-related infrastructure.[951] Also, during the 2003-2005 in the Hampton Roads area at least fifteen scallop vessels were sold to a New England processing company. Some fishermen see a trend where a few large companies are purchasing vessels, thus, creating a monopoly in the scallop industry. Concerns also exist that big business will squeeze small vessels out of the industry.[952]

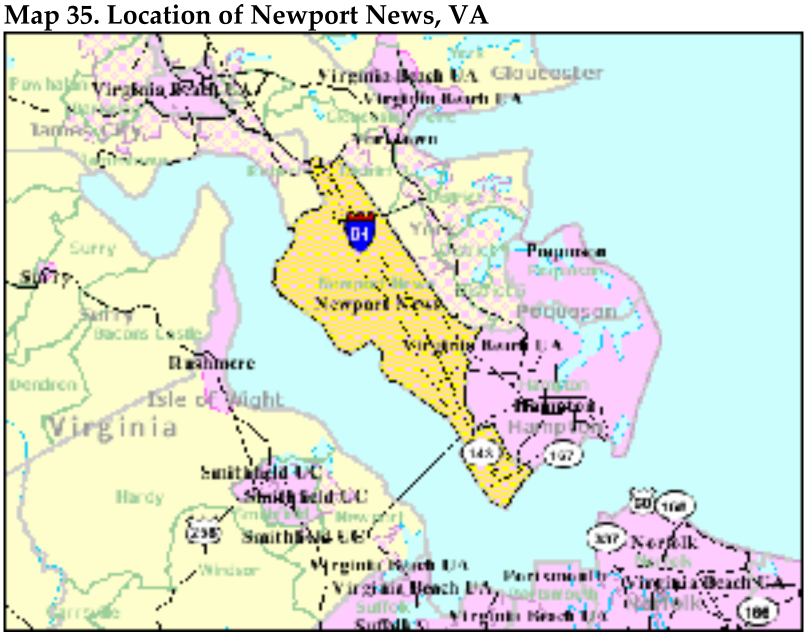
10.2 <u>NEWPORT NEWS, VA</u>

10.2.1 <u>People and Places</u>

Regional orientation

The city of Newport News, Virginia (36:98:86º N, 76:42:83º W) is located on the Virginia Peninsula in Isle of Wight County. The city is located 83 miles north of the North Carolina border, 180 miles from Washington D.C.[953] It is on the northeast side of the James River, the southern-most major river that leads into the Chesapeake Bay. The city encompasses 62.9 square miles of land area and has 43.5 miles of river shoreline.[954] Newport News is part of the Hampton Roads area, which includes Newport News, Hampton, and Virginia Beach, as well as a number of other cities and towns whose inclusion varies by source.[955]

Map 35. Location of Newport News, VA



Historical/Background information

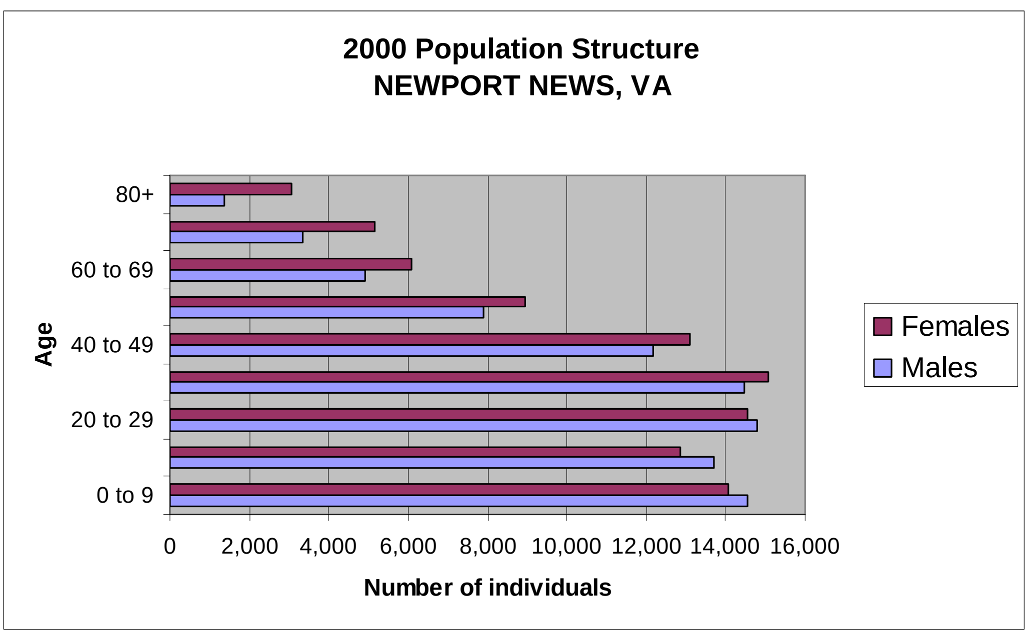
Irish colonists originally settled Newport News around 1620, but it did not become a large settlement until in 1881 when it was "chosen as the Atlantic deep water terminus of the Chesapeake and Ohio Railway (C&O)."[956] In 1886 the settlement's shipbuilding industry began. Newport News has become a major center for ship building and repair. Because of its safe harbor and strategic location in the Mid-Atlantic, the city also is a port for transatlantic and coastal shipping for products such as oil, coal, tobacco, grain, and ores.[957] The defense industry has been a strong influence in this city. The largest employer in not only the city, but also all of Virginia, is Northrop Grumman employing 19,000 people. The corporation boasts its status as "the nation's sole designer, builder and refueler of nuclear-powered aircraft carriers and one of only two companies capable of designing and building nuclear-powered submarines. The sector also provides after-market services for a wide array of naval and commercial vessels."[958]

Demographics

According to Census 2000 data, Newport News had a total population of 180,150, up from 170,045 the reported population in 1990. Of this total in 2000, 51.6% were female and 48.4% were male. The median age was 32 years and 67.7% of the population was 21 years or older while 11.9% were 62 or older.

Newport News' age structure showed slightly more males than females for age groups zero to 29 years, but then more females 30 to 80+ years. The population of age groups was relatively even from zero to 49 years and then there was a major decrease in population, which accelerated as with increasing age. This implied either that men and women leave (move or die) Newport News around age 50 years, or that a younger population has moved in recently. The latter is more likely, especially since there is a large military presence in the city.

Figure 140: Population structure by sex in 2000



The majority of the population of Newport News in 2000 was white (53.8%), with 39.4% of residents Black or African American, 1.1% Native American, 3.0% Asian, and 0.3% Pacific Islander or Hawaiian. Only 4.2% of the total population was Hispanic/Latino.

Residents linked their heritage to a number of ancestries including: German (9.6%), English (8.3%), Irish (7.4%), Italian (3.2%), French (2.0%), and Scottish (1.6%). With regard to region of birth, 48.1% were born in Virginia, 44.4% were born in a different state and 2.7% were born outside of the U.S. (including 2.3% who were not United States citizens).

Figure 141: Racial Structure in 2000

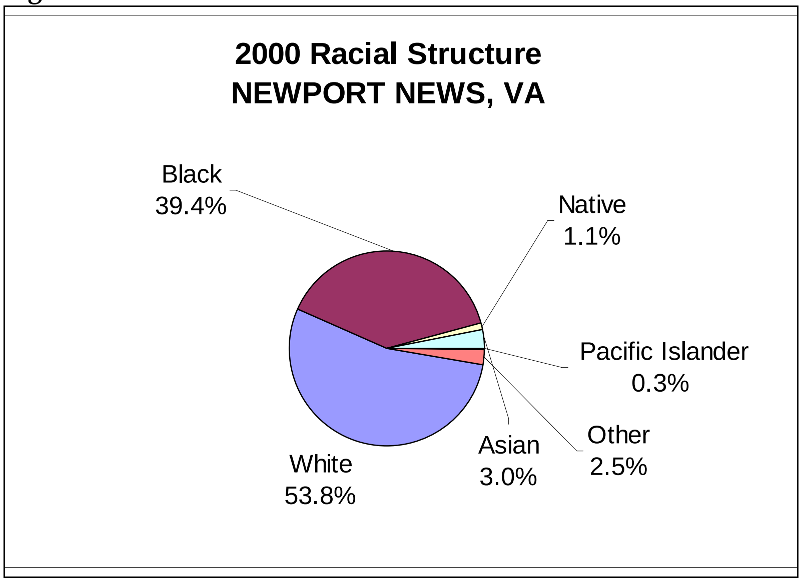
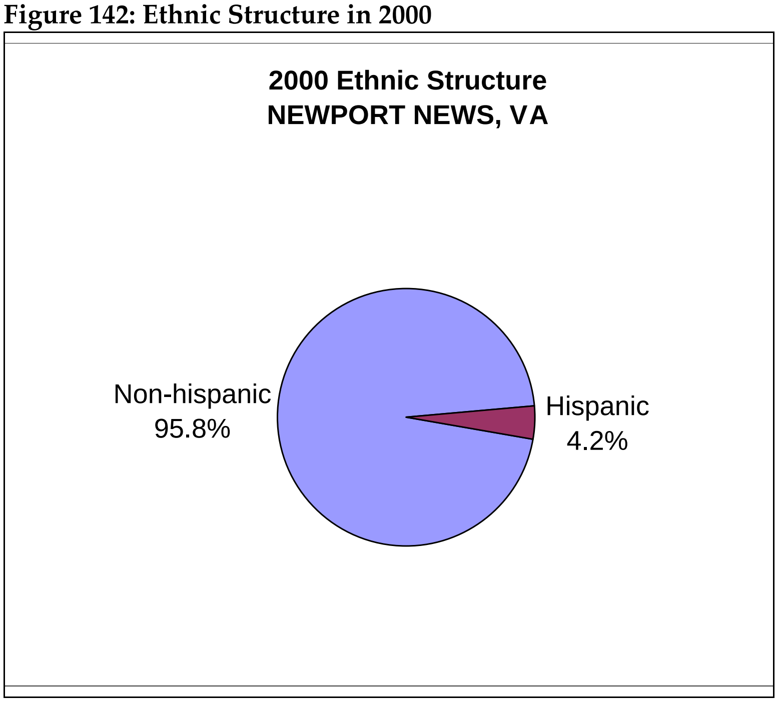


Figure 142: Ethnic Structure in 2000



For 91.7% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 8.3% in homes where a language other than English was spoken, and including 2.8% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 84.5% were high school graduates or higher and 19.9% had a bachelor's degree or higher. Again of the population 25 years and over, 4.2% did not reach ninth grade, 11.3% attended some high school but did not graduate, 30.1% completed high school, 27.2% had some college with no degree, 7.3% received their associate degree, 13.4% earned their bachelor's degree, and 6.5% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Newport News County was Southern Baptist with 21 congregations and 19,296 adherents. Other prominent congregations in the county were Catholic (4 with 11,414 adherents), and Methodist (11 with 7,478 adherents). The total number of adherents to any religion was up 0.5% from 1990.

Issues/Processes

Fort Eustis in Newport News has been placed on the EPA National Priority List because of contamination of the surrounding watershed by chemicals leaching from the facility. There has been concern about recreational fishermen consuming fish taken from waterways around Fort Eustis, as some fish have been found to be contaminated with PCBs.[959]

The city's plans to construct a large reservoir in the Mattaponi River have been highly controversial, resulting from concerns that construction will harm an important spawning ground for shad in the river.[960]

Cultural attributes

The Board of Commissioners for the Virginia Marine Resources Commission allocates some of its funds to support a children's fishing clinic every July at the James River Pier with the Peninsula CCA.[961] There is also a popular Oyster Roast in October.[962] The Mariners' Museum holds weekly talks on maritime history, though few of these are related specifically to fishing[963]. The Peninsula Salt Water Sport Fisherman's Association, based in Newport News, sponsors a variety of fishing tournaments throughout the year.[964]

Hampton, which is adjacent to Newport News, celebrates the Hampton Bay Days[965] (a family oriented festival about Chesapeake Bay) and the Seafest[966] (a large marine trade show). Both of these are in early September.

The Mariners Museum noted above holds a large collection of artifacts and information about maritime history[967]. The *Monitor* National Marine Sanctuary has its headquarters at NOAA's Maritime Archaeology Center, which is on the grounds of the Mariners

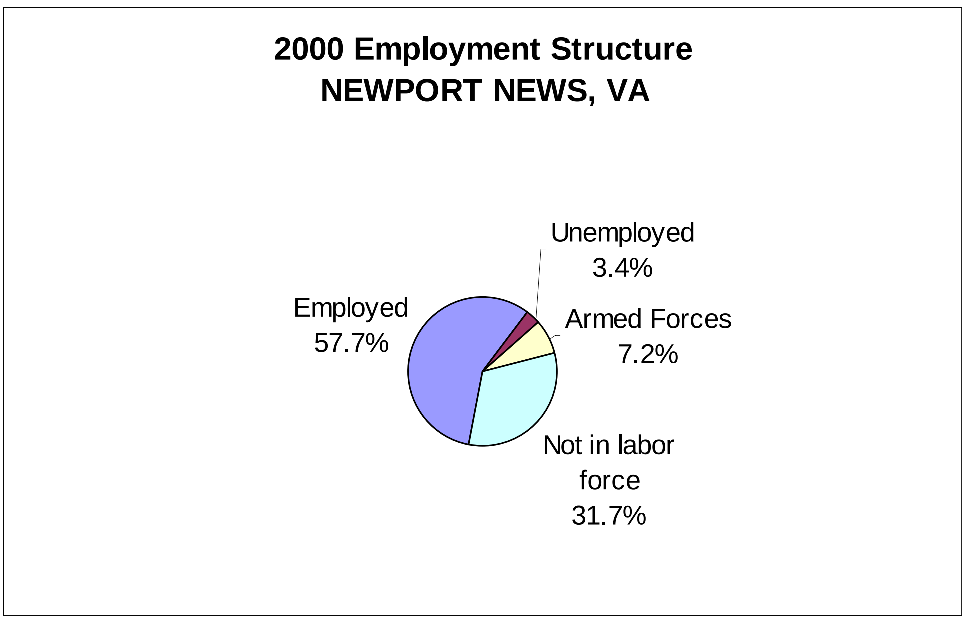
Museum. This National Marine Sanctuary itself is located 16 miles off-shore and was established to protect and preserve the remains of the U.S.S. Monitor.[968]

10.2.2 Infrastructure
Current Economy

The location of Newport News is strategic for its easy access and safe harbor for shipping and transport. It currently has a large defense sector (military bases, shipbuilding, and support industries), but has been working to diversify its economy for the past twenty years. The technology sector has increased, probably attracting younger workers.[969] This may explain the age structure discussed in the demographic section.

According to the U.S. Census 2000, 68.3% (92,586 individuals) of the total population 16 years of age and over were in the labor force, of which 3.4% were unemployed and 7.2% were in the Armed Forces.

Figure 143: Employment Structure in 2000



In Newport News the largest employers for manufacturing, distribution, teleservice and technology are Northrop Grumman (15,000+), Ferguson Enterprises (1000-2500) and Canon Virginia (1000-2500). The largest employers in the service industry include the U.S. Army Transportation Center at Fort Eustis (10,000+) and Newport News School System (5,000-10,000). The largest employers in the retail industry and temporary employment agencies are Production System Services and Wal-Mart/Sam's Club (both 500-1,000).[970] Additionally of interest, according to the 2000 census 19.9% of the civilian population 18 years or over had veteran status.

According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 211 positions or 0.3% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 3,256 positions or 4.2% of jobs. Education, health, and social services (19.3%) was the industry grouping accounting for the most employment. Additionally, manufacturing (15.3%), retail trade (12.8%) and arts, entertainment, recreation, accommodation and food services (10.0%) were prominent.

Median household income in Newport News in 2000 was $36,597 (up 33.2% from $27,469 in 1990) and per capita income was $17,843. For full-time year round workers, men made approximately 40% more per year than women.

The average family in Newport News in 2000 consisted of 3.04 persons. With respect to poverty, 11.3% of families (down from 12.2% in 1990) and 13.8% of individuals earned below the official US Government poverty line, while 47.4% of families in 2000 earned less than $35,000 per year.

In 2000, Newport News had a total of 74,117 housing units, of which 94.0% were occupied and 50.7% were detached one unit homes. Only 5.2% of these homes were built before 1940. There are a number of mobile homes/vans/boats in this area, accounting for 2.1% of the total housing units; 93.0% of detached units have between 2 and 9 rooms. In 2000, the median cost for a home in this area was $96,400. Of vacant housing units, 5.1% were used for seasonal, recreational, or occasional use. Of occupied units 47.6% were renter occupied.

Governmental

The City Manager and City Council govern Newport News. The City Manager oversees administration and day to day business of the city government. The city employs over 2,500 people and has a $554 million budget.[971]

Fishery involvement in government

The Virginia Marine Resources Commission offices are located in Newport News. It has committees to advise the Commission on the needs and utilization of the recreational and commercial fisheries for: blue crab, clam, finfish, seaside eastern shore oyster replenishment, and shellfish. Only the Shellfish Management Advisory Committee has a member who is a resident Newport News. Additionally, there are committees to advise the Commission on spending the Marine Fishing Improvement Fund and the Virginia Saltwater Recreational Fishing Development Fund (derived from commercial license fees). The latter recreational fishing advisory committee has one member who is a resident of Newport News. There are also committees to advise on the marine fish citation program and on the needs and utilization of intertidal and aquatic habitat in Virginia.[972]

Fishery associations

At the federal commercial level, there are no apparent active fishery associations in the Hampton Roads area. At the State level, there are several local "Waterman's" Associations, formed generally to address specific regulations being considered by the VMRC. These associations focus primarily on Chesapeake Bay fisheries.[973]

There are two sportfishing associations in Newport News. The Peninsula Saltwater Sportfishermen Association (PSSA) represents fishermen from the entire Virginia Peninsula. The Virginia Coastal Conservation Association's (CCA) local Newport News chapter has many of the same members as the PSSA.[974] Barbara Stevenson's list of fisheries organizations reports two in Newport News: James River Watermen's Association and Virginia Marine Products Board.[975]

Fishery Assistance Centers

The Virginia Department of Game and Inland Fisheries administers the Saltwater Recreational Fishing Development Fund, which is generated from license fees. A Board decides biennially how to allocate the funds. This fund has contributed towards increasing public access, improving boat ramps, and the annual Children's Fishing Clinic (see "Cultural attributes"). Some of the funds also go to the Virginia Institute of Marine Science (VIMS) research projects focusing on recreational fishing.[976] For a full list of the funding and projects of this fund, see http://www.mrc.state.va.us/swrfdf.pdf.

Other fishing-related institutions

The Virginia Seafood Council is located in Newport News and represents the whole state.[977] The Coastal Conservation Association (CCA) operates a state chapter out of Virginia Beach, VA. The CCA is a non-profit organization aiming to education the public about marine conservation, whose members are primarily saltwater anglers.[978]

Physical

The Williamsburg/Newport News airport is located in the city. There are also two international airports located nearby (Norfolk International and Richmond International Airports). Amtrak provides passenger railway service in and out of Newport News. This city has transportation systems by air, road, railway, and water.[979] Many of the fishing-related businesses are located in the Newport News Seafood Industrial Park.[980]

A variety of public access sites are available for recreational fishing. The pier at Denbigh Park is available daily for saltwater fishing, and fresh water fishing on shore or with private or rental boats is available at Lee Hall and Harwood's Mill Reservoirs.[981]

Leeward Marina offers 200 slips for private recreational vessels of up to forty three feet in length.[982]

10.2.3 Involvement in Northeast Fisheries

Commercial

There are five bait and tackle stores, 12 fish and seafood markets, and eight seafood wholesale and processing plants in Newport News, indicating a demand coming from the fishing industry. "Because of problems with Oregon Inlet, many seafood dealers have moved their marketing and processing operations from Wanchese to the Newport News/Hampton Roads region, both expanding their seafood buying capabilities and creating more integrated linkages between the two landing centers."[983]

Scallops were the fish landed with the total highest valued catch in both the average from 1997 to 2004 and for 2003. The three highest valued species from landings in 2003 were Sea Scallop ($34,823,672), Summer Flounder ($1,374,465), and Blue Crab ($780,344). Blue crab is managed under state fisheries regulations only, while sea scallop and summer flounder are jointly managed by state and federal governments. From value of landed species data in Table 1, it is evident that fisheries for several species or species groups were inactive in 2003, but were open within the past six years.

Both the numbers of boats that are home ported and the number of vessels permitted with Newport News as the owners' city have increased from 1997 to 2003. Landings value by home port have risen from $2 million to over $17 million from 1997 to 2003, with a similar pattern for landings value by landed port.

There are several large seafood processing plants in Newport News[984]; two of the largest are Chesapeake Bay Packing, specializing in scallops and conch[985], and Icelandic USA, Inc., "the largest importer of frozen groundfish for the foodservice industry in the U.S.[986]". There are several other processing plants, wholesalers, and packing houses located in the Newport News Seafood Industrial Park.[987]

Landings by Species

Table 74: Dollar value of Federally Managed Groups of landing in Newport News, VA

Species	Average from 1997-2004	2003 only
Scallops	20,415,886	34,823,672
Summer flounder, Scup Black Sea Bass	1,215,816	1,645,381
Red crab	238,159	0
Monkfish	182,686	59,074
Dogfish	49,951	0
Squid, Mackerel Butterfish	23,205	2,989

Bluefish	6,246	3,396
Skate	5,305	16
Largemesh groundfish	2,843	0
Lobster	405	0
Smallmesh groundfish	189	0
Herring	3	4
Other	2,190,312	1,850,955

Vessels by Year

Table 75: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	11	9	2,652,367	15,194,635
1998	15	9	3,924,764	15,945,730
1999	16	6	8,904,712	19,190,220
2000	21	9	13,055,962	26,514,096
2001	20	11	13,598,770	29,745,272
2002	22	15	17,005,061	34,434,618
2003	24	15	16,431,790	38,385,487

Recreational

There are many businesses in Newport News that serve recreational boaters and fishermen, which could indicate a substantial dependency on the recreational fishing industry. These include boat dealers (20), boat cleaning services (2), boat repair (15), canoe and kayak dealers (1), marine engine repair (2), marine propeller repair (1), marine supplies and equipment (14), and retail outboard motors (4). There are also several charter fishing boats. The James River Fishing Pier attracts fishermen from all over to fish off the pier.[988]

Fish caught for recreation include Black Drum, Bluefish, Cobia, Croaker, Flounder, Red Drum, Sea-Bass, Spadefish, Spanish Mackerel, Spot, Striped Bass, Tautog, Trout and Triggerfish.

In 2005, the economic impact generated by marine recreational fishing in Newport News was second highest in the state behind Virginia Beach. The total sales/economic activity for Hampton was $70,114,000, a cumulative income of $39,189,000, and recreational fishing employed 999 people. In 2004, 20 % more marine recreational licenses were sold than in 1994.[989]

Subsistence

No information has been found through secondary sources at this time on subsistence fishing in Newport News, Virginia.

Future

During the 2003-2005 in the Hampton Roads area at least fifteen scallop vessels were sold to a New England processing company. Some fishermen see a trend where a few large companies are purchasing vessels, thus, creating a monopoly in the scallop industry. Concerns also exist that big business will squeeze small vessels out of the industry.[990]

11.0 NORTH CAROLINA

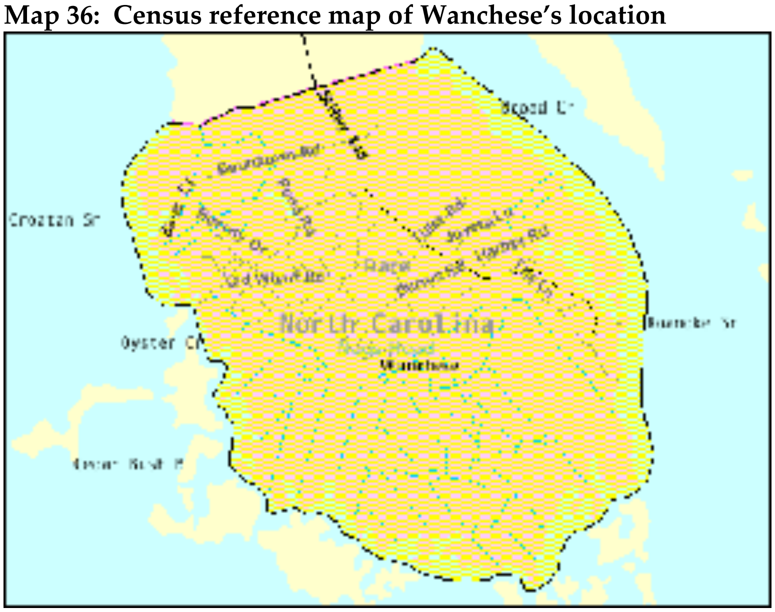
11.1 WANCHESE, NC

11.1.1 People and Places

Regional orientation

The village of Wanchese (35.8°N, 75.6°W) is located on Roanoke Island in North Carolina's Outer Banks. It is 68 miles from Elizabeth City, NC and roughly 100 miles from the Norfolk/Virginia Beach/Hampton area in Virginia.[991]

Map 36: Census reference map of Wanchese's location



Historical/Background information

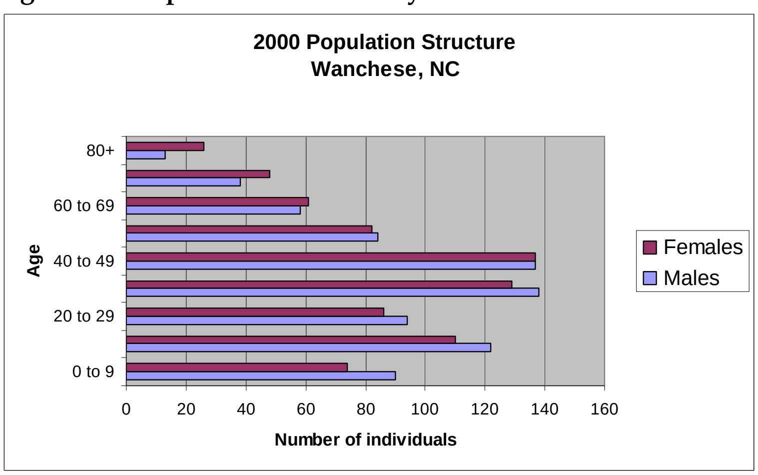
Wanchese is located on Roanoke Island, famous for its role in American History as the site of the first attempt, ultimately a failed attempt, at European settlement in the New World. The settlement of 117 men, women, and children sent here by Queen Elizabeth I and Sir Walter Raleigh in the late 1500s disappeared without a trace, and became known as the Lost Colony, a mystery which has yet to be solved. Wanchese and Manteo are named for two Native Americans who were brought back to England from a 1584 expedition to the island.[992] Archeological exploration of Wanchese found large piles of shells, indicating that the area's early Native American residents were harvesting oysters and other shellfish, and probably fish, from the waters around Roanoke Island long before European settlers established a tradition of fishing here.[993] The English colonists who settled here were also very dependent upon harvesting marine species.[994] Today Wanchese is advertised to tourists as a quaint fishing village where visitors can watch the fish come in to port and be shipped around the world.[995]

Demographics

According to Census 2000 data, Wanchese, NC had a total population of 1,527, up 10.6% from the reported population of 1,380 in 1990. Of this total in 2000, 49.3% were female and 50.7% were male. The median age was 37.2 years and 73.0% of the population was 21 years or older while 15.0% were 62 or older.

Wanchese's age structure shows a dip in the number of 20-29 year olds, indicating that many people may leave town for college or in search of employment around this age, characteristic of many fishing towns.

Figure 144: Population structure by sex in 2000



The majority of the population of Wanchese in 2000 was white (98.0%), with 0.4% of residents Black or African American, 0.9% Native American, 0.1% Asian, and 0.0% Pacific Islander or Hawaiian. Only 1.8% of the total population were Hispanic/Latino. Residents linked their heritage to a number of ancestries: English (23.6%), Irish (14.8%), and German (11.8%). With regard to region of birth, 55.6% were born in North Carolina, 42.6% were born in a different state and 1.2% were born outside of the U.S. (including 1.2% who were not United States citizens).

Figure 145:Racial Structure in 2000

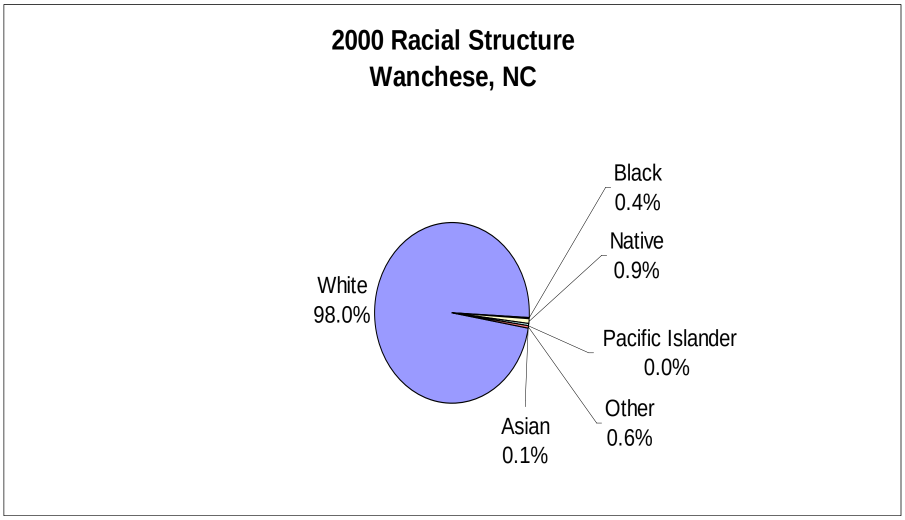
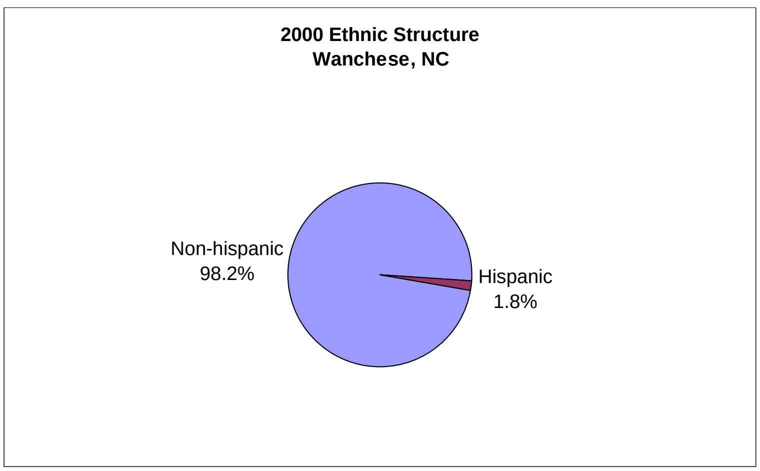


Figure 146: Ethnic Structure in 2000



For 98.8% of the population 5 years old and higher in 2000, only English was spoken in the home, leaving 1.2% in homes where a language other than English was spoken, and including 0% of the population who spoke English less than 'very well'.

Of the population 25 years and over, 76.5% were high school graduates or higher and 16.2% had a bachelor's degree or higher. Again of the population 25 years and over, 4.5% did not reach ninth grade, 19.0% attended some high school but did not graduate, 36.0% completed high school, 20.5% had some college with no degree, 3.8% received their associate degree, 11.6% earned their bachelor's degree, and 4.5% received either their graduate or professional degree.

Although religious percentages are not available through the U.S. Census, according to the American Religion Data Archive in 2000 the religion with the highest number of congregations and adherents in Dare County was United Methodist with 14 congregations and 4,686 adherents. Other prominent congregations in the county were

Catholic (4 with 2,097 adherents), Assembly of God (8 with 1,184 adherents), and Southern Baptist Convention (6 with 1,783 adherents). The total number of adherents to any religion was up 32.9% from 1990.

Issues/Processes

For the last 43 years the Army Corps of Engineers has been continuously dredging a channel at the entrance to Oregon Inlet, which connects the Roanoke Sound with the Atlantic Ocean. The Oregon Inlet receives heavy vessel traffic as it is the only navigable inlet between Cape Henry, Virginia and Hatteras Inlet, North Carolina, and it is commonly used by commercial fishing vessels from North Carolina and from other states.[996] However, traveling the inlet can be dangerous; most vessels have to wait for high tide to pass, and a trawler was lost here in 1981. Some people argue that the Corps is fighting a losing battle against nature in dredging the Inlet. But without dredging an important port would be lost. [997] This could have a negative effect on many area businesses.[998] Some vessels from Wanchese now fish out of Hampton Roads, Virginia because of the danger involved with passing through the Inlet.[999] The Corps received authorization in 1970 to construct two jetties alongside the inlet to stabilize the shifting sands and to dredge a channel through Roanoke Sound, making passage in and out of Wanchese safer for commercial fishing vessels as well as recreational boats, but as of 2002 this project had yet to be completed due to a variety of objections and proposed alternative plans.[1000] The construction of the jetties has been highly controversial, opposed by environmentalists and others who believe changing the dynamics of this poorly-understood estuary will have negative consequences.[1001] In April 2005, the Army Corps of Engineers announced it would discontinue its regular dredging of Oregon Inlet because of federal budget cuts.[1002]

The Wanchese Seafood Industrial Park has been controversial since it was built in 1979, and many fishermen opposed it. It was originally supposed to house a processing plant as well as a restaurant and cannery, but the facilities were never built. The park opened itself to marine related businesses, and has seen a boom in boatbuilding at the facility.[1003]

Cultural attributes

The Dare County Parks and Recreation Department runs a fishing school for children during the summer months as well as a fishing tournament for children.[1004] The North Carolina Maritime Museum on Roanoke Island in neighboring Manteo is dedicated to the region's maritime history and includes exhibits on early commercial shad fishing and an old shad fishing vessel.[1005] Until recently Wanchese held a blessing of the fleet and seafood festival[1006], but it seems these activities no longer exist here.

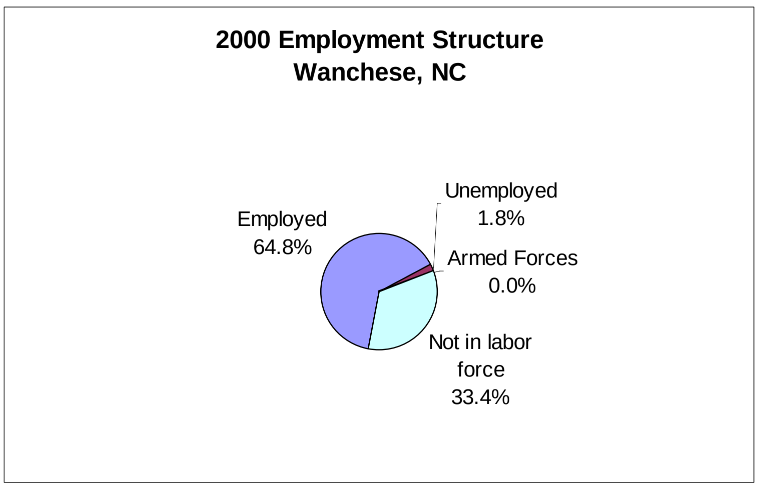
11.1.2 Infrastructure

Current Economy

The Wanchese Seafood Industrial Park houses a number of businesses, many of which are related to fishing or other marine industries. Davis Boatworks was the largest employer in the park in 2001, employing 180 people, though many of the Park's businesses are Mom and Pop operations. [1007] Davis Boatworks was recently bought by a larger New Jersey company and moved to New Jersey. Another boatbuilder, Scully Boatbuilders, moved into the facility previously occupied by Davis Boatworks,[1008] and the former owner of Davis Boatworks has opened a new boatbuilding.[1009] The Moon Tillett Fishing Company in Wanchese, which is a processing, packing, and distribution facility located on the harbor, employs over 40 people in all areas of the operation.[1010]

According to the U.S. Census 2000, 66.6% (799 individuals) of the total population 16 years of age and over were in the labor force, of which 64.8% were unemployed and 0% were in the Armed Forces.

Figure 147: Employment Structure in 2000



According to Census 2000 data, jobs in the census grouping which includes agriculture, forestry, fishing and hunting, and mining accounted for 64 positions or 8.2% of all jobs. Self employed workers, a category where fishermen might be found, accounted for 128 positions or 16.5% of jobs. Education, health, and social services (22.0%), manufacturing (13.1%) and retail trade (11.7%) were the primary industries.

Median household income in Wanchese was $39,250 (up 51.1% from $25,977 in 1990) and per capita income was $17,492. For full-time year round workers, men made approximately 34.1% more per year than women.

The average family in Wanchese in 2000 consisted of 2.96 persons. With respect to poverty, 5.1% of families (down from 6.5% in 1990) and 8.1% of individuals earned below the official US Government poverty line, while 46.5% of families in 2000 earned less than $35,000 per year.

In 2000, Wanchese had a total of 690 housing units, of which 89.0% were occupied and 67.4% were detached one unit homes. Less than ten percent (8.0%) of these homes were built before 1940. There were a number of mobile homes/vans/boats in this area, accounting for 31.5% of the total housing units; 98.6% of detached units had between 2 and 9 rooms. In 2000, the median cost for a home in this area was $104,900. Of vacant housing units, 51.0% were used for seasonal, recreational, or occasional use, while of occupied units 24.3% were renter occupied.

Governmental

Wanchese is still an unincorporated village within Dare County.[1011] The county is governed by a seven-member board of commissioners. They are elected in county-wide elections to serve four-year staggered terms. There is also a County Manager who is the chief administrative officer for the government. The county seat is in Manteo, six miles from Wanchese, also on Roanoke Island.[1012]

Fishery involvement in the government

One of the twenty one voting members of the Mid-Atlantic Fishery Management Council is from Wanchese. The Council is responsible for planning and decision making to carry out provisions of the Magnuson-Stevens Fishery Conservation and Management Act of 1976.[1013] In addition, the North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries has an active field office on Harbor Road in Wanchese.[1014]

Institutional

Fishing associations

The North Carolina Fisheries Association has been supporting fishing families since 1952, with the goal "to celebrate and preserve commercial fishing families, heritage, and seafood" in North Carolina. This is achieved through lobbying federal, state, and local legislators and through public awareness projects. Several members of the Board of Directors are from Wanchese.[1015]

Fishery Assistance Centers

No fishery assistance center was identified for Wanchese through secondary sources at this time.

Other fishing related organizations

No other fishing related organizations were identified through secondary sources at this time.

Physical

Wanchese is located along Route 345, off Interstate Highway 64 which runs through Manteo. Rt. 345 provides the only land access to the village. Wanchese is 6 miles from the Dare County Regional Airport in Manteo, 192 miles from the Raleigh-Durham International Airport, and 100 miles from the Norfolk International Airport in Virginia.[1016]

Wanchese is home to the Wanchese Seafood Industrial Park, "the only Federal, State and County-financed project devoted entirely to the seafood processing and fishing industries",[1017] built to enhance fishing and marine-related industries in the area and to increase the area's economic growth.[1018] The facility houses a number of businesses involved with building, repairing, and outfitting commercial fishing and sport fishing vessels, as well as one company that sells seafood packaging.[1019]

The Broad Creek Fishing Center in Wanchese is a full service marina for the sportfishing industry, with fishing gear and bait, and also houses a number of charter vessels.[1020] Many charter vessels are also docked at the Thicket Lump Marina, which also has a bait and tackle shop.[1021] There is one public boat ramp in Wanchese operated by Dare County.[1022]

11.1.3 <u>Involvement in Northeast Fisheries</u>

Commercial

Wanchese has a very diversified fishing industry, based on a large number of species landed. Fishing operations here readily switch gear to target different species depending on availability and market demand. Gear and vessel types here include longlining, scallop dredges, gillnetting, otter trawling, and crab pots.[1023] The top three landings in Wanchese in 2003 by value were blue crab ($3,298,125) and Atlantic croaker ($1,582,495), both of which fall under the 'other' category, and summer flounder ($1,396,720). The values of the species categories in which these species fall were higher in 2003 than the 1997-2004 average values. However, the landings of monkfish were considerably lower in 2003 than the 8-year average, and dogfish, once a valuable species in Wanchese, was not caught at all in 2003.

The value of fishing for home-ported vessels increased steadily between 1997 and 2003, and in 2003 was almost three times the 1997 value. The number of vessels, while showing considerable variability, seems to have also increased.

The Moon Tillett Fishing Company in Wanchese is one of the largest fishing and seafood trading operations in the Outer Banks. The company includes retail and wholesale sales and distribution, including importing and exporting fish, and processing both fresh and frozen seafood.[1024] O'Neal's Sea Harvest, Inc. is a wholesale and retail distributor of fresh and frozen seafood.[1025] They specialize in crabs and make crab pots as well.[1026]

Landings by Species

Table 76: Dollar value by Federally Managed Groups of landings in Wanchese

	Average from 1997-2004	2003 only
Other	6,151,810	7,172,566
Summer Flounder, Scup, Black Sea Bass	1,491,236	1,,837,785
Bluefish	550,761	530,339
Monkfish	400,280	164,514
Scallop	350,362	263,522
Dogfish	83,217	0
Squid, Mackerel, Butterfish	76,064	112,774
Lobster	2,595	0
Herring	1,454	0
Skate	1,325	135
Tilefish	1,110	1,342
Largemesh groundfish	973	224
Smallmesh groundfish	70	65

Vessels by year

Table 77: All columns represent vessel permits or landings value combined between 1997-2003

Year	# Vessels home ported	# vessels (owner's city)	Level of fishing home port ($)	Level of fishing landed port ($)
1997	30	22	3,199,133	6,328,469
1998	29	17	3,866,523	8,906,794
1999	40	25	3,861,804	9,748,684
2000	47	32	5,316,849	13,907,486
2001	51	30	7,939,403	10,904,337
2002	46	28	7,772,627	9,307,889
2003	49	29	9,535,872	10,083,266

Recreational

The Outer Banks area is known as "the billfish capital of the world",[1027] and recreational fishing is a billion dollar industry in North Carolina.[1028] The neighboring town of Manteo, also on Roanoke Island, has a marina that hosts a number of billfishing and other sportfishing tournaments throughout the year.[1029] There are also a number of marinas that have charter fishing vessels in Wanchese.[1030] Some of the younger fishermen have switched from commercial fishing to charter fishing, which is a more profitable industry. Clamming used to be done commercially here but is no longer done as a commercial activity. Instead it is generally done by families looking to take home clams to eat.[1031]

Subsistence

No information has been obtained at this time through secondary sources on subsistence fishing, other than the clamming noted above.

Future

As it becomes increasingly difficult to make a living from fishing in Wanchese, much of the village's industry has shifted to boatbuilding, which has proved to be a profitable industry for many. However, many of the seafood packing and distribution houses in Wanchese are still in operation after several decades.[1032] Dare County has recently worked with residents to propose a zoning plan for Wanchese, which currently lacks zoning of any kind, to protect the character of the town by designating commercial, residential, and mixed-use districts for the town, including a marine commercial district.[1033]

In 2002 Will Etheridge III, owner of Etheridge Seafood, one of the oldest businesses in Wanchese, believed the fishing industry will be put out of business by environmentalists and recreational fishermen, and because the public was not aware of the commercial fishing industry. He claimed that he would not encourage his children or grandchildren to go into the seafood business.[1034] Some commercial fishermen see the industry as inevitably declining, and see charter fishing in the recreational fishing industry as a fallback way to make a living.[1035]

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ESSENTIAL FISH HABITAT (EFH) OMNIBUS AMENDMENT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS)

PHASE 1

APPENDIX H
"SCOPING REPORT"

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1.0 INTRODUCTION

In the 1996 Magnuson-Stevens Act Fishery Conservation and Management Act (Magnuson-Stevens Act) reauthorization, Congress recognized that one of the most significant long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats. To ensure that habitat considerations receive increased attention for the conservation and management of fishery resources, the amended Magnuson-Stevens Act included new essential fish habitat (EFH) requirements. As such, each fishery management plan (FMP) must describe and identify EFH for the fishery, minimize adverse effects on EFH caused by fishing to the extent practicable, and identify other actions to encourage the conservation and enhancement of EFH. EFH is defined in the Magnuson- Stevens Act as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

In October 1998, the New England Fishery Management Council (Council) adopted Amendments 11/9/1/1 to the northeast multispecies, Atlantic sea scallop, Atlantic salmon fishery management plans, respectively, and the EFH components to the herring fishery management plan and submitted them for review by the Secretary. These amendments were approved by the Secretary (FR 64, No. 76, p. 19503), in accordance with Section 304(a) of the Magnuson- Stevens Act. The purpose of the Omnibus EFH Amendment of 1998 was to identify and describe the EFH for all species of marine, estuarine, anadromous finfish and mollusks managed by the Council to better protect, conserve, and enhance this habitat. The 1998 EFH Amendment also identified the major threats to EFH from both fishing and non-fishing related activities and conservation and enhancement measures. The Council began implementation of the SFA's EFH requirements based on guidance provided by NMFS on interpreting the mandate and timelines. Amendments to the FMPs managed by the Council were initiated in 1998 and combined in one management action that was termed the "Habitat Omnibus Amendment of 1998." The Council approved the final EFH FMP amendments (EA) in September 1998 and the EA was submitted to NMFS in October 1998. The Secretary of Commerce approved the amendments to all FMPs, with the exception of the Monkfish FMP, on March 1999. The EFH requirements of FMPs that were not included in the Omnibus Amendment of 1998 were completed on the following schedule: Monkfish FMP (April 1999), Red Crab FMP (October 2002), and Skate FMP (July 2003).

In Amendment 13 to the Northeast Multispecies FMP, the Council evaluated gear impacts and selected measures to minimize impacts to the extent practicable which included effort reduction and closed areas (FR Vol. 69, No. 113, p.32900). In Amendment 10 to the Atlantic Sea Scallop FMP, the Council evaluated gear impacts and selected measures to minimize impacts to the extent practicable which included effort reductions, closed areas, gear modifications and research set-aside monies (FR Vol. 69, No. 120, p. 35194). In Amendment 2 to the Monkfish FMP, the Council has evaluated gear effects and determined that adverse impacts to EFH from the monkfish fishery are occurring. As a result, the Council selected measures to minimize these impacts to the extent practicable, which included gear modifications and closed areas (FR Vol. 69, No. 36, p. 8367). The draft EIS has been submitted to NMFS and the public comment period runs through July 2004. In Amendment 1 to the Herring FMP, the Council has evaluated gear effects and determined that no adverse impacts rise to the threshold of more than minimal and temporary in nature. Therefore, the Council doe not need to develop a range of alternatives to minimize adverse impacts to the extent practicable.

In February 2004, the New England Fishery Management Council (Council) initiated the development of an Omnibus Essential Fish Habitat (EFH) Amendment under the authority of the Magnuson-Stevens Fishery Conservation and Management Act (M-S Act) (FR Vol. 69, No. 36, p. 8367). This action will amend all of the fishery management plans (FMPs) managed by the Council and will become Amendment 14 to the Northeast Multispecies FMP, Amendment 11 to the Atlantic Sea Scallop FMP, Amendment 3 to the Monkfish FMP, Amendment 2 to the Herring FMP, Amendment 1 to the Skate FMP, Amendment 1 to the Red Crab FMP and Amendment 2 to the Atlantic Salmon FMP. This action is designed to determine whether and how to amend the Council FMPs pursuant to Section 307(a) of the Magnuson-Stevens Act and based on the EFH Final Rule in 50 CFR, part 600 subpart J. More specifically, the intent of this action is twofold: (1) To meet NMFS' published guidelines for implementation of the Magnuson-Stevens Act's EFH provisions to review and revise EFH components of FMPs at least once every five (5) years; and, (2). To develop a comprehensive EFH Management Plan that will successfully minimize adverse effects of fishing on EFH through actions that will apply to all Council-managed FMPs. The Council is not satisfied with its current practice of evaluating EFH and EFH management through individual plans and believes that it would be preferable to meet the EFH requirements by developing a comprehensive EFH Omnibus Amendment for all its FMPs. The topics under consideration include, but are not limited to, the following:

1. Review and update the description and identification of EFH
2. Review and develop analytical tools used to analyze alternatives to minimize adverse effects of fishing on EFH
3. Review and update the non-Magnuson-Stevens FCMA fishing activities that may adversely affect EFH
4. Review and update the non-fishing related activities that may adversely affect EFH
5. Review and update the cumulative impact analysis
6. Review and update the conservation and enhancement recommendations
7. Review and update the prey species information
8. Identify and consider new Habitat Areas of Particular Concern (HAPCs)*

9. Review and update research and information needs including the consideration of Dedicated Habitat Research Areas (DHRA)*
10. Integrate alternatives to minimize any adverse effects of fishing on EFH across all FMPs principally managed by the Council

2. 0 SCOPING PERIOD, PUBLIC SCOPING MEETINGS, AND ISSUES

On February 24, 2004, the Council published in the Federal Register a Notice of Intent (NOI) to prepare this EIS. The NOI solicited written comments to determine the issues of concern and the appropriate range of management alternatives to be addressed in the EIS and included notification regarding noticed five scoping meetings in communities in Maine, Massachusetts, Connecticut and North Carolina (FR Vol. 69, No. 36, p. 8367).

2.1 Summary of Scoping Meetings

The Council conducted scoping hearings in accordance with NEPA requirements. The Chair of the Council's Habitat Committee, the Habitat Plan Development Team Chair and a member of the NMFS NERO Habitat Conservation Division attended each hearing. The hearings were organized and informational material was provided by the Council staff.

Table 1. Schedule of public scoping hearings

Date	Location	Number of Attendees
Friday, March 5, 2004 12:00 p.m.	Samoset Resort 220 Warrenton Street Rockport, ME 04846	22
Wednesday, March 10, 2004 7:00 p.m.	Whaling Museum 18 Johnny Cake Hill New Bedford, MA 02740	9
Monday, March 15, 2004 7:00 p.m.	Office of Public Safety 173 S. Broad St. (Route 1) Stonington, CT 06378	8
Tuesday, March 16, 2004 6:30 p.m.	Shell Island Suites 2700 N. Lumina Avenue Wrightsville Beach, NC	17

	28480	
Tuesday, March 23, 2004 6:00 p.m.	Tavern on the Harbor 30 Western Avenue Gloucester, MA 01930	19

2.2 Format of Scoping Meetings

A presentation with relevant overview information was given by the NEFMC Habitat Committee Chairperson and NEFMC and NMFS staff answered questions. The public attendees were asked to sign in and were afforded unlimited time with which to comment on the proposed issues. Additionally, the public was allowed to ask staff clarification questions that would enable the public to provide more informed comments.

2.3 Written Comment Letters

Table 2. Comment Letters and Issues

Letter Number	Source	Date
1.	Conservation Law Foundation, Dr. Priscilla Brooks, Dr. John Crawford, Mr. Roger Fleming	April 30, 2004
2.	Penobscot Marine Research Center, Dr. Ted Ames	March 5, 2004
3.	East Coast Fisheries Federation, Mr. Jim O'Malley	March 15, 2004
4.	North Atlantic Clam Association, Mr. John Brisen	March 16, 2004
5.	Mr. James Fletcher, Manns Harbor, NC	March 22, 2004
6.	Wallace and Associates, Mr. David Wallace	April 30, 2004
7.	Stellwagen Bank National Marine Sanctuary, Dr. Craig MacDonald	April 30, 2004
8.	Northeast Seafood Coalition, Ms. Jackie O'Dell	April 30, 2004
9.	Coonamessett Farm, Mr. Ron Smolowitz	March 6, 2004
10.	B. Sachau, Florham Park, NJ	February 17, 2004
11.	The Ocean Conservancy, Ms. Susan Farady and Mr. Geoff Smith	April 28, 2004
12.	Oceana, Mr. Chris Zeman	April 30, 2004
13.	Fisheries Survival Fund	April 30, 2004

	Mr. David Frulla and Mr. Shaun Gehan Dr. Trevor Kenchington	

Table 3. Summary Count of Comments within Comment Categories

Issue	Number of Comments	Number of Unique Comments
Review and update the description and identification of EFH		
Review and develop analytical tools used to analyze alternatives to minimize adverse effects of fishing on EFH		
Review and update the non-Magnuson-Stevens FCMA fishing activities that may adversely affect EFH		
Review and update the non-fishing related activities that may adversely affect EFH		
Review and update the cumulative impact analysis		
Review and update the conservation and enhancement recommendations		
Review and update the prey species information		
Identify and consider new Habitat Areas of Particular Concern (HAPCs)*		
Review and update research and information needs including the consideration of Dedicated Habitat Research Areas (DHRA)*		
Integrate alternatives to minimize any adverse effects of fishing on EFH across all FMPs principally managed by the Council by developing a comprehensive EFH Management Plan.		

3.0 SIGNIFICANT ISSUES THAT SUGGEST ALTERNATIVE ACTIONS

A principal objective of the scoping and public involvement process is to identify a reasonable range of management alternatives that, with adequate analysis, will delineate critical issues and provide a clear basis for distinguishing between those alternatives and selecting a preferred alternative. NEPA requires that only significant issues need to be analyzed in depth for environmental effects, formulating alternatives, and prescribing mitigation measures. The term "significance," has a different meaning under NEPA than statistical "significance" as generally used in scientific documents. Following guidance by the Council on Environmental Quality implementing regulations for NEPA, determinations of significance require consideration of both the context and the intensity of the issue (40 CFR 1508.27).

3.1 Review and update the description and identification of EFH

1. Recognize that EFH is not limited to the seafloor but also includes waters and their associated physical, chemical, and biological properties

2. Give appropriate weight to both the water column and seabed facets of fish habitat.

3. Do not base EFH designations on proxies for the functional value of habitat such as habitat complexity or sediment types.

4. Continue to use the approach approved in the 1998 EFH Omnibus Amendment to designate EFH which bases the designations on the distribution of resource species.

5. Reduce the scale of the EFH designations from 10 minute squares to either a 1 or 3 nautical mile square.

6. The entire time series of the NMFS survey data and all the tows should be used.

7. Utilize the data from state surveys in determining EFH.

8. Modify the existing EFH designations to include known deep-sea coral habitats

9. Maintain present EFH designations until new scientific research supports refinement

10. Place greater emphasis on the text description of EFH so that EFH is clearly defined as portions of the spatial scale selected to represent EFH in map format.

11. Use higher spatial resolutions to designate EFH such as the 3-mile grid used in the SMAST video survey or a 2.5, 3.3 or 5-minute intervals of latitude and longitude.

3.2 Review and develop analytical tools used to analyze alternatives to minimize adverse effects of fishing on EFH

<u>Gear Effects Evaluation</u>

1. Address the seafloor habitat impacts from bottom tending mobile gear

2. Threshold for an adverse impact that needs to be minimized should be a function of the species's biomass levels: if the biomass is at the optimum yield, then EFH is not being adversely affected.

3. Depend on research results only from experiments that used actual commercial fishing gear operated in a commercial manner in areas that are commercially fished.

4. Bottom trawls and scallop dredges have the greatest potential to cause long-term, significant adverse impacts to marine habitats designated as EFH

5. The habitat types that are most vulnerable include: 1) emergent epifauna and structure forming organisms; 2) gravels, cobbles and boulder reefs; and 3) deep water corals.

6. The first pass theory of habitat impacts has no scientific foundation.

7. No solid evidence for a linkage between gear impacts and fish production exists.

<u>Minimizing Adverse Impacts</u>

1. Focus habitat protections on the most important and/or sensitive EFH. Areas of high concentration of juvenile groundfish should be the first priority for protection with achieving a certain level of protection for all groundfish species within each stock area.

2. Implement new or reconfigured habitat closures with appropriate gear restrictions
3. Develop a plan where bottom tending mobile gear use is limited
4. Habitat data should be analyzed and considered in the rotational area management scheme for scallop management.

5. Support and encourage the use of gears, such as rod and reel and hook-and-line gear, that reduce the habitat impacts of fishing.

6. Implement additional restrictions on rock hopper roller gear on trawl nets.

7. Encourage additional habitat protections in sector allocation and area-based management programs.

8. Require VMS on all commercial vessels

9. Implement an adequate observer program with a minimum of 20% coverage and greater coverage in areas where protected species are known.

10. Employ the natural protection of marine organisms provided by the very rough areas on George's Bank and the Gulf of Maine where fishing gear cannot be used (e.g. steep canyon walls or large boulder fields).

11. If habitat closures and MPAs are employed, they should only be closed for a period of time (e.g. 2-5 years) and then re-opened.

12. Develop a policy limiting the amount of area that can be closed for habitat protection to 2-3% of water less than 200 meters.

13. Two habitat types deserve greater attention by the Council for protection: boulder reefs and cerianthid anemone forests.

14. An updated review of the science on the effects of gear on EFH should be conducted.

15. Establish marine sanctuaries and prohibit all commercial and recreational fishing within the boundaries.

16. Reduce all quotas on commercial fishermen by 50% the first year and 10% each succeeding year.

17. Avoid the use of the precautionary approach (2)

18. Management under the precautionary approach is inappropriate.

19. Develop a broad range of habitat-specific closed areas that place special emphasis on identifying and protecting habitat types that are vulnerable to fishing-related impacts and important to spawning and juvenile life stages of fish. Improve existing habitat closures to better protect the most vulnerable habitat types in the NE region.

20. Approve measures that restrict trawls and dredges from vulnerable habitat areas including boulder reefs, gravel and cobble substrates, and deep-water corals.

21. The most important characteristics to be protected include: 1) unique habitat types; 2) emergent epifauna and structure forming organisms; 3) gravel, cobble, and boulder reefs that provide cover for juvenile and sub-adult fish; and 4) deep water corals due to their life history characteristics and vulnerability to fishing gear impacts.

22. The most important functions to be protected include: 1) providing cover and refuge; 2) providing spawning sites; 3) providing habitat for important prey species; and 4) providing healthy populations of all marine life to help maintain and enhance biological diversity and overall ecosystem health.

23. Develop the following types of alternatives to minimize adverse effects: gear modifications, time/area closures, HAPCs, zoning, fishing restrictions and a no fishing alternative

24. Structural complexity and prey abundance are the two most important characteristics to be protected from adverse fishing impacts

25. Shelter and food sources are the two most important functions of marine habitats that need to be protected from adverse fishing impacts to protect sensitive gravel habitats and deep-sea coral habitats.

26. In order to minimize the impacts of bottom-trawling on sensitive gravel habitats and deep-sea coral habitats considers a broad range of alternatives to: 1. Create no-trawl/dredge habitat closures in known gravel, cobble and boulder habitats, specifically in areas west of the Great South Channel that are designated juvenile cod EFH; 2. Create no-trawl/dredge habitat closures in HAPCs designed to protect the priority sensitive habitat; 3.Create no-trawl/dredge closures in known areas of deep-sea corals; 4. Exclude sensitive habitat types identified as HAPCs from scallop dredging rotational management areas and areas open to scallop dredging and 4. Protect the top 30-50% of juvenile cod EFH from bottom-trawling and dredging

27. Develop an alternative that will prohibit all bottom-trawling and dredging in areas that have been unfished for the past three years until such areas are mapped and it is shown that those areas do not contain sensitive marine habitats

28. The boundaries of the existing groundfish closed areas should be open for review.

29. With rare exceptions, any linkage between EFH issues and "overfished" status is inappropriate as species depleted by fishing pressure should be too scarce to fully utilize their available habitat and hence protection of their EFH should be less, not more urgent than is the case for other resources.

30. Focus the work on the importance of the inshore habitats to the fishery resources of New England.

31. Do not focus on the use of closed areas for habitat protection at the expense of other tools such as gear modifications.

32. Modifications of existing gears and adjustments in the balance of different gears used in the same fishery promise opportunities to ease any habitat-related restrictions on fishing efforts.

33. The principal interest in area-based responses to the habitat issue should be on area-specific controls short of complete bans: 1."low-effort" areas, where fishing pressure (by one or more gear types) is held below the level deemed optimal elsewhere, without shutting off all access to the sedentary resources on relatively vulnerable bottoms and/or 2."high-effort" areas, where the industry is encouraged to harvest migrant fish on seabeds thought to be less vulnerable than those elsewhere. Areas might be open only to particular gear types or to other gears subject to specific restrictions. Bottom trawls might be allowed in an area, for example, if they are used to target species (shrimp perhaps) which only live on muddy sand but not in fishing for species which would draw the effort onto hard-bottom patches scattered through the softer seabed.

34. In the few cases where closed areas are necessary to protect well-defined, highly-valued and highly-vulnerable areas, delineate the area to be protected, surround that with a buffer and draw the closure boundary around the outside of the buffer. There should be no need to then add a further external buffer subject to some form of partial restriction.

35. Establish specific review dates for existing and any new habitat closed areas.

36. Consider the use of positive incentives to encourage fishing practices that will reduce seabed impacts such as reopening closed portions of traditional fishing grounds and/or provide free steaming time to offshore areas so as to draw effort away from more vulnerable habitats, particularly inshore, rocky areas where mobile gear was not used in the past and where few fishermen would choose to use if they had alternatives.

37. Implementation dates of measures should occur at the beginning of a fishing year and not in the middle.

Tools and Methods

1. Develop analytical tools that improve the ability to quantify the expected benefits of area closures and subsequent habitat recovery to the overall productivity of fish populations and the ocean ecosystem.

2. Make available mapping and analysis to allow the public to develop well-informed alternatives for protecting habitat

3. Analyses should concentrate on the consequences of each alternative for designated EFH and specifically the designated EFH upon which particular gear types have been determined to have adverse impacts.

4. Consider the effects of migratory behavior on the survey data when determining which areas to consider in their analyses.

5. Include fishermen's knowledge as important information inputs.

3.3 Review and update the non-Magnuson-Stevens FCMA fishing activities that may adversely affect EFH

None.

3.4 Review and update the non-fishing related activities that may adversely affect EFH

1. The Council should review the recommendations on citing of finfish aquaculture sites in the near shore waters of coastal Maine

2. Environmental changes need to be considered in managing fisheries

3. Use the NOAA National Coastal Conditions Report to highlight areas with water clarity problems and protect the EFH contained therein.

4. Consider review the recommendations on acid rain, estrogen and estrogen-like chemicals and chlorine deposited from waste water treatment plants.

3.5 Review and update the cumulative impact analysis

1. Examine not only the trawling (and dredging) taking place today, but also at how that trawling combines with past trawling, and likely future trawling, negatively affects the marine environment;

2. Consider the synergistic effects of habitat damage with other fishing effects, such as food web effects that may result from removal of key ecosystem components like top predators or forage species; and

3. All reasonably foreseeable actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions.

4. Organize a regional workshop with scientists, staff from the Environmental Protection Agency and the Department of the Interior, and interested stakeholders, to develop a methodology and approach to analyze the cumulative impacts of the multitude of fisheries occurring in New England waters in a way that is scientifically-sound, provides helpful management data, and adheres to NEPA requirements

3.6 Review and update the conservation and enhancement recommendations

None.

3.7 Review and update the prey species information

1. Need to recognize prey species in existing EFH designations, list managed species prey species and their habitats and recognize the lost of prey from fishing as an adverse impact.

2. Place review and update emphasis on improving the understanding or key forage species (including herring, mackerel and sand lance).

3. Designate EFH for prey species.

3.8 Identify and consider new Habitat Areas of Particular Concern (HAPCs)*

1. Implement HAPCs with management measures containing the highest levels of protection from gear impacts

2. Consider designating larger HAPCs, or surrounding HAPCs with "buffer zones" (in nearshore areas, hook and line fishing could be conducted)

3. Review the existing cod HAPC to see if it's in the right location by analyzing the abundance of juvenile cod and types of substrate in that area as compared to other areas.

4. Develop a broad range of HAPC alternatives with special consideration given to unique habitat features and areas where habitat is particularly vulnerable to fishing-related impacts: 1) complex gravel cobble habitats with emergent epifuana, 2) boulder reefs, 3) deep-waters corals, 4) kelp forests and 5) spawning aggregations and juvenile life stages of fish species.

5. Designate as HAPCs, and protect from bottom-tending mobile gear, gravel, cobble and boulder habitats and deep-sea coral habitats

6. Consider the following habitat types for HAPC designation and protection: 1. Gravel, cobble, and boulder habitats; 2. Deep-sea coral areas in inshore and offshore areas in the Gulf of Maine and on Georges Bank; 3. Deep sea (>100 m), low-energy habitats that contain emergent epifauna, including cerianthids, sponges, and deep-sea corals; and 4. Areas known to have clay pipes, lemon squirts, and mussel beds.

7. Establish a procedure to assess existing and potential adverse impacts to specific places that contain these sensitive habitat types appropriate to be designated and protected as HAPC that includes the following: 1. Visually overlay or describe active and potential adverse impacts (fishing, non-fishing, cumulative) to the specific places designated as HAPC; 2. Visually overlay or describe existing protective measures for these specific HAPC places; 3. Identify any gaps that may exist in habitat protection; 4. Develop proposals recommended by the Habitat PDT, in addition to requesting proposals from the public on measures to protect these specific places.

8. Recommend reconsideration of the Council's HAPC designation process and the current cod HAPC.

9. Opposes any blanket list of restrictions to be applied in all HAPCs, without regard to the reasons that particular areas are deemed to be of particular concern.

*3.9 Review and update research and information needs including the consideration of Dedicated Habitat Research Areas (DHRA)**

1. Not only look at areas currently closed but also look at areas currently open to fishing.
2. The RFP should proposals based on best-available scientific data and use systematic and objective methods as criteria.

3. Designate a portion of the Stellwagen Bank National Marine Sanctuary as a long-term research/reference area where the effects of human activities on sanctuary resources can be discerned.

4. Develop a broad range of alternatives for DHRAs with emphasis on improving the understanding of ecological processes and habitat recovery rates.

5. Coordinate with SBNMS and consider DHRA sites within the Sanctuary boundary.

6. Consider a DHRA west of the Great South Channel in areas of historically highly productive juvenile cod EFH

7. Conduct an experiment to inter-calibrate the State and NMFS trawl surveys such that existing data from State waters could be used to extend the quantitative information on fish distributions for input into new EFH designations.

8. Urge the Council to direct its Habitat PDT to swiftly compile a prioritized list of other projects which could usefully be undertaken within the existing time constraints, such that the various agencies and institutions involved in fisheries research in New England can direct their attention and resources in appropriate directions.

9. Council should adopt an explicit policy requiring that the declaration of any DHRA be tied to an analysis showing that such action is expected to have a net benefit for the fisheries.

10. Proponents of any DHRA be required to show why the research to be undertaken there cannot be carried out in areas open to fishing and why it cannot be carried out in any existing closures, either within the waters subject to NEFMC management or elsewhere.

11. The number and size of DHRAs which can exist at any one time should be limited.

12. Should ensure that each DHRA passes the test of a positive net benefit for the fisheries, the selection of areas must proceed from identified research needs, through details of the studies required to provide the necessary knowledge, and thence to selection of an area which can provide the habitat types needed for those studies.

3.10 Integrate alternatives to minimize any adverse effects of fishing on EFH across all FMPs principally managed by the Council by developing a comprehensive EFH Management Plan.

1. Council should take an integrated approach to designing habitat alternatives minimizing the adverse effects of fishing on EFH

2. Opposes a coordinated, habitat management program but harmonization across multiple FMPs is necessary.

3.11 Other Comments

1. NMFS should expand the data collected in its trawl surveys in order to accumulate information on the biodiversity of the larger ecosystem and to collect data on benthic epifauna.

2. Identify deep sea corals in New England as EFH and implement measures to protect them.
3. Corals should be designated as HAPCs.

4. Designate EFH for deep-sea and coldwater corals

5. Protection needed for very sensitive areas in New England (e.g. coral beds and kelp forests)

6. Council should develop a series of workshops to provide a complete update of the most current EFH science and an explanation of the relevant legal and management decisions that have been made to date.

7. Support the development of a Habitat Assessment Workshop and Review Committee to bring together experts knowledgeable in methods and application of applied habitat research to review and improve the current EFH designation process.

8. Urge NMFS to increase the use of multibeam sonar, backscatter plots, video surveys, and ROVs to improve habitat characterization and mapping.

9. In order to minimize the impacts of bottom-trawling on deep-sea coral habitats consider creating no-trawl/dredge closures in known areas of deep-sea corals

10. Urge Council and NMFS to design a system that will provide serious review of the advice provided to the Committee and one which will provide full opportunity for the PDT to correct any deficiencies identified by the review.

3.12 Data Sources and Tools

1. Use MARXAN for integrating EFH measures across FMPs
2. Do not use MARXAN.

3.13 Literature Cited in Scoping Comments

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4.0 DETAILED SUMMARY OF COMMENTS AND ISSUES ADDRESSED IN WRITTEN COMMENTS RECEIVED DURING SCOPING

On June 16, 2004, the Council's Habitat/MPA Committee and Advisors met to review the comments received on the scoping process for completing the Habitat Omnibus Amendment #2. The Committee considered all the comments received and identified draft goals and objectives to guide the development of this action. Key issues raised in each of the comments that may suggest significant alternative actions will be developed by the Committee after the Council approves the goals and objectives at the July 2004 Council meeting. In some cases the Committee will make a call as to whether they think the issue is significant (yes/no). Significant issues are used to formulate alternatives, develop or analyze environmental effects. Issues are considered significant based on the extent, duration, magnitude, or intensity of the effect. The extent is the geographic distribution of the effects. The duration is the length of time the effect is likely to occur. The magnitude or intensity is the value of the effect relative to acceptable values and/or the intensity of interest or resource conflict.

4.1 Goals

The Committee approved the following draft list of goals for the Omnibus Essential Fish Habitat Amendment #2 to be submitted to the Council for approval at the July Council meeting. This list is a combination of required review components (R) as well as discretionary topics (D). Discretionary topics are those that the Council is not required to cover either due to the statutory time of review requirements of the EFH Final Rule that guides the development of the EFH components of the Council's FMP documents.

1. Update the identification and description all EFH for those species of finfish and mollusks managed by the Council, including the consideration of HAPCs. (R)

2. Review and update the major fishing activities (MSA and non-MSA) that may adversely affect the EFH of those species managed by the Council. (D)

3. Review and update the major non-fishing activities that may adversely affect the EFH of those species managed by the Council. (R)

4. Identify and implement mechanisms to protect, conserve, and enhance the EFH of those species managed by the Council to the extent practicable. (R)

5. Define metrics for achieving the requirements to minimize adverse impacts to the extent practicable. (D)

6. Integrate and optimize measures to minimize the adverse impacts to EFH across all Council managed FMPs. (D)

7. Update research and information needs. (R)

8. Review and update prey species information. (R)

4.2 Objectives

Based on their goals, the Committee developed a set of objectives to support the above stated goals. This list was developed via Committee discussion, input from the AP Chair and Vice Chair as well as staff input and assistance by the general public:

A. Identify new data sources and assimilate into the process to meet goals (state, federal and other data sources)

B. Implement review of existing HAPCs and consider modified or additional HAPCs (Goal #1)

C. Review EFH designations and refine where appropriate as improved data and analysis become available (Goal #1)

D. Develop analytical tools for designation of EFH, minimization of adverse impacts, and monitoring the effectiveness of measures designed to protect habitat (Goal #1, Goal #3 and Goal #5)

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

F. Support restoration and rehabilitation of fish habitat which have already been degraded (by fishing and non-fishing activities) (Goal #4)

G. Support creation and development of fish habitat where appropriate and when increased fishery resources would benefit society (Goal #4)

H. Develop a strategy for prioritizing habitat protection (Goal #4)

I. Develop criteria for establishing and implementing dedicated habitat research areas (Goal #7)

J. Design a system for monitoring and evaluating the benefits of EFH management actions including dedicated habitat research areas (Goal #7).

5.0 Significant Issues that Suggest Alternative Actions

To be developed.

6.0 Other Significant Issues to Be Analyzed in the EIS

To be developed.

SUPPLEMENTAL NOTICE OF INTENT

Background

Due largely to public clarity and issues of complexity, on September 9, 2005, the Council published in the Federal Register a Supplemental Notice of Intent to declare its intention to complete Omnibus Amendment 2 in a two-phased approach, as further described below. The two phases will be documented in on accompanying EIS with potentially two separate volumes. Separation of this large action into two phases (volumes) will allow for the continued sequential development of the Omnibus Amendment but avoids the creation of an extremely large and complex action that may not be decipherable from the public's perspective. Further, in order to meet the Sustainable Fisheries Act intention of the EFH mandate, it is prudent to take a step-wise approach. For instance, it is necessary to determine what is EFH prior to conducting an evaluation of the potential effects of fishing gear on EFH and to develop a range of alternatives to minimize, mitigate or avoid any impacts that are more than minimal and less than temporary in nature. The Council's approved goals and objectives for the two-phase EFH Omnibus Amendment are listed here. Bolded items denote those that apply to Phase 1 of the Amendment

GOALS

1. **Redefine, refine or update the identification and description of all EFH for those species of finfish and mollusks managed by the Council, including the consideration of HAPCs;**
2. Identify, review and update the major fishing activities (MSA and non-MSA) that may adversely affect the EFH of those species managed by the Council;
3. **Identify, review and update the major non-fishing activities that may adversely affect the EFH of those species managed by the Council;**
4. Identify and implement mechanisms to protect, conserve, and enhance the EFH of those species managed by the Council to the extent practicable;
5. Define metrics for achieving the requirements to minimize adverse impacts to the extent practicable;
6. Integrate and optimize measures to minimize the adverse impacts to EFH across all Council managed FMPs;
7. Update research and information needs;
8. **Review and update prey species information for each species in the FMU.**

In summary, the purpose (four-fold) of Phase 1, which is the focus of this Draft Supplemental Environmental Impact Statement (DSEIS) and Fishery Management Plan Amendment, includes the following four main goals:

1. Redefine, refine or update the identification and description of all EFH for those species of finfish and mollusks managed by the Council, including the consideration of HAPCs;

2. Identify, review and update the major non-fishing activities that may adversely affect the EFH of those species managed by the Council

3. Identify, review and update the major non-fishing activities that may adversely affect the EFH of those species managed by the Council;

4. Review and update prey species information for each species in the FMU.

Summary of Scoping Comments

The Council received two (2) comment letters during the supplemental NOI comment period and are summarized below.

- Support the concept of separating the EFH identification process from the development of management measures under the various fishery management plans but believe that identification of habitat areas of particular concern should be conducted in conjuction with Phase 2.

- Concerned that the Council will designate revisions and/or new HAPCs before they have considered gear impacts an potential management measures and that this should be done simultaneously.